Joint UNDP/World Bank Energy Sector Management Assistance Program

KENYA

COAL CONVERSION, ENERGY CONSERVATION, AND SUBSTITUTION ACTION PLAN

VOLUME I

A REPORT BY CONSULTANTS

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Energy Efficiency and Strategy Division
Energy Department
The World Bank
Washington, D.C. 20433

FOREWORD

The Energy Assessment report on Kenya, 1/ issued in May 1982, identified the country's dependence on costly imported energy as one of two major issues in the energy sector, the other being deforestation and the consequent decline in fuelwood supply. Subsequently, the Government of Kenya requested assistance from the Joint UNDP/World Bank Energy Sector Management Assistance Program (ESMAP) to evaluate the potential for increasing the efficiency of energy use in the industrial sector and in the tea industry, two major consumers of imported fuels. This evaluation was to include both measures to conserve on the use of energy and to substitute less costly fuels, including imported coal and indigenous biomass fuels.

This report, and a companion document, "Kenya: Energy Efficiency in the Tea Industry," present the results of that evaluation. This report was prepared by a team of consultants, led by the firm of Macdonald Wagner, in association with Merz and McLellan and Partners, Gavan McDonell and Company, Howard Jones and Associates, and Coopers and Lybrand W.D. Scott. Funding for the bulk of the consultants' services was provided by a grant from the Australian Development Assistance Bureau. The consultants were supervised jointly by ESMAP staff and the Government of Kenya.

Two points should be noted about the report. First, it is based on analyses of energy conservation and substitution options performed in 1985, prior to the collapse in world oil prices. Second, average biomass fuel costs, not location-specific supply and cost estimates, were used for the prefeasibility analysis of potential biomass substitution projects. The consultants' findings therefore must be interpreted carefully before projects are selected for feasibility analysis. This requires: (a) use of the report's fuel price sensitivity tests and economic fuel cost analysis to screen potential conservation and substitution investment projects for consistency with expected future energy prices and economic costs; and (b) identification and costing of specific fuelwood and/or other biomass fuel supplies for any project involving the substitution of fuelwood or other biomass for conventional fuels.

The report presents the consultants' findings and does not necessarily represent the views of either the Government of Kenya, the UNDP, or the World Bank. It has been distributed to the Kenyan authorities and to selected donor agencies. Further copies of the report are available on request.

1/ "Kenya: Issues and Options in the Energy Sector," Report No. 3800KE of the Joint UNDP/World Bank Energy Sector Assessment Program, May 1982.

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GLOSSARY OF TERMS

Units used throughout this report conform to the System Internationale (SI) using the following standard abbreviations and conversion factors. Where other units are used they are explained in the text.

Abbreviations	Meaning
GOK	Government of Kenya
ADAB	Australian Development Assistance Bureau
IBRD	World Bank (International Bank for Reconstruction and Development)
IEA	International Energy Agency
IFC	International Finance Corporation
IMF	International Monetary Fund
KPLC	Kenya Power and Lighting Company
MOERD	Ministry of Energy and Regional Development
UNDP	United Nations Development Programme
Consultants	Macdonald Wagner Pty Ltd in association with Merz & McLellan & Partners, Howard Jones and Associates, Gavan McDonnell and Company, and Coopers & Lybrand W D Scott (formerly W D Scott & Co)

Terms	Meaning
Target 1 (Short Term)	Energy savings target achievable based on conservation measures which could be taken almost immediately with minimum engineering input and, in general, minimum capital investment. Typically, such measures would show a simple payback of under one year and would include basic house-keeping and correct operating and maintenance practices.
Target 2 (Long Term)	Energy savings target achievable, based on conservation measures which could be taken, with appropriate planning and engineering input and the expectation of capital investment in new or improved plant or processes or a more economic energy source, and which would give an acceptable economic and financial rate of return, (i.e. greater than 15% real).
Energy Intensity	The ratio of energy consumption to production, typically expressed in units of gigajoules per tonne of product (GJ/t). Also referred to as specific energy consumption.
GSE	Gross Specific Energy, measured in GJ/t. GSE is used throughout this report. Net Specific Energy may be obtained by subtracting the latent heat of vaporisation of water formed in the combustion reaction, which is a function of the hydrogen content of the unburnt fuel. Typically, the ratio Net/Gross Specific Energy is about 0.94 for RFO and 0.98 for coal.
FY 1985	Financial Year (1 July 1984 - 30 June 1985).
CY 1985	Calendar Year (1 January 1985 - 31 December 1985).
mcwb	Moisture content wet basis
OD	Oven dry
AD	Air dry

Terms	Meaning
Fuelwood	Any combustible woody material, e.g. from trees, shrubs, coffee husks, etc.
Wood	Fuelwood from trees
Load factor	Ratio of average electricity demand to maximum demand.
MD	Maximum demand, expressed as kVA, is the highest rate of electricity energy usage in any twenty minute interval during the meter reading period, which is typically 30 days.
LPG	Liquified Petroleum Gas
GLN	Gasoline (petrol)
IDO	Industrial Diesel Oil
RFO	Residual Fuel Oil
GAO	Gas Oil

Units	Meaning
A	Amps (electrical current)
V	Volts (electrical pressure)
kV	kilovolts = 10^3V
W	Watt (electric power)
kW	kilowatts = 10^3W
kVA	kilovolt Amp
kVAr	kilovolt Amp (reactive)
kWh	kilowatt hours = 3.6 MJ
MWh	Megawatt hours = 10^3 kWh = 3.6 GJ
bar	bar (pressure)
kPa	kilopascals (pressure)
J	Joule (energy) = 1W.s
kJ	kilojoule = 10^3 Joules

Units	Meaning
MJ	Megajoule = 10^6 Joules
GJ	Gigajoule = 10^9 Joules = 278 kWh
TJ	Terajoule = 10^{12} Joules
kg	kilogram (mass)
t	tonne = 10^3 kg
L	Litre (volume)
kL	kilolitre = 10^3 L = $1m^3$
ML	Megalitre = 10^6 L = 1000 m^3
cp	centipoise (viscosity)
s	second (time)
min	minute = 60 s
h	hour = 60 min
a	annum (year) = 8760 h
m	metre
m^2	square metre
m^3	cubic metre
km	kilometre
km^2	square kilometre
ha	hectare
^oC	degrees Centigrade
toe	tonnes of oil equivalent (= 41.868 GJ) IEA Standard
tce	tonnes of coal equivalent (= 23.446 GJ) IEA Standard

Currency	Meaning
KSh	Kenya Shillings
kKSh	Thousands of Kenya Shillings = 10^3 KSh
MKSh	Millions of Kenya Shillings = 10^6 KSh
$	United States Dollars
$A	Australian Dollars

Conversion Factors - Imperial to SI (metric)

	Imperial		Conversion
Quantity	Meaning	Units	Imperial to SI
Area	square foot	ft^2	0.092 903 m^2
	square yard	yd^2	0.836 127 m^2
Density	pounds per cu.ft.	lb/ft^3	16.018 5 $kg.m^{-3}$
Energy	British Thermal Unit	Btu	1.055 06 kJ
Flow	gallon per minute	gpm	0.075 768 $L.s^{-1}$
Heat value	Btu per cu.ft.	Btu/ft^3	37.258 9 $kJ.m^{-3}$
	Btu per pound	Btu/h	2326 $J.kg^{-1}$
Heat flow	Btu per hour	Btu/h	0.293 071 W
Length	inch	in	0.0254 m
	foot	ft	0.304 8m
	yard	yd	0.914 4m
Mass	pound	lb	0.453 592 37 kg
	ton	T	1016.05 kg
Mass flow	pounds per hour	lb/h	0.000 126 $kg.s^{-1}$
Pressure	bar	bar	100 kPa
	pounds per sq. in.	lb/sq.in	6894.76 Pa
	inch of water	"wg	248.642 Pa
	inch of mercury	"Hg	3386.39 Pa

Conversion Factors - Imperial to SI (metric) (Cont'd)

	Imperial		Conversion
Power	horsepower	hp	745.7 W
Refrigeration capacity	ton	T	3.516 85 kW
Temperature	degree Fahrenheit	^oF	$[273 + 0.556 (F-32)]^oK$
Volume	cubic foot	ft^3	$0.028\ 316\ 8m^3$
	cubic yard	yd^3	$0.764\ 555\ m^3$
	gallon	gal	4.546 litres
Velocity	foot per sec	ft/s	$0.304\ 8\ m.s^{-1}$
	miles per hour	mph	$1.609\ 34\ km.h^{-1}$

Energy Conversion Factors

Energy Source	Gross Specific Energy	Density kg/m^3	Tonnes of Oil Equivalent toe
Coal	26.8	1130	0.56
Charcoal	29.0	NA	0.69
Wood 20% mcwb	16.3	443	0.39
30% "	14.2	541	0.34
40% "	12.2	640	0.29
50% "	10.2	738	0.24
60% "	8.1	836	0.19
70% "	6.1	933	0.15
Animal waste	8.6	NA	0.20
Bagasse (30% moisture)	12.6	115	0.30
Coffee husk	15.1	NA	0.36
Cotton seed husk	15.1	NA	0.36
Flax	15.3	NA	0.37
Jute sticks	12.6	NA	0.30
Leather shavings	15.4	NA	0.37
Maize cobs	15.0	NA	0.36
Municipal waste	8.7	NA	0.21
Nut shells	19.7	NA	0.47
Palm shell	18.8	NA	0.45
Palm shell & fibre	11.3	NA	0.27
Palm stalk	22.1	NA	0.53
Rice husks	12.6	NA	0.30
Spent tan bark	5.7	NA	0.14
Straw	11.1	NA	0.27
Sunflower husk	17.5	NA	0.42
Liquified Petroleum Gas (LPG) - Propane	50.0	508	1.08
Petrol (GLN)	46.5	726	1.05
Kerosene/jet fuel (DPK)	46.0	820	1.03
Gas oil (GAO)	45.7	827	1.02
Industrial diesel (IDO)	45.5	840	1.01
Fuel oil (RFO)	42.9	939	0.98
Electricity 1 MWh	(3.6 GJ)	NA	0.086

* Note: 1 cubic metre stacked wood = 0.6 cubic metre solid volume.

1. EXECUTIVE SUMMARY

1.1 Overview

Industry in Kenya appears both vigorous and enterprising. Conditions seem stable, domestic markets reasonably buoyant and growing, and the potential for export markets in eastern and southern Africa increasing. For efficient and enterprising managements the future should be attractive. However, as with much of the industrialised world, Kenya's industrial energy performance is still below what can be achieved in the light of today's energy management practices and technologies.

Kenya's older factories, of which there are many, were generally built when imported fuel oil costs were low, capital was scarce and extra expenditure on energy efficiency measures was unwarranted. Instrumentation and control in energy systems were, and still are, the exception rather than the rule and today, although energy prices and availability have changed dramatically, attitudes in general have not. There are exceptions, particularly in the large companies which generally have access through overseas parent or associated companies to energy conservation and fuel substitution technologies. At the national level, however, opportunities for further energy conservation are still substantial.

This situation has begun to be addressed by Kenya's Ministry of Energy and Regional Development (MOERD) which is to be commended upon the early effectiveness of its Kenya Industrial Energy Management Programme - a programme which was being developed during the preparation of this report. The MOERD has undertaken education and training courses and seminars, has set up steering and sector committees to encourage and publicise energy management information and case studies, and has established an energy usage database.

In addition, a number of important energy saving opportunities have been covered in this report which presents the overall findings of a comprehensive Study together with the results some 21 individual energy audit reports, each of which includes prefeasibility studies identifying potentially profitable opportunities to improve the efficiency of energy use. The industries audited include paper, cement, steel, foodstuffs, building materials, chemicals, textiles and beverages amongst others. The project was funded under the joint UNDP/World Bank Energy Sector Management Assistance Programme (ESMAP), using funds provided by the Australian Development Assistance Bureau in the initial, but subsequently revised, expectation of widespread substitution of coal in industry. The energy audit reports and prefeasibility studies were carried out as part of an ongoing programme to promote energy conservation and improved energy management techniques in industry. As the next step in this programme the Government will be seeking donor funds to take the studies to full feasibility level prior to investment.

The energy audit reports have identified energy savings under two broad headings, Target 1 - short term, representing improvements that can be made with limited investment and short pay back periods, and Target 2 - long term, representing energy saving investments in improved plant and processes. Conservatively, some 9% of all industrial energy could be saved under the Target 1 programme, with investments showing paybacks averaging 4 months. The majority of funding for this programme would be expected to be sourced from normal plant operating and maintenance budgets.

The simple economic paybacks for the various longer term Target 2 projects, identified by the prefeasibility studies and subsequently tested against a range of fuel prices, range from 0.2 years to 3.6 years. Taking all the recommended T2 projects together, the simple economic payback is 1.2 years. These quick pay back periods indicate that the more rigorous financial and economic rates of return analyses next required at the feasibility level are unlikely to exclude the projects proposed and may, in fact, identify additional projects. The individual projects proposed in this report are of low risk.

In anticipation of donor support the Government is making institutional arrangements such that, on completion of the donor funded feasibility studies, the investment phase of the industrial energy conservation programme can proceed. It is expected that, on completion of these studies, initial investments of at least $US 30 million will be warranted. It is proposed that, when completed, the projects be accepted as part of a demonstration programme, one of the proposed elements of the Kenya Industrial Energy Management Programme which is strongly recommended and supported.

1.2 Introduction and Energy Cost Background in Kenya

1.2.1 Project Report

This report on the Kenya Coal Conversion, Energy Conservation and Substitution Action Plan is in 23 volumes consisting of:

- Volume 1 - this document which contains 7 chapters
- Volume 2 - which contains 10 appendices, and
- 21 energy audit reports which are individually bound.

The report was prepared during 1985, covering the field work phase and 1986, the analysis phase, by the consulting team under the direction of the UNDP/World Bank Energy Sector Management Assistance Programme (ESMAP). The Bank prepared the Activity Initiation Brief for the project which was, in large part, funded by the Australian Development Assistance Bureau (ADAB).

1.2.2 Original Project Objectives

The primary objectives of the project were to identify the potential for, and means to achieve, meaningful reductions in industrial energy consumption and economic inter-fuel substitutions in industry in Kenya.

Coal and indigenous fuels were to be given specific attention as potential substitutes for industrial fuels refined from imported crude oil. Policy and investment issues to be addressed by the Government of Kenya in relation to these objectives were to be identified.

1.2.3 The Potential for Substitution of Fuel Oil

Previous studies, noting the burden on Kenya's balance of payments arising from the high usage of residual fuel oil and the low price of coal relative to oil on world markets in the early 1980's, had suggested that the substitution of fuel oil by coal and indigenous fuels would benefit Kenya.

Residual fuel oil accounts for approximately 40 percent of industrial energy use in Kenya. Bagasse and fuelwood together also represent about 40 percent. Low volatile coal unsuited to thermal boilers is imported from Swaziland and supplies a further 10 percent; but it is used only in one cement plant. Electricity accounts for about 8 percent of industrial energy use.

1.2.4 Fuel Prices

Since the early 1980's and especially during the period of this study there have been substantial movements in the relative prices of industrial fuels. World oil prices have fallen and future fuel oil prices are for some years expected to remain below those obtained in 1985; furthermore the economic cost of fuel oil is expected to remain below the financial cost in Kenya for some time. World coal prices have risen slightly. Usage of fuelwood has begun to outstrip yield from annual growth and prices are expected to rise. In addition, the rising cost of additional power generation capacity has led to the situation where electricity tariffs in Kenya are less than half the economic costs of electricity supply despite recent increases.

1.2.5 Revised Emphasis on Project Objectives

Accordingly, and with the agreement and understanding of the World Bank and the Government of Kenya, while the focus on achieving reductions in energy consumption was retained, the fuel emphasis of the project was changed away from coal substitution towards stimulating the supplies and potential replacement role of indigenous fuels.

Particular emphasis was also placed upon testing all recommendations for their sensitivity to a wide range of fuel price variations, both financial and economic, since the project investment recommendations made in this study depend for their viability upon the future energy prices which are highly uncertain.

1.2.6 Energy Conservation Targets and the Audit Reports

The technical groundwork upon which the report and its findings are based lies in each of the 21 energy audit reports. Taken at its simplest, the reports ask, and provide answers to, just three questions on energy usage in each plant:

- How much energy is being used now, and where is it being used?
- What savings in energy can be achieved with the present plant and processes? (Defined as Target 1 or T1 - Short term savings).
- What further savings in energy can be achieved with improved methods or processes? (Defined as Target 2 or T2 - Long term savings).

1.2.7 Fuel Supply Policies

There is little more that Kenya can do to influence the supply of imported fuels. A surplus of residual fuel oil is produced in Kenya as a result of refining sufficient crude to meet demands for higher transport fuels.

Supply of indigenous fuels could be improved through the development of supply institutions and by the relaxation of price control on derived fuels such as charcoal. There are sources of added indigenous supplies but all involve substantial new managerial and institutional efforts. The aim should be to establish reliable supplies of uniform quality fuels from variable quantities and qualities of biomass and byproducts as well as plantation products.

1.3 Principal Findings

The principal findings of the report can be summarised as follows:

1.3.1 Target 1 - Potential for the 21 Audited Plants

In common with experience worldwide, considerable industrial energy savings can be made in Kenya in the short term by introducing energy management practices at very little cost. These immediate or short term actions are identified as Target 1 (T1) and anticipated energy savings conservatively average around 9 percent of the total industrial usage measured. Of the 21 plants audited, energy savings of 1159TJ can be made at an estimated capital cost of KSh 25 ($US1.5) million, saving KSh 71.3 ($US4.2) million per annum at 1985 financial prices. In general these savings arise from changes in the energy management practices and improved housekeeping at the plants. The means of achieving them are described in the audit reports and are generally, though not always, within the capability of the individual managements as part of normal housekeeping and plant maintenance programmes.

1.3.2 Target 1 - Potential for Kenyan Industry

As the 21 audited plants consume about half Kenya's industrial energy, simple doubling suggests that Target 1 savings approaching KSh 145 ($US 8.5) million per annum could be achieved for a total investment of under KSh 50 ($US 2.9) million. Moreover these savings (at 1985 financial prices) can be achieved by immediate action in many cases, drawing particularly on ideas developed during the audit programme.

1.3.3 Target 2 - Potential for Audited Plants

Further substantial savings can be realised in the longer term by implementing a range of viable project investments at plants, primarily directed at plant refurbishment and modernisation, improved combustion equipment, fuel substitution, waste heat recovery and electricity co-generation. It is estimated that industry wide savings in excess of KSh 440 ($US 25.9) million per annum could be achieved through a spread of investments totalling around KSh 520 ($US 30.6) million, again based on fuel prices remaining at 1985 levels in real terms. These longer term investments are identified as Target 2 (T2) and, in general, will require external engineering, management and financial support.

1.3.4 Potential for Reducing Electrical Load Growth

Both the T1 and T2 investments, extended across all Kenyan industry, will help to reduce the rate of electricity demand growth, and so defer or reduce investment in planned public electricity generating capacity. A saving of some 20 MW below present forecasts is estimated by 1995, based on the potential for reduced demand by industry arising from effective energy conservation and demand management. This reduction may well offset a large portion of the cost of investments in energy conservation measures.

1.3.5 Recommendations Unchanged by Fuel Prices

The gains to be made from energy source substitution will be influenced by the relative prices of fuels, especially fuel oil and fuelwood. While price forecasts for both these fuels are very uncertain, sensitivity analysis has shown that even under a range of financial and economic prices very substantial savings can still be achieved by implementing the recommended measures. It is therefore appropriate to complete the engineering and economic feasibility studies for the projects recommended and shortlisted in the report; and to monitor the fuel price position closely and continuously so as to be able to include other prospects as further opportunities emerge.

1.3.6 Fuel Substitution Potential and Policies

Much of the saving in fuel substitution is anticipated to result from the substitution of fuelwood or biomass residues for residual fuel oil. In this connection it should be noted that the prospective indigenous fuel demand of industry represents a very small fraction of the overall demand (for fuelwood) in Kenya from the domestic sector. Nevertheless, recommendations to improve the supply of indigenous fuels have been made in the report. These include the establishment of dedicated fuelwood plantations, policies to raise the price of fuelwood towards the cost of replacement, and policies to encourage the development of enterprises specialising in the provision of commercial fuels based on biomass or biomass residues.

Of prime importance to industry contemplating conversion to fuelwood is the provision of secure economic supplies. This will require the establishment, where appropriate, of more dedicated fuelwood plantations to offset prospective natural fuelwood shortages which have been forecast; to guarantee security of supply to the industries concerned; and to reduce haulage distances and hence transport costs which might otherwise render fuelwood uneconomic. Fuelwood delivery distances over 50 km currently approach the limits of viability.

Where fuelwood substitutions are viable, the use of reconditioned locomotive boilers is not recommended unless substantial modifications are effected to improve overall heat recovery and hence thermal efficiency. Although they involve a low initial cost they are not, in their 'as found' condition, thermally efficient and so waste a precious resource. Moreover, even where conversion is effected, it is recommended that provision be retained for fuel oil firing.

The further fuel substitution potential in Kenya under this heading draws upon the substantial volume of unused but available biomass and biomass residues, including the possibility of generating commercial fuelwood from forest thinnings. The emergent but proven combustion technologies proposed for these forms of fuel are described in the audit reports, and a trial and demonstration project is recommended to introduce and prove such technologies in the Kenyan environment.

1.3.7 Coal Substitution Potential

At 1985 financial price differentials between fuel oil and thermal coal, with the landed cost of the latter estimated at about 80 percent of that of oil, there was no justification for further coal substitution to meet the energy requirements of industry. The 1986 economic price comparison indicates even less potential for coal. Under the forecast price ranges for both these fuels it is not anticipated that opportunities for coal substitution will emerge within the 10 year time horizon of the Action Plan.

Coal is being used by the Bamburi Cement Company at Mombasa and the question of additional supplies for conversion of the existing oil fired cement plant at Athi River was raised. But doubts exist about the size of the market for cement.

Should it be decided, however, that at some time in the future Kenya should expand the use of coal, the port of Mombasa would be capable of handling import quantities of up to 600,000 t/a through the current dual wharves at Mbarake, with some additional bulk handling facilities added. While there is insufficient space behind Mbarake for a thermal coal fired power station, the upgraded facilities could handle the coal required for a 120 MW power station.

1.3.8 Energy Management Awareness

In common with experience in many countries, there is limited but growing energy management awareness in industry, and hence training for energy management in Kenya is at an early stage. Action should therefore be taken to further develop this awareness, and to foster increasing energy savings for Kenya and its industries. This is envisaged as including such measures as energy management and education programmes, publicity, awards for performance, and price controls tied to energy management initiatives.

1.3.9 Prices Related to Energy Management

The linking of price control procedures to energy conservation has proven to be a means of encouraging more effective energy management. Rather than having price increases automatically reflect cost increases, they can be made contingent upon measures progressively taken by a company - such as the completion of thorough energy audits, the pursuit of T1 energy efficiency opportunities (requiring little investment), and the achievement of defined energy intensity targets.

Action should be taken in Kenya to introduce such a price control mechanism. With appropriate co-ordination between the Ministry of Finance and the MOERD, this should stimulate management interest in energy improvement opportunities and create more efficient industry.

1.3.10 Ministry of Energy and Regional Development

The Ministry of Energy and Regional Development (MOERD) is the focal point for the national energy conservation effort. The Ministry has already embarked upon an intensive and effective campaign of public and industry education, including the Kenya Renewable Energy Development Programme and the establishment of a national industrial energy use survey. It has run numerous energy conservation seminars and has taken steps to rationalise fuel prices. Moreover it has also been very successful in promoting action by industry, notably through a cooperative programme with the Kenya Association of Manufacturers (KAM).

The Ministry should be encouraged to implement the recommendations presented within the report, with special attention being given to supporting and extending the work of the KAM.

1.4 Recommended Action Plan

In order to ensure that the momentum from this study continues and that Kenya gains from the opportunities which have been identified, the following specific recommendations are made, some of which have been foreshadowed in the findings above.

1.4.1 Formulation of Energy Policy

Overall energy policy in Kenya should be directed to include the areas identified in this report and should continue to be guided and overseen by the Ministerial Energy Planning Committee. In this regard particular attention should continue to be given to the position with two of the major fuels being electricity, the relatively low tariff for which is the subject of a current review, and residual fuel oil where export parity pricing appears relevant under the existing refinery operating rule.

1.4.2 Kenya Energy Management Programme

The MOERD, as the national focal point of energy conservation, should continue to develop the Kenya Energy Management Programme, guided both by the findings of this report and the work of the Kenya/Canada Advisory Project. One recommended programme, which is already in place and administered through the KAM, , is the Kenya Industrial Energy Management Programme (KIEMP). Other recommended programmes, beyond the scope of this report but vital in the long term national interest, include the domestic, commercial, transport and agricultural sectors.

The KIEMP should continue to be managed by the Kenya Association of Manufacturers, the body best placed to provide the essential industry knowledge and interface between government policy and support on the one hand and industry action and investment on the other. This should also include attention given to the financial and commercial aspects of energy investment. This report should prove of substantial assistance to that programme.

Since energy management investment has been shown in all industrialised countries to generate substantial benefits in the national economy, it is recommended that all elements of the programme continue to be supported by the Government of Kenya.

1.4.3 Programme Elements

The KIEMP should include for each industry sector (food, textiles, chemicals, etc.), the following elements:

- Training, especially for energy managers
- Seminars and workshops
- Consultant support schemes
- External consultant assistance
- Energy research projects
- Demonstration projects
- Establishment of industry energy conservation targets in each sub-sector (Database)
- Award schemes
- Publicity via media outlets (press, television, radio)
- Technical publications
- Peer group conservation successes published (case studies)

1.4.4 Education and Training

A well thought out and long term programme of education and training is recommended in order to develop a competent pool of energy managers; men and women who are able and experienced in the control of thermal and electrical plant in place or projected in Kenya, who are capable of controlling and minimising energy consumption in existing plant, and who can plan and execute economic investments in energy saving equipment.

1.4.5 Recommended Target 2 Investment Projects

A total of six projects to convert from fuel oil to fuelwood or biomass residues are recommended for serious consideration. A further nine projects to recover waste heat and so save other fuels, three projects to generate electricity from fuelwood or fuel oil and seven projects requiring investment in efficiency improvements are also recommended. All recommended projects remain viable across a wide range of fuel prices, but all have only been examined to preliminary feasibility level. All should now proceed to a full feasibility study covering engineering, economic, funding and implementation issues.

1.4.6 Demonstration Programme

A demonstration programme, comprising investment in the above T2 projects, which are described in more detail in the reports, is strongly recommended.

This approach is to ensure that:

- Limited technical and financial resources are not overextended;

- Financial risk is minimised, for example in the event of major fuel price movements;

- Understanding of the sometimes new technologies is achieved, provided the projects selected are made fully visible and accessible so as to facilitate maximum technology transfer to Kenyan engineers;

- Individual projects are shown to be attractive to both the World Bank and other overseas aid energy investment programmes.

1.4.7 Fuelwood and Biomass Residues

Indigenous fuelwood, particularly of the lower grades unsuited to prime use, together with available biomass residues such as sawdust and coffee husks, represents an important but as yet undermanaged and inefficiently utilised national resource - both in the industrial and domestic sectors. Significant attention and further resource evaluation studies in this vital area are recommended in this report, in the companion report on Energy Efficiency in the Tea Industry, and in the forthcoming UNDP/World Bank ESMAP Peri-Urban Fuelwood Study.

Further resource evaluation studies and, eventually, a pilot demonstration project to evaluate means of enhancing the production and distribution of purpose grown plantation fuelwood are recommended to establish methodology, costs and opportunities. Supply options need more detailed economic assessment as well as evaluation of transportation, distribution, delivery and storage methods.

1.4.8 Instrumentation and Control

Energy conservation policy should be directed towards encouraging the more rapid development of a competent and mature instrumentation and control sector of industry. Continued reliance on high cost overseas components and protection of local industry is insufficient in itself to achieve such development. Consideration should be given to relaxation of existing import tariff burdens on certain items of energy conservation equipment.

1.4.9 Pricing Policy Issues

In relation to pricing policy it is recommended that more realistic charges should be made for fuelwood to reflect land and stumpage costs, thereby lifting fuelwood prices towards the cost of replacement and encouraging fuelwood development.

In addition an energy efficiency review should be introduced into manufacturing price control procedures i.e. to ensure that appropriate energy management initiatives are being taken before price increases are awarded.

1.4.10 Industrial Energy Usage Database

The Industrial Energy Usage Database, which gives the energy performance reported and targets set for all audited plants should be updated annually by ongoing use by the MOERD of the proforma industrial energy usage questionnaire developed for the project. This would serve to enhance energy awareness and understanding at both ministry and individual plant level. The monitoring of individual plant energy performance or energy intensity (GJ/t), as derived in this report, should be included as part of the annual performance report of the KIEMP.

1.4.11 Action Plan

In summary, therefore, the Consultants recommend that a practical and potentially highly beneficial energy conservation and substitution action plan be now formally carried forward by the Government of Kenya with appropriate financial support from bilateral and multilateral funding sources.

2. INTRODUCTION

2.1 Objectives and Terms of Reference

The objectives of the Kenya Coal Conversion Action Plan project were originally set out in the Terms of Reference prepared by the Energy Assessment Division of the World Bank dated May 1984. This document was subsequently redated May 1985 for inclusion in the Contract for Consultants' Services. However, it was then superseded at the time of signing the Contract by an Activity Initiation Brief dated April 1985, which was then adopted by the Consultants as the "Brief".

The project was established with the principal objectives to:

- identify the potential for and means to achieve cost-effective reductions in industrial energy consumption;
- identify economic options for inter-fuel substitution of indigenous for imported energy supplies in the industrial sector;
- evaluate and establish the potential market for coal as a substitute for petroleum products in Kenya;
- on the basis of that potential market, specify a least-cost coal user and infrastructure investment programme that would permit the market potential to be achieved; and
- recommend appropriate government policies and initiatives to support a possible coal conversion programme.

In addition, the project was to lead to specification of short-run improvements in the efficiency of energy use, the identification of cost-effective options for investment in energy conservation and possible indigenous fuel-substitution measures and, if economically attractive, the definition of a long-range coal conversion programme to the year 1995.

The analysis and results were required to provide both the strategic and project-specific technical information for related decision-making and subsequent action in a comprehensive national programme of energy conservation, indigenous fuel substitution and potential coal conversion investment by:

- the community of potential coal users and suppliers;
- government policy makers;
- the international donor community; and
- potential private investors within and outside Kenya.

In order to better organise and define the Consultants' work plan, the project Activity Initiation Brief set out two separate, but inter-related tasks:

Task 1 Assessment of Potential Energy Conservation and Indigenous Substitution Opportunities in the Industrial Sector and Outline of an Energy Demand Management Strategy for the Sector; and

Task 2 Evaluation and Development of a Potential Coal Conversion Programme for the Period 1985 - 1995.

Each of these tasks was to be broken down into the following specific sub-tasks:

Sub-Task IA Review the Environment and Incentives for Energy Conservation in Industry.

Sub-Task IB Conduct Plant Energy Audits, and Identify Potential for Reduced Energy Consumption.

Sub-Task IC Identify Potential for Substitution of Oil by Indigenous Energy Resources.

Sub-Task ID Define an Energy Demand Management Programme and Estimate Costs and Benefits of Energy Savings.

Upon the completion of these four sub-tasks, the Consultants were to review with the World Bank and the Ministry of Energy and Regional Development (MOERD) the need to continue working in part or in whole on the remaining sub-tasks:

Sub-Task IIA Evaluate Potential for End-User Coal Conversion.

Sub-Task IIB Prepare Coal Market Projections.

Sub-Task IIC Review Options for Coal Procurement and Importation.

Sub-Task IID Analyse the Infrastructure Requirements to Serve Coal End-Users.

Sub-Task IIE Assess Current Institutional Capacity, Operations and Policy with Respect to Coal Conversion.

Sub-Task IIF Prepare Cost/Benefit Analyses of Potential Coal Conversion Programmes.

Sub-Task IIG Develop Specific Options for a Coal Conversion Action Plan.

The Consultants can report that each of the above project objectives was addressed.

Sub-Tasks IA to ID inclusive were comprehensively undertaken, and at the same time Sub-Tasks IIA, IIB, IIC and IID were examined in sufficient detail to enable the mid-term review referred to above to lead to the determination of the direction the project should take during its second phase.

The review held at end September 1985 concluded that there was little potential at then current world market prices for utilising coal as a substitute for petroleum products in Kenyan industry.

Hence the World Bank and MOERD jointly requested the Consultants to reduce the project Sub-Tasks IIA to IIG inclusive to a brief examination and report on Sub-Tasks IIA and IID only. However, because the first phase of the project identified great scope for energy conservation and significant possibilities for indigenous fuel substitution, the direction of the project during the second phase was extended by the Bank and MOERD to the identification of fundable projects which could be implemented within these two areas and to the undertaking of a detailed study of the availability of indigenous biomass fuels for use in industry.

The report following gives a response in detail to each of the expressed requirements in the Brief as amended following the mid-project review.

2.2 Project Implementation

2.2.1 Introduction

The project commenced on 6th May 1985 with the arrival in Nairobi of the Team Leader. The contract for Consultants' Services was signed by the IBRD and the Consultants on that day. After discussion with the World Bank and the Ministry of Energy and Regional Development a memorandum of understanding was signed agreeing to a formal project review at the end of September 1986 to determine whether an economic potential for coal use had been identified and to determine the direction of the project for the second phase.

2.2.2 Administration

The Consultants operated from a suite of four offices made available with secretarial services by the Ministry of Energy and Regional Development (MOERD). A Ministry vehicle (Range Rover) was made available also, with the Consultants being responsible for its total cost of operation and maintenance. For their part the Consultants introduced a range of office, computer and energy audit equipment and materials which were used during the project and then left for the Ministry's continued use subsequently.

Each month a detailed progress report was prepared and issued to the Ministry of Energy and Regional Development, the World Bank and the Australian Development Assistance Bureau which provided the majority of funds for the project. The report covered action during the month relating to all facets of the project, including cost to date and forecasts of time and cost to complete.

2.2.3 Steering Committee

During the first month of the project the MOERD established a Steering Committee which then met approximately every two months thereafter to assist in the coordination of all the appropriate organisations and Government Ministries. The Committee comprised representatives of:

- Ministry of Energy and Regional Development
- Ministry of Finance and Planning
- Ministry of Transport and Communications
- Ministry of Commerce and Industry
- Kenya Railways
- Kenya Ports Authority
- Kenya Association of Manufacturers
- World Bank - Regional Office (Nairobi)
- The Consultants' Team

While not all members were able to attended each meeting, the Committee contributed most usefully to the effective completion of the project.

2.2.4 Project Work

As required by the Activity Initiation Brief, 20 plants, later increased to 21, were required to be selected to represent Kenya's energy consuming industry (hereinafter in this report referred to as "industry"). The plants for audit were selected during May 1985 following the criteria set out in Chapter 5.

During Phase One (May to September 1985) the Consultants carried out the fieldwork for 19 of the plant energy audits. Of these, 14 were completed by the Energy Audit Engineer with the remaining 5 by a second team mobilised in Nairobi. The final 2 audits were completed by the Energy Audit Engineer during the period 1st to 10th October 1985. MOERD provided three counterpart engineers from its permanent staff to participate in the field data gathering and later in the office analysis of that data and in the drafting of portion of the audit reports. They were also trained in the use of the project microcomputer and the relevant software.

Also during Phase One the Economist and Institutional Specialist, assisted by three economists from the MOERD staff, set in train an investigation of current costs and trends to be able to commence the preparation of growth and demand forecasts to year 1995. At the same time the Coal Procurement Specialist and the Infrastructure Engineer undertook work on the costs associated with the supply (and availability) of coal to Kenya and its distribution to industry. Moreover, it was decided appropriate during Phase One to develop a Kenya Energy System Model utilising linear programming principles.

The mid-project review determined that the Coal Conversion Action Plan per se would not proceed and that the Consultants would only report on the infrastructure which would be required should, for any reason, coal quantities imported into Kenya be increased beyond the current use by Bamburi Portland Cement Co.

On the other hand, the review addressed in detail the whole matter of energy conservation and indigenous fuel substitution. The Consultants were directed that Phase Two should concentrate on the establishment of fundable conservation projects and a review, in greater depth, of the availability of indigenous biomass fuels for use in industry. Each plant audited was to have an individually prepared and bound self contained Energy Audit Report which would identify short term energy conservation measures and economical capital investment conservation projects and, where practicable, indigenous fuel substitution opportunities. The Consultants were directed not to complete the Kenya Energy System Model to the level proposed but just to report upon work to end September, 1985.

An early draft of each of the 21 audit reports was issued to and discussed with senior staff of each plant in the plant itself during the period end November 1985 to mid December 1985 following which the Consultants' Nairobi office was closed.

During the period mid December 1985 to end March 1986 all 21 audit reports were upgraded to the final draft stage and the project report with its seven appendices prepared to the same stage for review by the World Bank and MOERD resulting, at end April 1986 in a request for some additional work and change of emphasis. A representative of MOERD visited Australia at end May 1986 for discussion on these matters and a second edition of the final draft was issued by the Consultants at end July 1986. A formal review and discussion was held in Nairobi with representatives of the World Bank, MOERD and the Consultants in mid October 1986 and the final report was printed and distributed in December 1986.

It is noted that early in September 1985 the Consultants were appointed to carry out, with basically the same team and under the same contract, a parallel study "Energy Efficiency in the Tea Industry" to be completed at the same time as the project now reported. The Coal Conversion (Energy Conservation and Indigenous Fuel Substitution) and the Tea Industry studies formed two of a quintet of World Bank ESMAP studies undertaken in Kenya during 1985-1986. The other three studies were the Peri-Urban Fuelwood Study, the Solar Water Heating Study and the Power Sector Master Plan Study.

2.3 Acknowledgements

The Consultants wish to acknowledge the continued and willing cooperation given by the Ministry of Energy and Regional Development, especially by Mr P.M. Nyoike, Principal Planning Officer, by the Project Manager, Mr S.A.R. Bagha, Senior Planning Officer and their staff and by members of the Kenya/Canada Energy Advisory Project Team.

Valuable cooperation was also obtained from senior officers of the Kenya Association of Manufacturers, the Kenya Power and Lighting Company, Kenya Railways, Kenya Ports Authority and from the Government Ministries of Finance & Planning, and Transport and Communications.

Special thanks must also be given to each of the members of staff of the 21 factories, works, plants and establishments which were subjected to the energy audit. All gave willingly and courteously of time and enthusiasm to assist the audit teams in their work and to assist the Consultants' Team Leader and the Deputy Leader and Energy Engineer in discussions on the preliminary findings of each audit. Particular thanks are due to Mr. Shaukaut Sangrar of the Nairobi office of Spirax-Sarco whose time and professional advice on steam systems was freely given. The project work was characterised throughout by harmony and goodwill which the Consultants found rewarding and stimulating.

It is hoped that the encouragement and support of all those mentioned above, together with many others too numerous to add, is reflected in the findings of the report and, more importantly, in the determination of the Government of Kenya and of Kenyan industry in general to follow up the recommendations with vigour, to achieve the targets which have been identified, and to reap the consequent rewards.

3. ENERGY SITUATION IN KENYAN INDUSTRY

3.1 The Pattern of Energy Consumption in the Industrial Sector

3.1.1 Introduction

The major energy using manufacturing industries in Kenya are food and beverages, cement and ceramics, and paper manufacturing. In aggregate, industry in Kenya used 25 petajoules (PJ) of energy of all types in 1983 with these three industry groups using almost 86% of this total.

In order to establish the pattern of energy consumption in the Kenyan industrial sector and to formulate a predictive model for future years, an Industrial Energy Usage Database was prepared and is included as Appendix C. In this the industrial sector was divided into International Standard Industrial Classifications (ISIC) Industry Groupings, modified for use in Kenya as follows:-

ISIC INDUSTRY GROUPINGS

31 Food, drink and tobacco
32 Clothing and footwear
33 Wood products
34 Paper products
35 Chemical products
36 Ceramic products
37 Basic metal industries
38 Metal products
39 Other products

Tables 3.1 and 3.2 below, taken from the Database file KENYA 2BA, give the overall existing and projected future pattern of energy consumption in Kenya in the industrial sector, firstly by ISIC grouping and, secondly, by energy source for the years 1983-1995 inclusive at five year intervals. The projections are made using Base growth rates as identified in Appendix B. From these data it will be seen that total industrial energy consumption in 1995, the end of the study period, is predicted as 47 PJ, with allowance made for the effect of reductions due to this report's proposed energy management measures of 2% per annum for the years 1986-1989, and 1% per annum for the years 1990-1995. These energy management targets are achievable, being broadly consistent with results achieved by energy management programmes in other industrialised countries.

TABLE 3.1: ENERGY CONSUMPTION BY ISIC GROUPING 1983 - 1995

ISIC	INDUSTRY GROUPING	SHARE % (1983)	Petajoules (PJ) 1983	1985	1990	1995	Assumed Growth Rate from 1985 (%)
31	Food, drink and tobacco	45.4	11.4	15.7	19.9	26.3	7.7
32	Clothing and footwear	4.1	1.0	1.2	1.7	2.6	8.5
33	Wood products	1.3	0.3	0.4	0.5	0.6	4.5
34	Paper products	10.9	2.7	2.8	3.4	4.2	6.0
35	Chemical products	6.3	1.6	1.3	1.5	1.8	5.5
36	Ceramic products	29.5	7.4	7.3	8.5	10.2	9.0
37	Basic metal industries	0.0	0.0	0.0	0.0	0.0	8.0
38	Metal products	2.1	0.5	0.5	0.7	0.9	7.5
39	Other products	0.4	0.1	0.3	0.3	0.4	10.0
TOTAL ENERGY CONSUMPTION		100.0	25.0	29.5	36.5	47.0	

NOTE: Refer Appendix C - Database File KENYA 2BA

TABLE 3.2: ENERGY CONSUMPTION BY ENERGY SOURCE 1983 - 1995

ENERGY SOURCE	SHARE % (1983)	Petajoules (PJ) 1983	1985	1990	1995
Petroleum derivatives					
LPG (Liquid Petroleum Gas)	0.2	0.05	0.04	0.05	0.07
GAO (Gas Oil)	0.2	0.04	0.54	0.68	0.89
IDO (Industrial Diesel Oil)	0.8	0.21	0.40	0.50	0.65
RFO (Residual Fuel Oil)	38.5	9.61	10.27	12.57	16.09
Electricity	8.3	2.08	1.84	2.30	3.00
Coal	9.5	2.37	4.92	5.85	7.25
Biomass fuels					
Wood	14.4	3.61	1.95	2.32	2.87
Bagasse	28.1	7.02	7.53	9.46	12.38
Other	0.0	0.00	2.02	2.77	3.80
TOTAL ENERGY	100.0	25.00	29.50	36.50	47.00

NOTE: Refer APPENDIX C - Database File KENYA 2BA

3.1.2 Scope for Industrial Energy Conservation in Kenya

To provide some dimension to this potential, total industrial energy usage in 1984 was in the region of 28 PJ/a (Refer Database File Kenya 2BA - Appendix C). The industrial energy audits, which covered approximately 50% of this total industrial energy useage, identified the potential for savings of some KSh 290,000,000 (US$17,000,000) per year even excluding possible savings in transportation. Consequently the potential saving for all Kenyan industry may be estimated as having a value at the point of use approaching KSh 600,000,000 (US$35,000,000) per year at typical 1985 energy prices. Very importantly, such savings would add directly to industry profit, and in most cases increased profits would be easier to achieve from energy conservation than say from increased sales.

By 1995, if unchecked, Kenyan electricity demand is likely to have increased by at least 60% (See Database File Kenya 2BA). On the other hand, this study has identified an annual energy savings potential of at least 8.5% on short term (Target 1) projects alone, a level of energy conservation which, if maintained or improved, could remove or at least defer the need in Kenya by 1995 for additional power generating plant of up to 20MW capacity; this being some 8.5% of the national capacity assigned to serving the needs of industry in 1995. A number of long term (Target 2) projects, which involve co-generation, would also add to the inventory of private power generating capacity in Kenya, and hence could further displace or defer the requirement for equivalent new capacity from KPLC. There is a major difference, in terms of scarce capital and human resources alone, between the effort needed for the development and execution of effective industrial energy management policies on the one hand and for the mobilisation of human and financial resources to provide this additional generating capacity on the other. Opportunities for successful energy policy setting for the 1990's are available in the mid 80's, before scarce resources and valuable foreign exchange are committed, or committed before the need.

3.1.3 Energy Conservation Awareness

3.1.3.1 Government

The Government of Kenya (GOK), particularly through its Ministry of Energy and Regional Development (MOERD), is very conscious of the importance of minimising the utilisation of imported petroleum derived fuels in every consuming sector: industrial, commercial, transportation and domestic.

3.1.3.2 Industry

At present, Kenyan industry has a limited but increasing awareness of the benefits to be achieved from industrial energy conservation. Few companies have an energy management programme; of the 21 companies audited less than 25% had such an energy management programme in place. Few only have achieved a measurable result from energy conservation efforts. A high proportion has little idea of the cost of energy either in total or as a percentage of production costs. Notable exceptions exist; often, though not always, in those companies with access to the energy management programmes of their overseas parent companies.

While the audit teams were always accepted with courtesy and willing cooperation, it was felt that there was sometimes little awareness of the benefits to be gained - a factor which led to the delayed completion in some cases of the Energy Survey Questionnaire which forms an essential part of every energy audit report. Moreover, in many cases, the questionnaires revealed that the basic recording of energy usage data is sometimes minimal, and its value probably not recognised. Management time is required to monitor and control energy use in industry and in much of Kenya's industry there appears to be little management effort devoted to these tasks.

Given this situation, it is not surprising that industrial energy conservation is not recognised as providing one of the better opportunities to enhance company profit and to achieve the overall national objective of minimising dependence on foreign oil imports.

Nevertheless experience in various International Energy Agency (IEA) member countries shows that gains from energy conservation efforts occur slowly but surely. Such gains can also be achieved by Kenyan industry.

3.1.3.3 Overseas Industrial Energy Conservation Experience

The scope for energy savings in industry worldwide has been highlighted by a wealth of published studies carried out in nearly all industrialised countries. These generally indicate the achievement of short term energy saving targets (Target 1, or T1) of between 15% and 25% per unit of industrial output through improved energy utilisation and conservation. In the longer term these targets should be exceeded with investment in appropriate new technologies associated with appropriate fuel and equipment substitution (Target 2, or T2). Many industries have initiated energy management programmes within the last fifteen years and almost always the energy savings achieved have matched or exceeded initial expectations. Moreover, the reductions have often led either to deferment or even cancellation of proposed capital expenditure on additional energy consuming plant, or resulted in the closing down of costly and outdated facilities long thought to be indispensible.

It has also been found that, apart from additional profit to the enterprise, energy conservation can yield valuable benefits by way of reduced demand growth. For example, based on broad figures applicable to the typical current cost per installed kilowatt of hydro capacity in Kenya, KPLC has assessed that each kilowatt saving in electrical demand can save fixed capital of around KSh 25,000 in generating, transmitting and distributing plant and equipment in the form of dams, power stations and transmission lines, not to mention the associated investment of human and environmental resources. These figures are comparable with overseas experience. For these reasons, in some countries energy management services are provided free of charge, with government support, to reduce investment in energy producing and distributing plant and equipment that may not be needed.

On the technological side, one of the more encouraging and significant overseas developments is in the field of programmable electronic energy management systems (EEMS), where the increasing capability and decreasing cost of computer technology based control equipment are beginning to be appreciated. Appearing on the market is a range of instrumentation, measurement, and control systems which can be programmed for a wide variety of input variables and output commands, reports and analysis. For example, a number of buildings or industrial energy consuming processes can be centrally connected to a computer which measures and controls energy expenditure on lighting, air conditioning, electrical maximum demand and the like, taking into account the whole range of relevant variables. Such systems are still relatively in their infancy in Kenya and it may be some time before the market develops. Nevertheless they have a strong future and are already showing remarkable savings. Their rate of development and application is quite dramatic.

The worldwide energy management industry is cohesive, cooperative and liberal with information. It is strongly recommended that Kenya makes maximum use of the very extensive experience in industrial energy management available in other countries through the International Energy Agency, and through informal linkages with national Departments of Energy.

3.1.3.4 Current Energy Conservation and Substitution Efforts in Kenya

Although the cost of energy has risen sharply in the last decade (except for the 1986 which sharp decline in crude oil prices), the energy conservation potential of Kenyan industry has only just begun to be realised.

Among other considerations it was in recognition of the potential for industrial energy conservation in Kenya that the Ministry of Energy and Regional Development (MOERD) was established. Since its formation the MOERD has embarked upon an intensive campaign of public and industry education, including the Kenya Renewable Energy Development Programme (KREDP) and the establishment of a national industrial energy use survey. The Ministry has already set up the Kenya Energy Management Programme, has established an effective working liaison with the Kenya Association of Manufacturers (KAM) and with individual firms, and has run numerous energy conservation seminars. It has taken steps to rationalise fuel prices and has put in place some substantial modelling of energy supply and use. These efforts, and recommendations for their further development, are discussed in some detail in Chapter 6.

As regards results achieved in Kenya, most case studies have confirmed that it is not unduly difficult to achieve savings between 15% and 25% of current energy costs through fuel substitution as well as direct energy conservation. In Kenya much has already been done in the Target 1 area of industrial 'first aid', i.e. maintenance of steam traps, replacement of faulty or inadequate insulation, the repair of leaky valves and joints and so on, although this is essentially only proper maintenance. As yet, there has been little longer term "thermodynamic restructuring' or Target 2 work in industry, i.e. the critical overview of the role of energy in a total integrated operation with high grade energy used only where appropriate, and with low grade or 'waste' heat recovered and re-employed wherever possible.

It seems that present day managements in Kenya, as is the case in industry worldwide, still concentrate investment more on production increase than waste reduction, even where conservation investments can show demonstrably higher rates of return at lower risk. Such investments are, however, less visible and hence seemingly less attractive.

3.1.4 Barriers to Energy Conservation

3.1.4.1 Existing Equipment

The design and condition of existing energy using and converting equipment in Kenya is an important barrier to progress in energy conservation.

Kenya's industry is equipped with thermal plant which for the most part was designed for a world of low energy costs, high capital costs and low labour costs. In the modern environment such outdated plant is often operated at well below achievable energy performance levels, and is typically poorly equipped with control and monitoring equipment. Energy managers in Kenya are therefore not able to achieve and maintain the best performance from their plant, and this situation is exacerbated by lack of adequate instrumentation and, as yet, of a sufficiently mature instrumentation and control sector of the process industry.

The proposals contained in each of the 21 Energy Audit Reports are directed at improving the management, condition and operating efficiency of existing plant and equipment; and at installing modifications which would substantially improve the energy efficiency. Section 3.4.2 notes the common barriers to energy conservation overseas.

3.1.4.2 Common Barriers to Energy Conservation Overseas

In spite of the very considerable benefits of energy conservation to both government and industry, it is common experience - even in highly developed industrialised countries - to find that the known conservation technologies and practices are adopted only slowly and hence much of the potential cost saving is not being achieved.

It has been found that the barriers which need to be taken into account policy setting and analysis, if energy management is to be meaningful and effective, include the following:

- Energy conservation measures are often complex and highly disaggregated - with responsibility consequently being difficult to assign and results difficult to measure.

- Market prices fail to reflect fully the non-renewability of many resources and the environmental and social costs associated with energy production, distribution and use. For example, in Kenya fuel oil prices are low relative to other refined products.

- There is a widespread lack of awareness and information about real energy costs and about the benefits and methods of reducing energy consumption.

- Some managements, usually those having little or no technical background, are unaware or unjustifiably cautious of technological initiatives.

- Managements, particularly of developing enterprises, generally favour increased production and sales even where energy efficient alternatives have higher rates of return and can make a more immediate contribution to profit.

- Finance for energy conservation measures is difficult to secure, due in part to an historical bias among lenders and borrowers alike towards low initial cost solutions, even when more energy efficient alternatives have far lower lifetime costs.

- Risk is associated with investing in some emerging conservation technologies and with uncertainty about future energy savings and exchange rates. In addition the cost of capital is high and there is already an existing heavy burden of foreign debt.

- Managements are committed to existing capital stock with consequent inertia towards energy saving changes even when they are shown to meet or exceed the enterprise's investment criteria.

- Social factors such as habit, status, fashion, prejudice, etc. often override rational economic behaviour.

- Institutional barriers in the form of the law, import duties, regulations, tariffs and administrative structures can cause anomalies that discourage energy conservation.

- Trained and capable engineering staff are perceived as having more value in other areas, for example project design work, production, routine maintenance and even sales. Such staff are furthermore all too involved in day to day crisis management.

- Government policy in several areas such as price control, which allows energy costs to be passed on to customers, and industrial development policies, which encourage energy intensive industry over energy efficient industry, works against overall energy management.

The steps recommended later in this report will help to overcome such barriers in Kenya and thus limit the overall level of energy consumption.

3.2 The Pattern of Energy Supply

3.2.1 The Current Position

The industrial energy situation in Kenya is characterised by the heavy use of fuel oil, bagasse and fuelwood, these accounting for more than 80% of industrial energy use.

By far the largest industrial energy source in Kenya is residual fuel oil (RFO), delivered throughout Kenya from Mombasa where it is refined from imported crude. It amounted to 38.5% of the total energy consumed in 1983 and around 35% in 1985, as shown in Table 3.2.

Fuel oil is followed closely by bagasse, used almost exclusively by the sugar industry which crushes the cane and , though highly energy intensive, draws little upon imported fuels other than fuelwood.

Fuelwood is used quite widely in the tea industry, especially in its private sector, but to date to no great extent in general industry. It is however the dominant fuel in the domestic sector. The general perception of Kenyan government, industry and the community is that, apart from favoured locations, fuelwood cannot be considered seriously as an industrial fuel on the ground of security or adequacy of supply, or future price perceptions, or both. In other sections of this report and the companion report entitled Energy Efficiency in the Tea Industry the potential for supply and price of fuelwood is examined. At the time of preparation of this report the ESMAP Peri-Urban Fuelwood Study was in hand and, in due course, its findings will be of considerable importance in furthering knowledge of fuelwood potential in Kenya.

Coal with about a 10% share in 1983 increasing to about 15% in 1985 provides a substantial component of Kenyan industrial energy but is used only in the cement industry and then in only one of the two plants. This is the Bamburi Portland Cement plant, located near the port of Mombasa. The coal now used is imported from Swaziland and, while low in volatiles, is high in carbon and ash which are of benefit to cement production. These characteristics are, however, generally unsuitable in thermal coal for steam raising.

Electricity provides about 8% of industrial energy use, but in terms of cost of energy to industry is much nearer one third.

3.2.2 Scope for Beneficial Energy Supply Policies

The major indigenous energy resources of Kenya, if properly developed and managed, could provide a substantially greater share of the energy demands of the industrial sector than is the case at the present time. However, as indicated in the following, the scope for policy to expand energy supplies in Kenya is restricted by the limited extent of indigenous energy resources and by Kenya's inability to exert a significant influence over imported supplies.

MOERD and other GOK departments are well aware of the quite severe supply and cost constraints upon the development of indigenous energy resources: electricity from hydro and geothermal sources, biomass from forests or agricultural wastes, and the small but not unimportant sources such as solar and wind. Unfortunately for Kenya, to date at least, no fossil fuels can be included in the list of indigenous energy resources.

3.2.3 Position with Individual Fuels

3.2.3.1 Residual Fuel Oil (RFO)

The RFO used in industry in Kenya is refined from crude oil at the Kenya Petroleum Refineries Limited refinery in Mombasa. Present policy is to operate this refinery to produce Kenya's requirements for motor spirit and gas oil (the "white oil" rule) and under these circumstances approximately twice as much RFO is produced as is required for Kenya's own use. The surplus is exported at spot market prices which are relatively low because the product is heavy, of variable quality and already plentiful on world markets.

The potential for modifying the refinery to achieve a range of end products more suited to Kenya's needs has been the subject of separate study and lies outside the scope of this report. It is understood, however, that these modifications could involve such a substantial investment that no early change can be anticipated in the RFO supply position.

While Kenya's refinery continues to be operated as currently there appears to be little scope for change without indigenous oil.

3.2.3.2 Coal

Kenya has no commercial indigenous coal mines; the only coal used in Kenya is imported by Bamburi Cement for use in its own kilns. As noted in Section 3.2.1 this imported fuel is not suitable for general use in boilers. No price control is applied although there is an import duty.

There is little scope for Kenya to benefit from alternative coal supply policies.

3.2.3.3 Electricity

Electricity supplies in Kenya are characterised by the use of hydro and geothermal sources for base load. Water storage capacity has been limited and a share of Kenya's hydro power is also imported from Uganda. Thermal power plants have been used for peaking and for drought years. The low cost of base load hydro has had an effect in reducing the operating cost savings available from off peak cogeneration.

There are plans for additional supplies of centrally generated electricity. A programme of investment in water storage is underway which will help the position. However, the capital cost will be high and will contain a significant import component. As regards other forms of supply there is limited scope for such development except through cogeneration and, as noted, this is likely to be restricted by the low marginal generating cost of Kenya's base load sources.

3.2.3.4 Fuelwood

Fuelwood policies in Kenya are affected by the very large shortfall projected between existing supply from forest yield and demand for the large quantities used for charcoal and fuelwood for urban household use.

There is a very large number of existing and potential supply sources ranging from land clearance through agroforestry to Government plantation forests. However, supplies are uncertain and organisation is limited. Moreover much industrial fuelwood comes from Government forests at prices which do not recover the costs of growing.

In order to overcome the uncertainty, this report recommends that industrial use of fuelwood be considered only where the user is confident of a secure supply. In some instances this would require the user to invest in a fuelwood plantation, as is the case of the private sector of the tea industry, or to contract with a commercial source of fuelwood. Moreover all fuelwood recommendations include the proviso that existing fuel oil combustion facilities be retained to enable consumers to respond to price changes in the future. The selected fuelwood technologies are designed to permit this flexibility.

In order to meet growing demands, fuelwood consumed will need to be replaced by plantation or other forestry activity. Various sources were considered, including the thinning of existing forests to stimulate their growth while supplying current fuelwood. Agroforestry was also considered, attention being given to the arguments of agroforesters that wood could be made available from wasteland using underutilised resources (while at the same time taking into account the arguments of other observers that adequate land could not be freed in Kenya for intensive forestry or fuelwood production).

Kenya has attractive opportunities to benefit from untapped sources of fuelwood in the form of commercial or plantation forests which are not currently being thinned. When forests are not thinned, they produce less timber of marketable size - which in Kenya means less marketable timber for sawmilling or paper manufacture and lost forest revenue.

It has been reported that commercial forests are often not thinned because there are no funds available for the Forest Department to hire the workers required. However, in countries like Kenya where there is a market for the thinnings from the forest, thinning is often carried out at no cost to the forest owner by commercial organisations who pay the forest owner to gain access to the thinnings. This practice is widespread where there is an integrated forest industry which manufactures chipboard and particle board from the small sized thinnings product. Many plantation forests in Australia and New Zealand are thinned commercially and similar practices are followed in Europe.

In Kenya, thinnings could be used as industrial fuel with the fuelwood combustion technologies proposed, and this market might make commercial thinning of some forests viable. As noted in Appendix E, there are substantial volumes of forest thinnings available although there are significant costs of thinning and moving fuelwood from the forest to the user. The feasibility will depend upon fuelwood prices and costs of extraction. Thinnings could add from 25,000 to 400,000 tonnes per year to fuelwood supplies.

Appendix C of the companion report entitled "Energy Efficiency in the Tea Industry" examines the scope for additional supplies of fuelwood from Forest Department lands, plantations and unused roadside areas and other available public areas, and from smallholder woodlots. It seems very likely that those lands could yield from 25,000 to 50,000 tonnes per year of additional supplies of hardwood fuels. Forest Department lands could also provide up to 140,000 tonnes per year of conifer fuelwood from existing pulpwood resources although there are implicit difficulties.

Plantations on public lands could supply a further 10,000 to 25,000 tonnes per year of fuelwood with a high probability of success. Moreover smallholder woodlots could bring a further 50,000 to 100,000 tonnes per year to fuelwood supplies with medium to high probability of success.

Policy measures to develop fuelwood, which could also develop biomass fuels, are described in Section 3.2.3 following the discussion of the scope for biomass residues which follows.

3.2.3.5 Biomass Residues

Only limited attention has yet been given to exploiting the indigenous biomass energy potential of Kenya to meet the needs of industry. At least in the short term, however, it appears that there are some considerable difficulties - technical, economic and infrastructural - in achieving any substantial substitution for imported fuels.

To clarify the position a general biomass resource review, based on the literature available supported by an interview programme, was carried out and appears as Appendix E -Indigenous and Byproduct Fuels and, in the companion report on "Energy Efficiency in the Tea Industry", as Appendix C - Biomass as an Energy Source for the Tea Industry. This review has been based on all readily available written data (e.g. the Beijer report et al), the questioning of authorities and enterprises with information on biomass resources (e.g. the sugar, sawmilling, rice, sunflower, coffee, cashewnut, and forestry industries), and user information gained during conduct of both the coal and tea audit programmes.

At 1985 prices, substitution of biomass, or more particularly biomass residues having no other established market, appears to be a possibility for the displacement of fuel oil, and some plants have successfully made this substitution. Secure supplies at attractive prices would be required and are likely to be feasible in selected locations, with coffee husks, rice husks, sawdust, cashewnuts and bagasse being some examples.

The potential scope for additional supplies were seen to include over 60,000 tonnes per year of sawdust, 50,000 tonnes per year of bran, 25,000 tonnes per year of coffee husk, 13,000 tonnes of sisal flume run, 8,000 tonnes of rice husk, 60,000 tonnes of pineapple waste, 20,000 tonnes of coconut waste and 150,000 tonnes of papyrus. Prices vary, fuels are localised and some of the fuels require quite specialised combustion equipment and practices.

3.2.4 A Fuelwood and Biomass Residue Fuel Development Policy

By definition, byproducts are produced incidentally in the manufacture of other products. If byproducts are to substitute for commercial fuels, they must be reliably available in uniform quality. At the present time, however, the institutions to meet this requirement are not in place in Kenya, although substantial volumes of fuel may be available.

Institutional options to achieve the requisite uniformity and availability include:

- fuel users, who would organise their own supplies;
- suppliers, who would mount a fuel marketing system;
- private traders who would arrange to purchase surplus and sell on to users;
- a para statal organisation subject to the Ministry of Energy and Regional Development, and/or other Ministries.

Whichever of these options is chosen, a programme of demonstration and institution building appears necessary if byproducts are to be mobilised as fuels in Kenya. A number of policy choices are available. One which appears attractive is to identify potential users of fuel and to license a number of businesses to supply selected users.

Whether the institution takes the form of a Kenyan fuel development corporation, or a range of individual licensed businesses, it would contract to purchase fuels and sell them on to users. Fuels could come from any or all of the sources noted above, including smallholder woodlots, forest thinners and producers of byproduct wastes. Fuels would need to be delivered to specific users in uniform quality and this would be the special competence of the organisation.

Fuelwood from thinnings provides an example of the type of policy development which would be necessary.

Implementation would require policy co-ordination between the Ministries of Energy and Regional Development, Industry and Commerce, Agriculture and Livestock Development and Environment and Natural Resources (Forest Department) to develop the institutional framework to allow emergence of a profitable commercial thinning and fuelwood supply sector. The Forest Department could license a limited number of commercial operators to thin forests following an appropriate schedule. The Ministry of Energy and Regional Development could license these same operators as fuelwood suppliers to industry. Both Ministries would be responsible for ensuring satisfactory performance of the relevant operations of thinning and of delivery of fuel.

The Ministry of Energy and Regional Development could assist with technical support for fuelwood production and use. This could extend to commercial charcoal production for more distant markets. The Forest Department could assist with thinning schedules which ensure that reliable supplies continue to be available within a reasonable distance of users. The Ministry of Industry and Commerce could foster the entrance of investors into the new industry and possibly seek to develop an associated integrated forest industry producing a range of other products such as chip board, particle board and even charcoal.

This proposal is presented in outline only and would require the attention of the Ministries concerned - for instance, to consider the levying of licence charges for thinning in forests which are very near to a market, thereby encouraging thinning of more remote forests. The proposal brings together the objective of maximising the use of available indigenous fuels with the need to thin plantation forests to obtain maximum forest product. It also represents a rural based employment opportunity while at the same time complementing proposals to invest in the substitution of fuelwood for fuel oil in industry.

Policies and approaches such as those described above for generating additional fuelwood and mobilising thinnings would allow the development of a profitable biomass fuels supply sector, licensed to collect and sell biomass and wood for use as industrial fuels. The contribution to indigenous fuel supply in Kenya from such policy developments could be substantial and could significantly and beneficially re-shape the overall pattern of energy supply.

3.3 The Energy Pricing Environment and Incentive Framework

3.3.1 Introduction

The 1985 position with the principal fuels and their prices is described below while possible future variations in those prices are treated in Chapter 5, each fuel being covered under its respective heading. Table 3.3 summarises the economic and financial prices of fuels in Kenya while Table 5.2 presents the ranges of prices used for the testing of project results, the ranges being designed to test some extreme conditions as well as prospective fuel price levels over future years.

It should be noted that the analysis of fuel prices, including those for fuel oil, was completed during the fieldwork period in 1985 when world prices appeared stable. Subsequent to that work, in 1986, world prices for crude oil fell dramatically causing various authorities, including the World Bank, to revise oil price forecasts downwards. Because of the diversity of views about the future price of oil, this matter has been covered fully later in Chapter 5 and in Appendix D, using sensitivity analysis to provide a basis for relating investment decisions to expected prices.

TABLE 3.3 - KENYA: ECONOMIC AND FINANCIAL PRICES OF FUELS (KSh/GJ)
December, 1985

Fuel	Gross Specific Energy GJ/tonne	Economic Price	Market Price	Delivery Charge in Nairobi	
Imported Fuels		C.I.F. Mombasa	C.I.F. Mombasa	Economic	Financial
RFO 280 CST	42.9	25	53	11	9
Thermal Coal	26.8	42	42	20	18
Untraded Fuels		At mill or edge of forest	At mill or edge of forest	Charge 50km Radius	
Fuelwood	(30%) 14.2 mcbw	36	36	32	18
Sawdust	(50%) 10.2 mcbw	10	10	37	33
Grain By-product	13.9	7	7	27	24
Electricity	n.a.	392	164	n.a.	n.a.

Source: Appendix D - Economic and Financial Prices of Fuels. Table D.11

Note: Economic price is border price or opportunity cost. Financial price includes duties and charges. This table includes foreign exchange cost adjustment. Delivery charges for Untraded Fuels can be pro-rated for different distances.

3.3.2 Energy Pricing Principles

Energy pricing policy aims to discourage the wasteful use of scarce fuel resources. Efficient pricing ensures that the highest available return is obtained from the fuel and energy resources used.

Pricing policy has effects on the allocation of fuels between different purposes, on investment in and the expansion of fuel supply capacity, and on financial flows between user and supplier. As a result it has a widespread influence and a complete appraisal requires consideration of many factors including:

- simplicity, public acceptability and feasibility;
- stability of price level and of revenue yield adequate to meet supplier requirements;
- fairness between different users and between different fuel types.

In application, a fuel pricing policy should:

- reflect marginal costs of supply to consumers to discourage wasteful use;
- provide adequate revenues to suppliers to encourage capacity adjustments;
- distribute benefits and costs equitably between suppliers of different fuels and different classes of users;
- provide an incentive to suppliers and to users to carefully select and fully exploit efficient technological alternatives for energy supply and use.

The current application of these principles to each of the four major industrial fuels in Kenya is discussed in turn under the following headings.

3.3.3 Refined Oil Products

Residual fuel oil pricing in Kenya is inextricably tied to refining policy because the pattern of demand for the different refined products results in a substantial surplus of residual fuel oil when local demand for lighter refined fuels is met through local refining. Thus the policy of refining lighter fractions locally makes it necessary to export surplus residual fuel oil at prices which are well below CIF import costs.

Pricing seeks to recover the costs of imported crude and of refinery operation while discouraging transport use of fuel and avoiding consumer price increases which would flow from industrial fuel prices through the existing price control system. Transport fuels are priced above estimated import parity levels while domestic kerosene and fuel oil are priced below estimated import parity.

In general this system reflects marginal costs and apparently provides adequate operating revenues. However, it mitigates against the efficient selection and use of technology by industrial fuel users.

3.3.4 Fuelwood

Despite the reported depletion of forest resources, fuelwood prices in Kenya have shown little tendency to rise in relation to other fuels. Industrial users report very low prices and some difficulties in obtaining increased quantities. These low prices reflect stumpage charges which are below economic cost.

Direct use of fuelwood is more common in rural areas and prices for privately collected or grown fuelwood are not controlled. Price controls have however been applied to charcoal although the benefit to urban households has been eroded by repackaging. Much of the fuelwood used to produce charcoal is reported to come from land clearance and there are no charges levied for clearance of fuelwood.

The pricing of public forest fuelwood supplies in Kenya does not reflect the marginal costs of supply, does not provide adequate revenues to the public forests, is inequitable to private and public growers of fuelwood and reduces the incentive to use technology to improve use efficiency or to improve supply growth. Other observers have suggested the need for higher stumpage charges; it is suggested that supplies could be expanded through encouraging the sale of thinnings as fuelwood, provided that fuelwood stumpage charges were higher.

Price control on charcoal also understates the marginal costs of supply, provides inadequate revenues to attract large scale investment, is inequitable to rural households and suppliers of charcoal and reduces the incentive to use more efficient charcoal burning and production devices. It would not be practical to charge stumpage for land clearance (with the aim of encouraging investment in plantations for the production of fuelwood and charcoal).

On the other hand, higher stumpage charges from government forests and removal of price control on charcoal are recommended since these actions would encourage investment in fuelwood supply and more efficient use of fuelwood in industry and household - and move market prices more in line with the economic costs of supply.

3.3.5 Electricity

As indicated earlier, electricity supply in Kenya is marked by the large share of hydroelectric capacity in total generating capacity, limited water storage capacity restricting hydro flexibility and consequently the use of thermal plant for peaking supply.

Electricity pricing policies have been subjected to direct price control with a view to limiting the impact of price increases on consumers.

The tariff outcomes appear to have been directed to the recurrent revenue requirements of the supply authority. This has had the effect of averaging the low present costs of earlier capacity decisions with the high current costs of expansion.

As a result tariffs have fallen below the marginal costs of supply and there has been a reduced incentive to users to conserve or cogenerate, and to the supply authority to expand. There has been an inequity between consumers with access to electricity and those without and an associated pressure to expand electrification.

Meanwhile tariff policies have been under review and it is recommended that significant tariff increases be made in order to reduce the problems noted here.

3.3.6 Coal

Coal pricing policies appear to meet the required principles of reflecting the marginal costs of supply, providing adequate revenues to suppliers, allowing for equity and giving an incentive to efficient use of technology in combustion and in coal supply.

3.3.7 Policy Impacts Model

Finally in relation to energy pricing, the interactive effects of energy substitution in the Kenyan situation should be noted.

Because the different sectors of the Kenyan economy, households, industry, commerce and agriculture, make use of the same range of fuels, changes in fuel price or availability in one sector can have significant impacts on the others. Moreover in the now familiar circumstances of constantly changing demands, technologies and prices, the determination of the most economic pattern of processes, energy use and fuel substitution is very difficult. Yet it can be highly beneficial and justify important changes in policy. For instance for Kenya this might represent the scope for gaining from the pursuit of an alternative fuel in the domestic sector or from an alteration to the refinery operating rule.

In order to handle the many energy supply, demand and substitution inter-relationships and resolve the national cost/benefit questions raised by such issues, there is a need to quantify the effects of changes in policies or in market or process parameters; and to be able to identify fuel substitutions which are best for the nation rather than for any particular sector. For this purpose a Policy Impacts Model was developed early in the programme. However, at the mid-term review, and before significant results had been generated, it was determined that work on this model be terminated.

While the model was not then used in the subsequent evaluations it does represent an available aid to policy analysis; and accordingly a description is included in Appendix G for reference.

3.4 General Policy Impacts on Energy Conservation

3.4.1 Price Control Policy

Manufacturing price control in Kenya operates essentially on a cost plus basis. Manufacturers are able to obtain increases in controlled prices on the basis of increased costs. As a result at present, the price control system allows the passing on of energy price increases in product prices thus removing much of the incentive to conserve because the enterprise profits are insulated against rising fuel prices.

There is evidence from a number of countries and reported by the World Bank that the existence of cost-plus price control is a strong disincentive to conservation efforts 1/. Alternatives involve the coordination of price control and energy policy.

Linking price control procedures to energy management programmes is practised in the United States. It restores the incentive to improve profitability which can become lost under a price control system which allows the passing on of cost increases. It also links energy management with the reduction of inflation and provides a means of assisting realisation of national benefits of energy management.

Such a price control mechanism, with sufficient co-ordination between the Ministry of Finance and the MOERD, could stimulate the process of industrial audit and the progressive improvement of energy intensities; and draw attention to energy intensity targets, energy use and the profits available from pursuing T1 energy efficiency opportunities requiring little investment. In turn this could stimulate industry to undertake audits and to appoint Energy Managers and to create a more efficient industry.

One possibility would be to alter price control policies to allow energy prices to be passed on only on the basis of an energy audit. The expectation of rising costs and falling profits may be a stronger incentive to conservation than an expectation of rising costs and constant profits. This could be extended by allowing energy cost increases to be passed on only when an industry reaches predetermined energy efficiency standards although this could require significant regulation and monitoring costs.

This would necessitate some effort and especially some goodwill between price control officials in the Ministry of Finance and officers of the MOERD. While decisions on price control would remain with the Ministry of Finance, the latter would seek advice from the MOERD should any application received for a price increase be based on rising costs of fuels.

1/ See World Bank, Industrial Energy Rationalisation in Developing Countries, Report No. 5426 Industrial Energy Efficiency Unit, Industry Department, 1985, p43.

The MOERD could then provide advice on whether:

- The firm has undertaken an energy audit and the Ministry has information on its achievement of Target 1 energy intensity levels.
- The firm has or has not achieved target energy intensities for the relevant fuels.
- The firm has not undertaken an audit but is willing and is scheduled to undertake one.
- The firm has been apparently resisting approaches to conduct an audit.

The Ministry of Finance would then exercise its judgement in deciding the application. Possible responses are to pass and encourage continued attention to energy efficiency for those firms who have performed well or have shown the intention to undertake an audit. Firms which have been audited but perform poorly could have their application discounted in proportion to their failure to meet targets. Firms which were resisting energy audits might have price increases deferred pending conduct of an audit and satisfactory compliance.

This is an apparently simple procedure provided the number of firms involved is small and the number of firms already audited is large.

Fortunately, this can be expected to be the case. Price control is primarily administered only on large groups which dominate their markets and so influence the prices charged by other competing firms, if any. Most of Kenya's large firms have already had audits. Thus most enquiries would relate to firms already known to MOERD.

The decision to proceed and the detailed procedure to be followed could be established by the Ministerial Energy Planning Committee which involves both Ministries.

3.4.2 Tariff Policy

One barrier to effective energy management stems from the import duties which, while providing some protection for the import competing industry, do contribute to the higher costs of exporting industry and of non import competing industry. High duties on imported thermal equipment and instrumentation raise the cost to industries which use such equipment. It is to be noted that some thermal plant, such as small boilers and heat exchangers, is manufactured locally.

It is perceived, after consideration of industry policy on protection, that, while the present tariff policies are not substantial impediments to energy efficiency, several items of equipment and instrumentation which may be required by industry in order to improve energy conservation and management are subject to very high rates of duty and sales tax. There are provisions to provide exemptions from these duties (although exemptions are unusual) and Table 3.4 gives rates of duty and sales tax on a typical range of items, for which exemptions might appropriately be sought.

The impact of these exemptions, if allowed, would have reduced Government revenue collections by KSh 19.25 million in FY 1983 and by KSh 23 million in FY 1984. Even if these rose to between say KSh 25 and 30 million in FY 1985 the lost revenue would have represented only 10% of the potential annual savings of the 21 audited plants alone at 1985 energy prices. Extending this to all industry this cost to Government would only total some 5% of the total national energy bill.

This indicates that substantial net gains could be made nationally by exempting these important items from duties.

TABLE 3.4

KENYA: RATES OF IMPORT DUTY AND SALES TAX, 1985

ITEM	Tariff Code	Rate of Duty	Sales Tax
CONTROL EQUIPMENT			
Oxygen Analyser	90.25.009	25%	17%
Carbon Monoxide Analyser	90.25.009	25%	17%
Flow Transmitter	90.24.009	35%	17%
Temperature Transmitter	90.23.009	35%	17%
Pressure Transmitter	90.24.009	35%	17%
Pressure Change Transmitter	90.24.009	35%	17%
Indicating Controllers	90.28.019	25%	17%
Recording Controllers	90.28.019	25%	17%
Thermometers	90.23.009	35%	17%
Pressure Gauges	90.24.009	35%	17%
Control Valves (electronic automatic)	90.28.019	25%	17%
Control Actuators	. 90.28.019	25%	17%
	. 90.24.009	35%	17%
MECHANICAL EQUIPMENT			
Temperature Control Valves	84.61.000	30%	17%
Pressure Reducing Valves	84.61.000	30%	17%
Manual Valves	84.61.000	30%	17%
Pipe Fittings	73.20.000	25%	17%
Insulation	69.01.000	Free	Free
Tanks	73.22.000	45%	17%
Boilers	84.01.010	25%	Free
Burners	84.13.000	25%	Free
Pressure Vessels	73.24.000	45%	Free
Combustors	84.13.000	25%	Free
Gasifiers	84.03.000	25%	Free
Economisers	84.02.010	25%	Free
Steam Traps and Ancillary Equipment	84.02.010	25%	Free
Condensate Return Pumps	84.02.010	25%	Free
ELECTRICAL EQUIPMENT			
AC Motors	85.01.020	25%	Free
Switch Boards)	85.19.019	40%	17%
Switch Gear)			
Circuit Breakers)	85.19.019	40%	17%
Cabling 2mm to 7.7cm	85.23.001	40%	17%
0.2mm to 2 mm	85.23.002	80%	17%
Transformers			
- Liquid Dielectric	85.01.070	25%	Free
- Other	85.01.080	25%	Free

3.4.3 Impact of Capital and Tax Policy

3.4.3.1 Supply of Capital

Restraint on energy initiatives has also been imposed by the fiscal and financial environment for investment in Kenya which has been dominated by the requirement to manage the external debt and the balance of payments. As observed in 1985, several years of rising oil prices and a strengthening United States dollar had combined with a domestic drought and the historically large role of parastatal organisations in the economy to place severe external constraints on growth. External debt, especially that denominated in U.S. dollars, was growing as the Kenya shilling devalued against that currency. Government participation in the economy was being reduced as a proportion of the total and new development was coming under increasingly tough economic scrutiny. Moreover policy makers were attempting to maintain positive real interest rates and avoid concessional financing of the commercial ventures of parastatals.

In these circumstances the domestic supply of capital was limited by, inter alia, low rates of savings (especially in the informal sector), high demand for funds from government, an expectation of continued devaluation of the Kenya shilling and a very low rate of capital inflow.

Development finance in Kenya was available for investments which would generate at least 40 percent of their value added in Kenya and which would acquire equipment which could be serviced in Kenya. Terms were 15 percent per annum over ten years with a one year grace period before repayments began and a required gearing of not less than 30 percent equity. Other finance was attracting 19 percent. Private investors were rejecting proposals yielding less than 25 percent per annum after interest and taxes. This climate was not conducive to investment in energy management measures even with returns which could, in general, justify each investment.

Moreover some financial institutions in Kenya were unfamiliar with the appraisal of energy conservation investments. This, therefore, was seen to be an area in which there is room to gain improvements through some general training together with more meaningful liaison between the financial institutions and the Ministry of Energy and Regional Development.

3.4.3.2 Foreign Exchange

In Kenya there has been the further problem of shortage of foreign exchange. By 1985 a widespread expectation of more or less continuous declines in the rate of exchange of the Kenya shilling with the United States dollar had been established. Private investors were very wary about undertaking a foreign exchange risk. Foreign exchange is itself difficult to obtain and costly. Imports to Kenya are subject to duty, import duties and sales taxes averaging in most instances about 17 percent in recent years.

While investors may wish to avoid exchange risk by domestic borrowing for imports, official policy of the Central Bank of Kenya is to promote use of overseas credits to finance imports where acceptable terms and conditions of credit are available. Long term credit is favoured for imports of capital items. Overseas financing of exports is not normally approved. This is significant because it restricts early repatriation of export sale proceeds by overseas controlled organisations. It also restricts the ability of borrowers to obtain hedging protection against exchange rate variations.

While foreign exchange costs and risks and the cost of imports all affect investments involving imported equipment the Consultants do not believe that this warrants a general change in policy.

3.4.3.3 Taxation

On the other hand, company taxation policies in Kenya do provide incentives to invest which are available to assist energy conservation initiatives. An investment allowance of 50 percent of capital expenditure on such measures is deductible from profits, before tax and after interest and depreciation, for firms located outside Mombasa and Nairobi. Accumulated losses of these firms can be carried over to be written back against profits in later years.

Corporate taxes are 45 percent on profits after depreciation of 12.5 percent per annum on declining balance for plant and machinery and 2.5 percent per annum straight line on industrial buildings.

3.5 Energy Options for Kenya

In summary, this Chapter suggests a range of options for energy management and policy in Kenya.

At present Kenya's industry is restricted in its capacity to invest by limited domestic savings and a heavy burden of international debt. Despite stable economic policies and a stable political structure, private capital inflow has also been limited. Moreover, foreign exchange is costly because of the perceived exchange risk and because domestic capital, which is relatively less costly, is limited in supply, although there is no apparent case for changes in fiscal policy to benefit energy conservation.

The most attractive policy developments in energy conservation should therefore require little investment if they are not to be thwarted by the limited availability of funds. In this situation, it is noted that efforts to improve the integration of policy may be rewarded. The Ministry of Energy and Regional Development should continue to have regular liaison with each of the other Ministries, with the Kenyan Association of Manufacturers, with energy suppliers and with the engineering and scientific community to ensure that policies in all areas support energy conservation.

In this connection imported fuel pricing policy in Kenya is highly constrained and there are few viable alternatives available. Electricity and indigenous fuels are priced at levels below their economic costs and this fosters over-use of energy and under-investment in indigenous fuel supply. It is recommended that attention be given to ways in which these policies could change.

There is also scope for expanding the supply of indigenous fuels but this scope is restricted by the current lack of institutions capable of converting biomass and byproducts into reliable supplies of uniform quality fuel. A programme of institution building is recommended which could result in the development of a profitable fuel supply sector based on indigenous fuel sources.

Next, an important area needing attention is that in which the general economic policies of government may work against energy efficiency. In Kenya examples may be found in manufacturing price control and government ownership of enterprises. Industrial development policies could support energy policy by encouraging a local energy efficiency services and supply industry and by discouraging new energy intensive industry which is not warranted by market conditions. In addition, scientific and engineering activity and technical education might more effectively support energy efficiency in industry. Education of energy managers and awards to enterprises and individuals who achieve predetermined energy standards should also be considered. Moreover, the successful energy managing enterprises should be given more attention, publicity and promotion.

Efforts to promote energy conservation will also tend to require supporting financial policies. It is important to ensure that the financial sector is equipped to appraise energy management investments and that funds are equally available to energy as to other investments.

Accordingly initiatives are needed in four areas:

- To ensure appropriate and integrated policies in the energy sector to reinforce energy conservation.

- To foster the development of an energy efficiency services and supplies industry.

- To create and train through an energy management programme a widespread body of energy managers who are able and experienced in the control of energy using and conversion equipment in place in Kenya.

- To ensure that Kenya has adequate skills to appraise the financial costs, risks and benefits of investment in energy conservation.

Chapter 6 discusses proposals for an energy management programme which takes into account the industry development, training and evaluation matters noted above.

4. INDUSTRIAL ENERGY AUDIT PROGRAMME AND POTENTIAL FOR ENERGY CONSERVATION

4.1 Approach and Methodology

As required by the Activity Initiation Brief, 20 plants, later increased to 21, were selected in close conjunction with the MOERD as appropriate subject sites for energy audits. The criteria governing the choice were several but can be summarised as follows:

- A selection of the major industries of Kenya;
- A selection of industries in each ISIC sector which could be regarded as 'signpost' industries which would be likely to serve as national examples or case studies;
- A selection of industries which were expected to show substantial energy savings; and lastly
- A selection of industries with fuel substitution potential.

Clearly, the full application of each of the criteria would lead to a list considerably greater than 21. Accordingly a degree of judgement was applied to achieve a reasonable balance and the list set out below in alphabetical order represents the final selection:

Bamburi Portland Cement Co
B.A.T. Kenya Ltd
Clayworks Ltd
East African Portland Cement Co Ltd
East African Sugar Industries
Emco Steel Works Ltd
Firestone E.A. (1969) Ltd (added later)
Kaluworks Ltd
Kenya Breweries Ltd
Kenya Calcium Products Ltd
Kenya Canners Ltd
Kenya Cooperative Creameries
Kenya Glass Works Ltd
Kenya Meat Commission
Kenyatta National Hospital
Madhupaper International Ltd
Magadi Soda Co P.L.C.
Oil Extraction Ltd
Panafrican Paper Mills (EA) Ltd
Rift Valley Textiles Ltd
Thika Cloth Mills Ltd

The above list was approved by the Steering Committee at its meeting in Nairobi on 31st May 1985, and reported to the World Bank in Progress Report Number 1 - May 1985. A standardised approach and format was developed by the Consultants comprising a Model Energy Audit Report and a Model Energy Survey Questionnaire. The former document was designed to indicate the type of data being sought and the standard of reporting which would be presented. The Energy Survey Questionnaire appears as Appendix A to each of the 21 individual Energy Audit Reports and is included as Appendix H.1 to this Report.

The MOERD and the Consultants jointly organised an Energy Managers' Workshop (held in Nairobi on 28th and 29th May 1985) to explain these two models. After the Workshop, the Consultants made a brief visit to a representative selection of plants to be audited in order to determine attitudes to energy auditing, to assess likely responses and to foreshadow any particular problems of approach and methodology. As well, the opportunity was taken of drawing on MOERD experience and personnel. The audit fieldwork was then commenced with Energy Survey Questionnaires being first issued to managements of each of the plants to be audited.

During the months of June to October, 1985 the audit teams, initially one but later extended to two, embarked on the fieldwork. Each plant was visited typically for a period of two to four days, during which time plant management and engineers were drawn into a detailed review of processes, particularly those to do with energy consuming and converting plant. When available, the completed Energy Survey Questionnaire was reviewed in detail with the management and guidance given on the type and extent of information required. During the field visits, tests and measurements were undertaken for boiler and combustion efficiency, furnace combustion temperatures, flue gas analysis, surface temperatures of pipework, electrical current, electrical demand, power factor, lighting levels, and the like, together with the usual recordings of energy purchases covering all energy sources and demands, and prices paid, in almost every case on a month to month basis over a three year period.

By mid October 1985 the audit fieldwork programme was complete, and work then commenced on assessing and analysing data, using the project microcomputer and the Lotus 1-2-3 spreadsheet programme, with worksheets specifically designed for the project. Where reasonably comprehensive energy consumption figures were provided by the plants the worksheets enabled careful analysis of both consumption patterns and the relationship of energy consumption with production in order to derive energy intensity, energy trends and the like. Linear regression was used to establish lines of overall energy performance and to highlight anomalies due either to poor experience or limited data. From this analysis it became possible, along with data from comparable industries, to postulate lines of best performance, to establish realistic energy consumption and energy intensity targets, and to derive and quantify the many recommendations upon which management action would have to be taken to achieve those targets.

The results of the audit programme are given in a comprehensive series of 21 individual Energy Audit Reports, each bound separately from this report. Copies have been provided to the MOERD and a copy of the respective report passed on to each of the companies audited. The Executive Summary from each of these reports is repeated in Appendix I.

4.2 Energy Managers' Workshop

At the suggestion of the MOERD and the World Bank, the Consultants organised and conducted a two day Energy Managers' Workshop. The programme for this workshop, held in May 1985, is included as Appendix H.2. As reported, papers were presented on aspects of energy conservation, fuels, combustion, coal handling and coal transportation.

The workshop seemed very successful in gaining the increased understanding and response of those present, although it was disappointing that a number of those invited, who represented the companies to be audited, were unable to be present.

4.3 Industrial Energy Usage Database

The major findings of the industrial energy audit programme have been closely related to data contained in Appendix C - Industrial Energy Usage Database. (For the establishment of this Database, refer to Chapter 3.)

As noted in this Appendix, the Database provided information on:

- Plant - ISIC Sector, Name, Province, Plant Installed, Production and Energy Source, and
- Energy Source - Type, Cost, Actual Consumption, Target Consumption.

Energy demand projections for each energy source were developed from 1983 as the base year, the last for which reliable statistics were available at the time, together with economic factors (essentially industry growth rates as experienced in Kenya) as derived in Appendix B - Industry Growth Rates. To compare projections, growth rates denoted Base (BA), High (HI) and Low (LO), were entered.

With this basis, it became possible to factor in the energy conservation potential as appropriate for each individual plant, each ISIC sector, and each energy source, the latter reflecting the consequences of energy substitution in national energy consumption forecasts. In addition, the conservation potential in industry could be expressed, for simplicity, in terms of achievable targets for energy use per unit of production, typically GJ/tonne. The targets were defined at two levels, thus:

Target 1 (Short Term)	Energy savings target achievable based on conservation measures which could be taken almost immediately with minimum engineering input and, in general, minimum capital investment. Typically, such measures would show a simple payback of under one year and would include basic housekeeping and correct operating and maintenance practices.

Target 2 (Long Term)	Energy savings target achievable based on conservation measures which could be taken, with appropriate planning and engineering input and the expectation of capital investment in new or improved plant or processes or a more economic energy source, and which would give an acceptable economic and financial rate of return, (i.e. greater than 15% real).

Targets were set in accordance with:

- the results of the audit programme as presented in a total of 40 Energy Audit Reports (21 from the industrial audit programme and 19 from the tea industry programme),

- internationally accepted standards for the industry or plant concerned (suitably modified for Kenyan conditions), and

- the Consultants' experience in similar work.

In this way, the Data Base and target settings were used to establish existing and future energy consumptions and to compute energy conservation and cost saving potential for the industrial sector.

4.4 Delivered Energy Costs

For the purposes of the audit programme and audit reports the delivered costs of each energy source appropriate to each factory were taken from individual plant cost records current at the time of the audit and summarised in the questionnaire response appearing in each individual report.

The costs used are summarised in Annex 4 - Delivered Energy Costs at Plant in 1985. The Annex covers:

Annex 4.1 Fuel Oil
Annex 4.2 Electricity
Annex 4.3 Fuelwood

For the purposes of subsequent financial and economic analysis averages were derived, based on this data, as explained in Chapter 3.

4.5 Major Findings of the Audit Programme

Industrial energy audits were carried out at 21 plants, their combined energy consumption in 1984 being approximately 13.5 PJ, nearly half of the estimated total 1984 energy consumption of 27.8 PJ for the whole industrial sector (Reference Database File Kenya 2BA Sheet 6).

The Target 1 and Target 2 conservation potentials identified by the 1985 audit programme are summarised in Table 4.1 below and are set out on a plant by plant basis in Table 4.2 (for Target 1 measures) and

Table 4.3 (for Target 2 measures) which follow. The savings based on 1985 prices would be considerable both in energy and financial terms, although it is noted that there would be in fact only a slight decrease in energy consumption if all Target 2 projects were undertaken (because a number of the T2 projects involve cogeneration which increases energy intake at the plant boundary but decreases energy demand at the national level, mainly as generated electricity). Moreover, there could be a substantial potential for substitution of imported fuel oil by indigenous fuel.

TABLE 4.1: OVERVIEW OF ENERGY CONSERVATION POTENTIAL

(21 Audited Plants Only)

Target	Potential Saving TJ/a	%	MKSh/a	M$US	Investment MKSh	M$US	Payback Years
1	1,159	8.5	71.3	4.2	23.6	1.4	0.3
2	45	0.3	218.9	12.9	260.1	15.3	1.2
TOTALS/WEIGHTED AVERAGE	1,204	8.8	290.2	17.1	283.7	16.7	1.0

Note: Exchange rate adopted - $US = 17 KSh

Extended to reflect all industry by simple doubling, the energy conservation potential can be seen to reach significant levels in terms of the national economy and the reduction of Kenya's dependence on imported oil, the overall thrust of the Activity Initiation Brief. The potential savings for the whole of Kenyan industry may be higher than the weighted averages appearing in Tables 4.2 and 4.3 since the audits included some very large and well managed enterprises. These expectations are consistent with results obtained in industry in other countries, and with the results of energy conservation studies previously undertaken in Kenyan industry by the MOERD.

It should be noted, however, that subsequent to developing these proposed targets, there was a marked drop in the international price of oil. Moreover, it was perceived that there was likely to be an increase in fuelwood prices. As discussed later in Chapter 5 and in Appendix D, these projects were then in 1986 subjected to sensitivity analysis and, in a number of instances, found to be unattractive at the new low price levels. Furthermore, Government policy of not making fuelwood available for industry in peri-urban areas, notwithstanding the apparent financial attraction in some instances, was taken into account. This led to the dropping from further attention of some five projects earlier identified in the individual audit reports. The results of these analyses are discussed in Chapter 5. Nevertheless the balance of projects, attractive at 1985 energy prices, have still been presented in this report so as to document areas of prospective opportunity should oil prices rise as the Consultants forecast, and should fuel price differentials return to around the 1985 levels.

4.6 Opportunities for Energy Conservation

4.6.1 Target 1

The 21 energy audit visits, as well as the 19 tea factory audits, and subsequent energy analyses indicated several recurring areas which require attention. Although there are, as noted, many exceptions, the typical technical issues encountered by the audit engineers, and which if attended to would lead to energy savings, may be summarised as follows:

- Very few organisations have an Energy Management Programme or an Energy Manager appointment. A chapter of each Energy Audit Report addresses this vital area.

- Oil fired burners, mainly in boilers and furnaces, are often inefficiently adjusted and so waste fuel oil due to poor atomisation and/or incorrect fuel/air ratios. Excess air levels are often very much above the realistic minimum for good combustion. However, controls and instrumentation are frequently not available, nor fitted, nor calibrated to detect such inefficiencies. An Appendix in each Energy Audit Report deals with oil firing in some detail.

- Fouling of heat transfer surfaces by fire side deposits due to poor atomisation and dirty burners is a continual problem and adds to maintenance costs as well as fuel costs due to reduced thermal efficiency.

- Automatic burner controls need to be converted from "high-low-off" control to smoothly operating continuously modulating systems for correct fuel/air ratio control over the full firing range. In many factories this will mean the installation of new burner control equipment but the efficiency gain will soon pay for this. Existing heavy tariff barriers on such control equipment need however to be reviewed.

- Manufacturers' specified operating conditions for combustion equipment need to be followed much more closely in most industries if good furnace/boiler efficiency is to be achieved.

- Variations from standard combustion conditions need to be monitored by continuously logging furnace suction pressure and flue gas outlet temperature and analysis (oxygen and/or carbon dioxide). In most factories this requires the addition of instrumentation which is currently not available or suffers from high import duties. Again, import tariffs need to be reviewed.

- Steam and condensate return systems are often improperly designed, poorly insulated, and have numerous leaks. Condensate is often discharged to waste. Attention to steam systems shows immediate return for limited outlay. Each Energy Audit Report includes a detailed Appendix on the design, installation and operation of steam systems.

- Electrical maximum demand control and the potentially large cost penalties that can arise are not well understood. Accordingly, each Energy Audit Report includes an Appendix explaining to factories how to improve load factor, reduce maximum demand, and so reduce electricity costs.

- Power factor correction is also poorly understood, even though some corrective equipment is installed in most factories. Each Energy Audit Report includes an Appendix explaining how to improve power factor correction and so reduce costs.

- Lighting systems, particularly in the older factories, are far from energy efficient, given the availability of modern low energy lighting systems. Again, each Energy Audit Report includes a guiding Appendix on the subject.

- Compressed air systems frequently leak, or are set at needlessly high pressures. Each Energy Audit Report gives advice on how to measure and deal with this costly problem.

All or most of the above measures, it is believed, can and should be dealt with under the Target 1 Programme; that is, energy savings achievable based on conservation measures which can be taken almost immediately with minimum engineering and capital investment.

4.6.2 Target 2

Of longer term impact are those projects denoted as Target 2. These are projects which achieve energy savings based on conservation measures which require planning and engineering input and the expectation of capital investment in new or improved plant or processes, or in a more economic energy source, and which are expected to give an acceptable economic and financial rate of return. Such projects include, but are not necessarily limited to, conversion from fuel oil to an indigenous fuel, where appropriate wood or biomass residues; or recovery of process waste heat; or extension of a factory's energy structure to include a cogeneration scheme. Cogeneration involves the combined production of electricity and process heat. Given that the need for process heat exists, and can be met by steam raising, then the additional energy required to generate electricity by higher pressure steam is often particularly cost effective, the conversion efficiency from primary fuel to electricity with back pressure generation being inherently far higher than with convential condensing generation.

The main fuel substitution option for Kenyan industry is from fuel oil to biomass. Industry on the whole sees some significant difficulty in conversion to fuelwood, or biomass residues, due to a perceived lack of assured supply. Certainly, fuelwood is currently in deficit in high population density areas of high agricultural potential, including the regions near the major cities. However, the Consultants found several examples of financially successful conversions from fuel oil to fuelwood or biomass residues, with others proposed or in hand. The Consultants, furthermore, believe that adequate indigenous biomass potential does exist in many regions of Kenya, without using existing native forests, and believe that in those regions biomass must represent one of the more attractive but poorly utilised resources available to Kenyan industry. This issue is dealt with at some length in the companion report prepared by the Consultants entitled Kenya: Energy Efficiency in the Tea Industry.

Tuning up and otherwise improving the thermal efficiency of the many boilers that already use biomass residues or fuelwood is an issue which needs to be very carefully taken up. The widespread use of old locomotive boilers for fuelwood combustion, while understandable from the point of view of low initial capital cost, is disastrous from the standpoint of energy efficiency or fuelwood conservation. Such boilers may consume nearly twice the biomass material compared with modern purpose designed plant to produce the same useful heat output. Those industries which rely on biomass have so far not addressed the energy conservation issue very seriously as the fuel is perceived to be and is cheap. The potential fuel savings from improved efficiency could well be utilised by other industries which at present rely on fuel oil.

TABLE 4.2: ENERGY CONSERVATION POTENTIAL - TARGET 1

COMPANY	1984 CONSUMPTION		TARGET 1			INVESTMENT	
	Total		Potential Savings			Cost	Payback
	TJ/a	kKSh/a	TJ/a	%	kKSh/a	kKSh	Yrs
Bamburi Portland Cement Co	4189	222,848	475	11.3	22,900	1400	0.1
BAT Kenya Ltd	25	2,728	4	16.7	480	160	0.3
Clayworks Ltd	61	983	6	9.0	129	89	0.7
East African Portland Cement Co Ltd	1723	112,694	134	7.8	10,795	3535	0.3
East African Sugar Industries	2022	3,627	No projects identified*				
Emco Steel Works Ltd	83	8,313	6	7.1	865	620	0.7
Firestone E.A. (1969) Ltd	173	15,033	7	3.8	552	230	0.4
Kaluworks Ltd	27	2,625	6	21.9	478	140	0.3
Kenya Breweries Ltd	492	37,921	120	24.3	8,458	9646	1.1
Kenya Calcium Products Ltd	115	2,126	9	7.8	192	25	0.1
Kenya Canners Ltd	212	15,954	95	44.8	7,088	2459	0.3
Kenya Cooperative Creameries	21	5,118	4	5.9	256	140	0.5
Kenya Glass Works Ltd	374	26,699	18	4.8	2,114	1590	0.8
Kenya Meat Commission	243	17,334	36	14.8	2,195	569	0.3
Kenyatta National Hospital	160	12,215	62	38.7	3,915	950	0.2
Madhupaper International Ltd	94	8,864	18	19.6	1,142	245	0.2
Magadi Soda Co P.L.C.	609	35,167	32	5.2	1,849	198	0.1
Oil Extraction Ltd	30	2,167	8	26.6	553	443	0.8
Panafrican Paper Mills (EA) Ltd	2504	164,327	96	3.8	5,865	450	0.1
Rift Valley Textiles Ltd	207	17,562	13	6.2	795	445	0.6
Thika Cloth Mills Ltd	178	14,295	10	5.7	640	280	0.4
TOTALS/ WEIGHTED AVERAGE	13542	728,600	1159	8.5	71,261	23614	0.3

* The audit of EASI was devoted entirely to identification and evaluation of major T2 projects. While there is believed to be significant T1 potential it has not been evaluated at this point.

Note: Potential savings are based on Annex 4: 1985 Delivered Energy Costs.

TABLE 4.3: ENERGY CONSERVATION POTENTIAL - TARGET 2

COMPANY	1984 CONSUMPTION		TARGET 2			INVESTMENT	
	Total		Potential Savings			Cost	Payback
	TJ/a	kKSh/a	TJ/a	%	kKSh/a	kKSh	Yrs
Bamburi Portland Cement Co	3714	199,948	230	5.9	24,913	33425	1.4
B.A.T. Kenya Ltd	21	2,248	(14)	(65.7)	1,772	4424	2.5
Clayworks Ltd	55	854	(0.3)	(0.5)	270	360	1.3
East African Portland Cement Co Ltd	1589	101,899	No Project Identified*				
East African Sugar Industries	2022	3,627	127	6.3	5,854	11718	2.0
Emco Steel Works Ltd	77	7,448	3	3.0	132	375	2.8
Firestone E.A. (1969) Ltd	166	14,481	6	3.5	572	1010	1.8
Kaluworks Ltd	21	2,147	No Project Identified				
Kenya Breweries Ltd	372	29,463	59	15.7	22,837	23642	1.0
Kenya Calcium Products Ltd	106	1,924	11	9.1	179	585	3.0
Kenya Canners Ltd	117	8,971	(24)	(20.9)	10,901	14100	1.3
Kenya Cooperative Creameries	69	4,862	2	2.3	110	150	1.4
Kenya Glass Works Ltd	356	24,585	92	24.6	7,000	9600	1.4
Kenya Meat Commission	207	15,139	(30)	(14.4)	4,404	6490	1.5
Kenyatta National Hospital	98	8,300	No Project Identified				
Madhupaper International Ltd	76	7,722	(99)	(130.0)	2,503	10709	4.3
Magadi Soda Co P.L.C.	577	33,318	27	4.5	1,441	2450	1.7
Oil Extraction Ltd	22	1,644	No Project Identified				
Panafrican Paper Mills (EA) Ltd	2408	158,462	(167)	(6.7)	100,000	114795	1.1
Rift Valley Textiles Ltd	194	16,767	(97)	(50.0)	11,192	16447	1.4
Thika Cloth Mills Ltd	168	13,655	(81)	(47.9)	9,426	9859	1.0
TOTALS/ WEIGHTED AVERAGE	12435	657,464	45	0.4	218,898	260139	1.2

* The Consultants are aware of EAPC studies on conversion to the dry process and kiln firing with coal, however these major projects are beyond the study scope.

Note: Potential savings are based on Annex 4: 1985 Delivered Energy Costs. For sensitivities to movements in energy costs see Chapter 5. NPV and IRR of individual projects are given in Table 5.1.

ANNEX 4.1: DELIVERED ENERGY COSTS AT PLANT IN 1985 - FUEL OIL

AREA	COMPANY	LOCATION	USAGE TJ/a	COST kKSh	PRICE KSh/GJ	AVERAGE KSh/GJ
Athi River	KENYA MEAT COMMISSION	Athi River	217.2	12034	55.42	
	EAST AFRICAN PORTLAND CEMENT LTD	Athi River	1623.6	94274	58.07	57.75
Eldoret	RIFT VALLEY TEXTILE MILLS LTD	Eldoret	160.6	10117	63.01	
	KENYA CO-OPERATIVE CREAMERIES	Kitale	61.3	3654	59.58	
	PAN AFRICAN PAPER MILLS (EA) LTD	Webuye	2378.6	144962	60.94	61.04
Kisumu	EAST AFRICAN SUGAR INDUSTRIES	Muhoroni	15.0	946	63.27	63.27
Magadi	MAGADI SODA COMPANY P.L.C.	Magadi	536.6	28771	53.61	53.61
Mombasa	BAMBURI PORTLAND CEMENT CO.	Mombasa	658.2	34084	51.78	
	KALUWORKS LTD	Mombasa	13.5	732	54.08	
	KENYA GLASS WORKS LTD	Mombasa	302.2	17112	56.62	
	KENYA CALCIUM PRODUCTS LTD	Waa				53.31
Nairobi	BRITISH AMERICAN TOBACCO KENYA LTD	Nairobi	16.3	1037	63.77	
	CLAYWORKS LTD	Nairobi	4.3	276	64.04	
	EMCO STEEL WORKS LTD	Nairobi	51.1	2691	52.62	
	FIRESTONE EAST AFRICA LTD	Nairobi	135.7	9535	70.26	
	KENYA BREWERIES LTD	Nairobi	409.7	24618	60.08	
	KENYATTA NATIONAL HOSPITAL	Nairobi	137.4	8465	61.60	
	MADHUPAPER INTERNATIONAL LTD	Nairobi	77.6	5066	65.30	
	OIL EXTRACTION LTD	Nairobi	29.4	1936	65.80	62.24
Thika	KENYA CANNERS LTD	Thika	184.5	11085	60.08	
	THIKA CLOTH MILLS LTD	Thika	150.4	8942	59.44	59.79
	TOTALS/AVG/WEIGHTED AVG		7163.34	420337	59.97	58.68

ANNEX 4.2 : DELIVERED ENERGY COSTS AT PLANT IN 1985 - ELECTRICITY

AREA	COMPANY	LOCATION	USAGE TJ/a	COST kKSh	PRICE KSh/GJ	AVERAGE KSh/GJ
Athi River	KENYA MEAT COMMISSION	Athi River	26.3	5300	201.66	
	EAST AFRICAN PORTLAND CEMENT LTD	Athi River	99.0	18419	186.11	189.37
Eldoret	RIFT VALLEY TEXTILE MILLS LTD	Eldoret	45.6	7445	163.35	
	KENYA CO-OPERATIVE CREAMERIES	Kitale	12.0	1464	121.88	
	PAN AFRICAN PAPER MILLS (EA) LTD	Webuye	126.0	19401	154.02	154.23
Kisumu	EAST AFRICAN SUGAR INDUSTRIES	Muhoroni	5.7	1130	196.99	196.99
Magadi	MAGADI SODA COMPANY P.L.C.	Magadi	I/G	I/G	0.00	0.00
Mombasa	BAMBURI PORTLAND CEMENT CO.	Mombasa	362.5	57286	158.02	
	KALUWORKS LTD	Mombasa	6.5	1248	192.12	
	KENYA GLASS WORKS LTD	Mombasa	36.0	5665	157.25	
	KENYA CALCIUM PRODUCTS LTD	Waa	0.6	177	277.86	158.69
Nairobi	BRITISH AMERICAN TOBACCO KENYA LTD	Nairobi	8.3	1691	204.13	
	CLAYWORKS LTD	Nairobi	3.1	636	207.23	
	EMCO STEEL WORKS LTD	Nairobi	32.0	5622	175.48	
	FIRESTONE EAST AFRICA LTD	Nairobi	37.2	5498	147.67	
	KENYA BREWERIES LTD	Nairobi	81.8	13303	162.62	
	KENYATTA NATIONAL HOSPITAL	Nairobi	22.6	3750	166.08	
	MADHUPAPER INTERNATIONAL LTD	Nairobi	30.3	5356	176.64	
	OIL EXTRACTION LTD	Nairobi	0.9	261	279.74	167.01
Thika	KENYA CANNERS LTD	Thika	27.9	4869	174.80	
	THIKA CLOTH MILLS LTD	Thika	40.4	6354	157.09	164.31
	TOTALS/AVG/WEIGHTED AVG		1004.78	164875	174.32	164.09

Note: 'IG' indicates internal generation of electricity (using other fuel source)

ANNEX 4.3: DELIVERED ENERGY COSTS AT PLANT IN 1985 - FUELWOOD

AREA	COMPANY	LOCATION	USAGE TJ/a	COST kKSh	PRICE KSh/GJ	AVERAGE KSh/GJ
Athi River	KENYA MEAT COMMISSION	Athi River				
	EAST AFRICAN PORTLAND CEMENT LTD	Athi River				
Eldoret	RIFT VALLEY TEXTILE MILLS LTD	Eldoret				
	KENYA CO-OPERATIVE CREAMERIES	Kitale				
	PAN AFRICAN PAPER MILLS (EA) LTD	Webuye				
Kisumu	EAST AFRICAN SUGAR INDUSTRIES	Muhoroni	98.6	1331	13.49	13.49
Magadi	MAGADI SODA COMPANY P.L.C.	Magadi				
Mombasa	BAMBURI PORTLAND CEMENT CO.	Mombasa				
	KALUWORKS LTD	Mombasa				
	KENYA GLASS WORKS LTD	Mombasa				
	KENYA CALCIUM PRODUCTS LTD	Waa	114.3	1949	17.05	17.05
Nairobi	BRITISH AMERICAN TOBACCO KENYA LTD	Nairobi				
	CLAYWORKS LTD	Nairobi	53.8	71.0	1.32	1.32
	EMCO STEEL WORKS LTD	Nairobi				
	FIRESTONE EAST AFRICA LTD	Nairobi				
	KENYA BREWERIES LTD	Nairobi				
	KENYATTA NATIONAL HOSPITAL	Nairobi				
	MADHUPAPER INTERNATIONAL LTD	Nairobi				
	OIL EXTRACTION LTD	Nairobi				
Thika	KENYA CANNERS LTD	Thika				
	THIKA CLOTH MILLS LTD	Thika				
	TOTALS/AVG/WEIGHTED AVG		266.72	3551	10.62	12.56

Note: 'FUELWOOD' data for CLAYWORKS is for coffee husks

5. FUNDABLE PROJECTS

5.1 Introduction

Following the meetings held in Nairobi with the World Bank and the MOERD at the end of September 1985, the terms of reference were extended to include identification and reporting upon Fundable Projects.

The field work phase of the energy audits had indicated, by that stage of the project, that significant energy conservation and fuel substitution potential existed, much of which would, however, rely upon major engineering and capital inputs, i.e. the prerequisites of Target 2 Projects. Recognising that it would be necessary to have a strategy in place to provide the appropriate engineering and capital funding of such projects, the Consultants were asked to proceed sufficiently far with prefeasibility studies to establish an approximate order of capital cost, return on capital and outline engineering definition.

All Target 2 Projects require some level of investment: some may conserve more energy than could be achieved under the Target 1 programme, while others may serve the economic needs of the country by substituting an indigenous fuel for fuel oil without necessarily achieving any further saving in energy. Both types of Target 2 Projects, however, add to the profit of the company concerned, and both reduce dependence on imported fuel oil, to the net benefit of Kenya.

5.2 Methodology for Initial Financial Analysis

In order to achieve the Target 2 (T2) level of energy intensity in any industry or plant it is necessary, as defined in Chapter 4, to make investments in one or more capital projects. Such projects may be mutually exclusive, or independent of one another. Each of the 21 individual Energy Audit Reports includes a chapter which first defines and evaluates those T2 projects which might reasonably be considered, and then selects for short listing those which represent, at least on the information available, solutions which appear likely upon preliminary analysis to meet the investment criteria set by the World Bank.

The methodology adopted for the initial financial analysis of T2 projects was as follows:

- Conduct energy audit, analyse audit data, take account of site observations, and make recommendations to achieve the Target 1 (T1) level of energy intensity. All T2 Projects are then evaluated on the basis that Target 1 has already been achieved.

- Define individual projects and carry out only sufficient preliminary engineering and thermodynamics to establish leading project parameters.

- Prepare preliminary and indicative capital cost estimates, having in mind maximising local Kenyan manufacture and the use of Kenyan resources, but making due allowance for import duty and foreign exchange premiums on overseas supply and for engineering and contingencies.

- Prepare operating cost savings estimates, based on 1985 delivered energy costs (Annex 4) and quantities for the energy sources and conversion processes relevant to the project. Make due allowance in the cost streams for depreciation and investment benefits, having in mind ruling rates of taxation and other allowances and for any additional staff which may be required.

- Having estimated project cash flows over 10 years, carry out discounted cash flow (DCF) analysis using a 15% after tax discount factor. This analysis takes account of capital investment incentives including the taxation benefit of the depreciation allowance (which in many cases has a significant influence on project financial viability). The analysis develops, for each project, the net present value (NPV). If the NPV is positive, then the project IRR meets or exceeds the hurdle criterion for a rate of return of 15% after tax set by the World Bank for short listing. The analysis also determines the simple payback period (in years) and the internal rate of return (IRR) after tax, which are generally accepted methods for financial evaluation of investment projects in the private sector. Each of these parameters for each project identified is listed in the summary, Table 5.1.

- Prepare Project Feasibility Data Sheet, giving outline project particulars, approximate investment levels, target energy savings, simple payback time and IRR, and approximate project programme. These data sheets are included in each of the individual Energy Audit Reports.

Notwithstanding the relative rigour of the foregoing methodology, project evaluation was strictly to prefeasibility level only based on energy costs observed during the 1985 field audits. Should it be decided to proceed with one or more of the short listed projects, then more rigorous engineering, financial and economic evaluation to full feasibility level, complete with sensitivity analysis, is essential before any commitment of project funds. Cost estimates and DCF worksheets are retained on the Consultants' files.

5.3 Projects Identified

Each of the individual Energy Audit Reports includes a more detailed recommendation on Fundable Projects based on the initial financial analysis. Technical proposals including cost estimates, cash flows and rates of return were prepared as described in the preceding section. Table 5.1 sets out a summary of all identified fundable projects which would be recommended at energy prices ruling at the time of the fieldwork in 1985.

The total capital cost of all projects which satisfied the criteria established in the preceding section amounts to some MKSh 260 (M$US 15.3) . The average paybacks on the individual T2 investments making up this total are generally between one and two years.

In identifying the short list of preferred projects believed worthy of further analysis to full feasibility level, some 120 projects were initially examined, some of which had up to 3 or 4 mutually exclusive alternatives, each of which required study.

A number of these failed to meet the Target 2 investment criterion of greater than 15% real rate of return. Others were rejected as appearing to represent the less attractive alternative where mutually exclusive projects were competing. Lastly, and subsequent to the preparation of the audit reports where the projects are described, advice was received that recent government policy on the use of fuelwood in industry would preclude the further consideration of fuelwood conversion projects in major urban and peri-urban areas, notably around Nairobi and Mombasa.

Some of the projects short listed after initial financial analysis involve substitution from imported fuel oil to indigenous fuelwood, utilising recently developed, but simple, high efficiency combustion technology. In those plants utilising both steam and electricity, it was found in many instances worthwhile to commend internal cogeneration using a back pressure steam turbine or steam engine driving a generator to provide steam for process needs plus the electricity which can economically be generated. In some circumstances adequate electricity generating potential exists to permit export to the grid, while in others the opportunity exists to export steam. Particulars of the combustion systems and cogeneration schemes proposed are given in some detail in the individual Energy Audit Reports. Additional details on small scale (100 to 200 kW) schemes are given in Chapter 6 of the companion report Kenya: Energy Efficiency in the Tea Industry.

The use of fuelwood in Kenya, although seemingly attractive at 1985 delivered prices, is, however, subject to some important institutional and technological barriers. It has been emphasised in every individual Energy Audit Report that any plant which hopes to adopt indigenous fuel, either as fuelwood or biomass residue, must first ensure that long term supplies are secure as to availability and price. Furthermore any plant proceeding to a fuelwood conversion should retain the capability of firing fuel oil. Not only would this provide essential security but it would also enable the consumer to have some safeguard against adverse movements in fuel prices by always retaining the substitution option. This aspect is discussed in considerably more depth in the companion report Kenya: Energy Efficiency in the Tea Industry.

TABLE 5.1

SUMMARY OF INITIAL FINANCIAL ANALYSIS OF T2 PROJECTS

PROJECT	TITLE	CAPITAL kKsh	PAYBACK YEARS	IRR %	NPV kKSh
Bamburi Portland Cement Co. Ltd					
1.	Extend precalcination time for RK1	7000	1.2	59.77	12270
2.	Waste heat boilers on clinker coolers drive t/a set	25425	1.9	38.55	21673
3.	Steam heat RFO using waste heat 1/	50	0.3	NA	497
4.	Eliminate RFO from rotary kilns 1/	1000	0.2	NA	13804
	Sub-total	33425			
British American Tobacco (Kenya) Ltd					
1.	Boiler conversion to burn fuelwood	1424	2.3	28.50	696
2.	Burn tobacco waste	0	NA	NA	253
3a.	Electricity and steam cogeneration (no export) 1/	3000	2.8	21.25	672
3b.	Electricity and steam cogeneration (with export) 1/	3000	2.5	24.60	1055
	Sub-total	4424			
Clayworks Limited					
1.	Replace heat exchanger RFO firing with coffee husks	360	1.3	51.19	501
East African Portland Cement Co. Ltd					
	No T2 projects				
East African Sugar Industries-Muhoroni Factory					
1&2	Retrofit cyclonic combustors to boilers 1&2 Update boiler 3 furnace control	7480	3.1	23.50	2105
3.	Install t/a set in ACFC line	4238	1.3	49.39	6169
	Sub-total	11718			

1/ Mutually exclusive. Preferred projects only included in sub-total.

PROJECT	TITLE	CAPITAL kKsh	PAYBACK YEARS	IRR %	NPV kKSh
Emco Steelworks Limited					
1.	Billet soaking pit and recuperator 1/	1707	3.6	19.48	245
2.	Billet soaking pit 1/	318	2.8	26.26	116
3.	RFO preheater	57	3.2	22.85	15
	Sub-total	375			
Firestone East Africa (1969) Ltd					
1.	Boiler oxygen trim	800	2.7	25.41	338
2.	Recover heat of refrigeration	210	1.6	44.18	228
	Sub-total	1010			
Kaluworks Limited					
	No T2 projects				
Kenya Breweries Limited					
1.	Boiler conversion to burn biomass residue	6912	0.5	NA	30129
2.	Electricity and steam cogeneration	16730	1.6	38.82	15722
	Sub-total	23642			
Kenya Calcium Products					
1.	Fluidised bed combustor	585	3.0	23.30	162
Kenya Canners Limited					
1.	Cyclonic combustor fitted to RFO boiler to burn biomass residue	8000	1.9	38.32	6747
2.	Heat of refrigeration preheat boiler feed water	100	1.5	45.17	121
3a.	Electricity and steam cogeneration (burn RFO) 1/	6000	5.6	5.93	-1912
3b.	Electricity and steam cogeneration (burn wood) 1/	6000	0.9		1671
	Sub-total	14100			

1/ Mutually exclusive. Preferred projects only included in sub-total.

PROJECT	TITLE	CAPITAL kKsh	PAYBACK YEARS	IRR %	NPV kKSh
Kenya Co-operative Creameries Limited					
1.	Boiler conversion to fuelwood 2/	2318	1.0	65.41	4882
2.	Recover heat of refrigeration	150	1.4	51.92	212
	Sub-total	150			
Kenya Glass Works Ltd					
1.	Rebuild furnace and upgrade combustion controls	3900	1.1	49.12	6214
2.	Waster heat boiler and turbo-alternator set	5500	2.0	28.90	3306
3.	Oxygen trim fitted to furnace	200	0.3	NA	2046
	Sub-total	9600			
Kenya Meat Commission Athi River					
1.	Boiler conversion to fuelwood 2/	2967	0.4	86.07	15096
2.	Electricity and steam cogeneration	6390	1.5	48.47	8073
3.	Recover heat of refrigeration	100	1.7	43.21	104
	Sub-total	6490			
Kenyatta National Hospital					
	No T2 projects				
Madhupaper International Ltd					
1.	Boiler conversion to fuelwood 2/	1484	0.6	99.21	5499
2.	Electricity and steam cogeneration	10709	4.3	14.42	-202
	Sub-total	10709			
Magadi Soda Co PLC					
1.	Preheat combustion air	900	1.2	58.90	1543
2.	Improve combustion efficiency	1250	2.2	33.60	821
3.	Waste heat to preheat RFO	300	2.4	30.97	167
	Sub-total	2450			

2/ Project eliminated following advice received from MOERD that fuelwood would not be made available for these projects which are then excluded from the sub-totals.

PROJECT	TITLE	CAPITAL kKsh	PAYBACK YEARS	IRR %	NPV kKSh
<u>Oil Extraction Limited</u>					
1.	Boiler conversion to fuelwood 2/	1348	1.3	51.52	1960
<u>Pan African Paper Mills (EA) Limited</u>					
1.	Extend biomass burning	102120	1.0	66.68	211997
2.	Extend electricity and steam cogeneration	12675	2.5	25.58	4868
	Sub-total	114795			
<u>Rift Valley Textile Mills Ltd</u>					
1.	Boiler conversion to fuelwood	3561	0.5	NA	16284
2.	Electricity and steam cogeneration	12180	2.5	25.30	4612
3.	Thermic heater fuel substitution	706	0.7	89.25	2183
	Sub-total	16447			
<u>Thika Cloth Mills Ltd</u>					
1.	Boiler conversion to biomass residue	3949	0.7	85.64	12114
2.	Electricity and steam cogeneration	5625	1.4	45.19	6950
3.	Thermic heater fuel substitution	250	0.5	NA	1243
4	Jet dryer heat recovery	35	0.7	89.31	108
	Sub-total	9859			
	TOTAL	260,139			

2/ Project eliminated following advice received from MOERD that fuelwood would not be made available for these projects which are then excluded from the sub-totals.

5.4 Sensitivity Testing

5.4.1 Background

It was anticipated at the outset of the programme that the justification for any nominated projects would depend upon the level of fuel savings resulting from their proposed investments, and hence would be sensitive to changes in fuel prices. In order to ensure the soundness of any recommended investments it was therefore envisaged that sensitivity testing would be completed for an appropriate range of prices. This range, for both financial and economic prices believed appropriate for conditions ruling in 1986, and for the immediate years ahead, is developed in Section 5.4.2 hereunder.

For the T1 projects this was not necessary since they involved limited investment to produce very substantial benefits for the organisations concerned, and for Kenya as a whole - with any changes in fuel prices simply varying the magnitude of the saving which might be expected. In view of the investment requirements for the T2 projects, however, these needed to be checked to see whether or not they remained viable under varying energy prices; and the requirement for sensitivity testing to complete these assessments became especially important when oil prices changed so dramatically between 1985 and 1986.

Accordingly sensitivity analysis was applied to the full range of projects identified as promising in 1985 under the prices operating at that time - i.e. those projects referred to in Section 5.3 and summarised in Table 5.1, This clarified the viability of the various projects and at the same time provided a basis for assessing their priorities in the light of preferred price scenarios for the various fuels.

5.4.2 Price Scenarios for Fuels

The price ranges appropriate to use for the sensitivity analyses are considered for each of the fuels in turn.

5.4.2.1 Residual Fuel Oil

While Kenya's refinery continues to be operated as in 1985 the effect of any substitution of another fuel for oil would be to release more RFO for sale on the spot market. The economic price of RFO in these circumstances is approximately the return from its sale, as represented by the FOB price at Mombasa less the relatively insignificant cost of its handling at Mombasa, plus the saving in transporting oil to the users.

Prices of fuel oil have been affected by policy changes in Kenya which have held the financial cost well above the market prices outside Kenya as world prices have fallen.

World oil prices are unstable and will continue to have the potential to rise if producers regain control of total output and demand continues to grow, or to fall further while Middle East production costs remain well below current prices and Middle East production capability represents such a significant proportion of world supply. For the time being higher prices benefit only higher cost producers because of production shifts from the Middle East to British, US and other producers. On the other hand lower prices reduce the funds available for development of OPEC competing fields and thus create the conditions for higher prices benefiting OPEC in future.

In this study the base economic prices have been calculated from the FOB value for exported fuel oil which averaged 25 KSh/GJ between July, 1985 and July, 1986. To this needs to be added a foreign exchange loading as well as transport costs which are also foreign exchange loaded. This in fact somewhat undervalues fuel oil in Kenya because the grades used locally are of higher quality than those exported.

After assessment of the various factors influencing future oil prices provision has been made for fuel oil at Mombasa to fall to 20 KSh/GJ and possibly to rise to 50 KSh/GJ. The appropriate loadings are 20% for foreign exchange premium and a further 11KSh/GJ for the economic cost of inland transport.

Economic prices of fuel oil in KSh/GJ are therefore made up as follows:

	FOB Base	Foreign Exchange	Transport	Total
High	50	10	11	71
Base	25	5	11	41
Low	20	4	11	35

Financial prices of fuel oil have been set to reflect existing policy in Kenya. During the audits the average cost of fuel oil reported by Nairobi plants was 62 KSh/GJ. (See Chapter 4, Annex 4.1)

Transport costs to Nairobi from Mombasa are estimated to be 9 KSh/GJ giving a Mombasa cost of 53 KSh/GJ. This is also supported by observations obtained at the audited plants.

Despite substantial falls in world markets there were no substantial reductions in the domestic prices of fuel oil during the first half of 1986.

Since prices in 1985 were at the levels indicated by reasonably high world oil prices there is little argument to raise the high fuel oil price very much above base; while at the low end the figure suggested provides for a potential fall in response to possible falling world prices.

The range for the financial prices of fuel oil in KSh/GJ is accordingly:

	Mombasa	Transport	Nairobi
High	56	9	65
Base	53	9	62
Low	36	9	45

5.4.2.2 Coal

Financial and economic prices have been based upon supplies from world markets as assessed in 1985. The pressure on oil prices is expected to hold prices down, with some variation from low to high potentially, resulting from different sources.

The fuel substitution potential for coal in industry is affected by the preponderance of small oil fired boilers in Kenya, by the small market price differential favouring coal over 180 CST fuel oil (in Nairobi only about 4 KSh/GJ delivered and possibly even less following the sharp down trends in world oil prices), and by the unsuitability of high ash, low volatile coal imported from Swaziland for use in boilers. Survey results in industry do however indicate a reasonably positive attitude to the prospect of substitution from oil to coal, but at the present time there is very little economic incentive, even were there no import duty on coal. Currently the duty is 8% from the Preferential Trade Area of the Eastern and Southern African sub-region member countries and 20% in case of non P.T.A. member countries.

Estimates of the cost of delivering coal to Nairobi were made in 1985 and yielded a figure of approximately 60 KSh/GJ for the financial cost and 62 KSh/GJ for the economic price.

Following these estimates there has been a substantial reduction in oil prices and hence further pressure on coal prices. While the costs of coal mining, shipping and handling have not changed, the market will reduce return on capital and thus prices. To reflect this, base prices have been derived by reducing these figures by 10 KSh/GJ, with low prices a further 10 KSh/GJ lower for both financial and economic prices.

Economic and financial prices for coal are relatively close together because the customs duties which are not included in economic prices act to offset the effect of foreign exchange loadings which have been added into the economic prices of coal.

The ranges for the financial and economic prices of coal in KSh/GJ are accordingly:

	Financial	Economic
High	60	62
Base	50	52
Low	40	42

5.4.2.3 Electricity

Electricity supplies in Kenya are unusual in their reliance upon hydro and geothermal generation for base load and thermal generation for peak and emergency standby requirements. Electricity is also imported from Uganda. Tariffs are based on five year capital investment plans and demand projections.

Electricity prices will depend on future investment costs in hydro, geothermal and transmission system developments. For the purposes of this report electricity prices are assumed to rise in real terms as they have done in recent years, reflecting a policy shift towards the generation of reserves for system development and other purposes. Current policy for tariff design is to recover the costs of present day installed capacity and development projects from present day consumers rather than by servicing the debt over the long term from future customers.

Estimated financial prices have been developed as follows:

- The low financial price of electricity of 147 KSh/GJ is the 1985 tariff for 11kV supply.
- The base financial price of 164 KSh/GJ is the weighted average cost of all electricity used by audited plants in 1985.
- Given the expectation of an electrical energy shortage in Kenya in the period 1987-88 until the Kiambere hydroelectric power station is scheduled to come on stream, electricity tariffs will rise as growing demands are met from thermal power. For this reason the existing tariff has been escalated by 40% to give a high financial price of 206 KSh/GJ. (Tariff proposals in 1985 called for increases of an average of 12 cents per unit (kWh) in 1985 and 9 cents per unit each year up to 1990. The large industry tariff for energy was 51 cents per unit in 1985 and would increase to 64 cents in that year and to KSh 1.09 by 1990. This is a 214% increase).

Economic prices of electricity are affected by the considerably higher costs of more recently identified geothermal and hydroelectric projects, and by the large import component in the capital costs of generating and transmission equipment. Economic prices have been based on estimates of future system development costs in Kenya, allowing for a foreign exchange component of 20%.

The ranges of financial and economic prices for electricity in KSh/GJ become as follows:

	Financial	Economic
High	206	425
Base	164	392
Low	147	330

5.4.2.4 Fuelwood

The prices of fuelwood are determined by the expected future prices at the forest roadside and future transport distances to the plant.

It should be noted that proposals to use fuelwood in industry will have a negligible impact on total demand and hence prices in Kenya. Moreover such proposals generally refer to the use of purpose grown plantations of fuelwood; and transport distances should not increase in these cases. However other local users of fuelwood may or may not be growing their own supplies; and for non-growers the price of fuelwood will rise as the source of uncommitted timber becomes more and more distant. As a result industrial plantation timber could be more valuable when sold to local users than when used in industry. The economic cost of using plantation grown timber in industry would then be the value foregone by local households unable to grow their own supplies.

The economic price of fuelwood takes account of the view that wood is being consumed at a faster rate than can be satisfied by forest yield (Beijer, Peri-Urban Fuelwood Study, MOERD). Plantation cost was established at 400 KSh/tonne plus 100 KSh/tonne for the cost of land. Assuming a gross specific energy of 14.2 GJ per tonne this yields a cost of 35.2 KSh/GJ. Of the delivered costs of fuelwood approximately 15% are foreign exchange with an exchange rate loading of 20%. This yields an economic price of 36.3 KSh/tonne which is held constant to reflect the costs of growing trees.

The average financial price at the roadside in 1985 was found during the audits to be 18.31 KSh/GJ with most users of fuelwood collecting it nearby. This figure is felt to be low, as noted earlier in the report, and is expected to increase over ten years to reach the estimated economic price of 36.3 KSh/GJ, with the early period exhibiting relatively fast growth and resulting in a base price of 32.3 KSh/GJ.

Transport distance is also expected to increase as the forest resource adjacent to industry is depleted. In line with these expectations the base distance is set at 10kms while the high price, reflecting that depletion, assumes a haul of 50kms. Accordingly transport costs of 27.6 KSh/GJ (financial) and 31.5 KSh/GJ (economic) for 50 kms have been added for the high estimates, with pro rata amounts for 10 kms being added for the base estimates. These figures are based on estimates of operating costs collected from truck operators in Kenya.

In summary, the prices in KSh/GJ are made up as follows:

	Financial	Economic
High	36.3 + 27.6 = 64.9 (65)	36.3 + 31.5 = 67.8 (68)
Base	32.3 + 5.5 = 37.8 (38)	36.3 + 6.3 = 42.6 (43)
Low	18.3 + 0 = 18.3 (18)	36.3 + 0 = 36.3 (36)

5.4.2.5 Fuel Price Ranges

The price ranges representing the scenarios discussed above are summarised in Table 5.2.

TABLE 5.2

KENYA FUEL PRICE RANGES (at Nairobi)

Fuel	Financial Price	Economic Price
	KSh/GJ	KSh/GJ
Fuel Oil		
- high	65	71
- base	62	41
- low	45	35
Fuelwood		
- high	65	68
- base	38	43
- low	18	36
Electricity		
- high	206	425
- base	164	392
- low	147	330
Coal		
- high	60	62
- base	50	52
- low	40	42

5.4.3 Analysis by Project Category

From a careful review of the T2 investment projects it was seen that they could be grouped into six categories, each category having essentially the same characteristics. These categories covered respectively:

Category 1 Boiler conversion from fuel oil to fuelwood by the fitting of a cyclonic combustor;

Category 2 Boiler conversion from fuel oil to coal by boiler replacement;

Category 3 Wasteheat recovery to produce electricity to substitute for use of purchased electricity within the plant, using a wasteheat boiler and turbo-alternator set;

Category 4 Wasteheat recovery to preheat and so reduce use of fuel oil for heating;

Category 5 Available high pressure steam used to produce electricity and low pressure steam for use within the plant and so reduce purchase of electricity;

Category 6 Efficiency improvements by rebuilding facilities and upgrading furnace controls, thus reducing use of fuel.

5.4.4 Evaluation Procedure

All T2 projects had previously been subjected to financial analysis as a basis for checking their relative importance. This involved specifically the analysis of their internal rate of return, net present value at a 15% discount rate and simple pay-back period.

Representative projects from each of the above categories were then evaluated using three alternative sources of funds. These covered respectively an equity financed cash flow, a debt financed cash flow and a foreign debt financed evaluation. In addition, for each project, using prices selected from the ranges noted in Table 5.2, the breakeven price relationship was established for the principal fuel(s) involved (often between fuel oil and fuelwood). This cross-over analysis then was completed for both economic and financial prices, thereby enabling the viability of each project to be assessed for any forecast fuel price.

Both the economic and financial viabilities would be determining factors influencing Kenyan management and financing bodies to implement these prospective energy improvements, hence all economic and the financial results were subjected to sensitivity analysis to assess each project's viability in the light of forecast prices for the fuels.

It was then possible to identify those projects which appear strongly justified, those whose viability is suspect, and those which are marginal cases and would require more detailed analysis to determine their viability.

5.4.5 Conclusions by Project Category

The findings from this analysis are set out in more detail later in this Chapter. Overall, however, the broad conclusions can be summarised as being:

Category 1 Projects which substitute fuelwood or biomass residue for fuel oil appear well worth pursuing, even with lower oil prices.

Category 2 Investments to substitute coal for fuel oil cannot be justified at the fuel price levels operating and expected.

Category 3 Projects in which available steam is used to supply the electrical requirements of plant appear well justified.

Category 4 Wasteheat recovery to save fuel seems desirable in almost all cases.

Category 5 Fuelwood to produce in-house steam and in-house electricity appears sound economically but tends to be rejected due to the low electricity tariffs applying in Kenya.

Category 6 Added combustion controls appear especially rewarding, while moves to rebuild facilities for greater efficiency are less likely to be warranted.

5.4.6 Priorities for Projects

Project implementation will ultimately depend upon a number of factors including the demands for capital as well as the availability of skills and the impact of other government or lending authority priorities. However, experience has shown that the NPV (net present value) represents an effective criterion for early project evaluation. A positive NPV reflects an annual return of at least 15% real in this analysis, confirms the effective use of resources, and provides a measure of relative priority for that project.

Projects, therefore, have been listed in NPV order in Tables 5.3 et seq with the most attractive projects in each category having the greatest NPV and beginning each category list.

For sensitivity analysis purposes each of the categories was considered in turn, with the cross-over analysis providing price figures at which the NPV's would be reduced to zero (those figures being designated as the "breakeven" prices for the project, i.e. the price(s) at which the project would yield a 15% p.a. real return).

Where two fuels were involved the breakeven relationship between the two was also determined and presented in the form:

"Breakeven" price of Fuel 1 = Constant + Coefficient x Expected price of Fuel 2

This relationship provides a continuous basis for sensitivity testing, enabling the viability of the project to be assessed at any nominated forecast prices for the fuels concerned.

The projects in each list were reviewed against the current and expected prices for fuel oil, fuelwood and/or electricity as appropriate. In general it was seen that those projects with lower NPV's were the most susceptible to falling oil prices or rising fuelwood prices, while the low electricity tariffs current in Kenya had more wide ranging impact.

As already noted, this analysis was designed only to check the attractiveness or otherwise of the projects. Other factors will come into play in determining whether or not to proceed (including the results of more detailed feasibility studies). Very important amongst those factors will be the practicability of implementing a range of projects at the one time. Indeed it may be appropriate to begin with a small selection so as to achieve early success and ensure the sound development of an overall energy programme for Kenya.

It will be seen, however, that even after this sensitivity analysis a significant proportion of the projects continued to demonstrate viability having successfully negotiated these financial and economic hurdles, hence justifying their consideration for funding.

5.4.7 Sensitivity Results for Industry Projects

The following subsections provide the results of the sensitivity analyses, with the projects being grouped within the six categories noted earlier in Section 5.4.3.

Category 1 - Fuel Conversion: Fuel Oil to Fuelwood

The financial results for the eight identified projects in Category 1 are shown on Table 5.3. This lists the breakeven relationships in the form noted above in Section 5.4.6 with, for example, the figures for Pan African Paper Mills being:

Breakeven (=minimum acceptable) oil price =
10.52 + 1.07 (Fuelwood Price)

The table then uses those relationships to compute oil price thresholds below which the projects would not be viable. From this it becomes apparent that financially, at the "base" price or lower for fuelwood, virtually all of the projects with a possible exception of the BAT-Project 1 appear justified. However, should fuelwood prices increase to the high end of the price range, all projects could be in question.

When the economic position is considered there is little difference in the NPV ranking, although two projects result in negative values. However the position becomes more sensitive, requiring relatively high economic prices for oil, especially at higher fuelwood prices.

Overall, however, all projects except possibly BAT-Project 1 and Clayworks appear to justify further analysis with a view to implementation.

Category 2 - Fuel Conversion: Fuel Oil to Coal

Coal conversion was a key element in the initiation of this study. The conversion of a typical boiler to coal was aimed at achieving similar benefits to those obtained with fuelwood.

At Bamburi which is already using coal, coal fuel is viable, especially given the current financial prices of fuel oil in Kenya.

For other plants, however, coal conversion appeared not to be warranted on financial or economic grounds at current or anticipated prices.

Category 3 - Wasteheat Boiler and Turbo Alternator

This category of project is aimed at reducing purchases of electricity. The project is independent of buyback agreements and depends only on the capacity of the plant to use self-generated electricity.

From Table 5.5 it will be seen that the financial case for the three principal projects (excluding the EA Sugar option without the export of electricity) are very strongly supported, with the breakeven price for electricity being around 50% or less of current tariffs, only requiring 65-94 KSh/GJ to achieve zero NPV.

The economic position is also very strong, with all four projects requiring electricity prices well below the economic level of 330 KSh/GJ.

The implication is that other co-generation projects in Kenya could also be warranted on financial and economic grounds.

Category 4 - Wasteheat Recovery to Save Fuel

This type of project characterises one of the simplest of the fuel conservation opportunities.

From the financial picture represented in Table 5.6 it can be seen that all the projects would be readily justified under the current financial price position for oil in Kenya and that they should continue to remain successful in the future. All have relatively low breakeven prices for oil, generally being in the 10-30 KSh/GJ range.

The economic evaluation also strongly supports these Category 4 projects with two exceptions. The EMCO RFO preheater project requires a rather high oil price and may need to be considered carefully. The Bamburi project to use waste heat for the steam heating of RFO appears non viable (and in any case is less preferred than the mutually exclusive coal substitution project in Category 2).

Category 5 - Co-generation from Fuelwood or Fuel Oil

In this type of project, biomass is used to generate internally used electricity and steam. The efficiency is low and the capital cost can often include significant imported components.

The economic case set out in Table 5.7 (b) appears strong for the first five of these projects, plus the two mutually exclusive projects at BAT.

However, with the low electricity tariffs in Kenya, only the top three projects continue to reflect financial viability, having thresholds of around 150 KSh/GJ or less. The remaining four would perhaps be regarded as marginal under present tariff policies.

Because of their economic strength it could be appropriate for funds to be made available for such projects, even where their financial position may be marginal.

Category 6 - Efficiency Improvements

A range of different projects grouped in this category were all found to be strong contenders for implementation. As shown in Tables 5.8 (a) and (b), both the financial and economic cases are well proven, with only the economic case for Firestone requiring careful review - the breakeven prices for the most part being very significantly below the prevailing prices and those forecast for the time horizon to 1995.

TABLE 5.3: CATEGORY 1 - FUEL CONVERSIONS FROM FUEL OIL TO FUELWOOD/BIOMASS RESIDUE

Prices in KSh/GJ

(a) Financial Evaluation

Enterprise	Net Present Value k KSh	Breakeven Constant	Locus Co-efficient	At expected wood price of 18	38	65
				Project is warranted if expected oil prices exceed the price below		
Panafrican Paper	211,997	10.52	1.07	30	51	80
Kenya Breweries	30,129	6.50	1.06	27	47	75
Rift Valley Textiles	16,284	6.05	1.06	26	46	75
Thika Cloth Mills	12,114	7.79	1.06	27	48	77
Kenya Canners Ltd	6,747	17.67	1.06	37	58	87
BAT - Project 1 (fuelwood)	696	27.10	1.07	46	68	97
Clayworks Ltd	501	20.51	1.06	40	61	89
BAT - Project 2 (tobacco)	253	wood breakeven	16.97 KSh/GJ			

(b) Economic Evaluation

Enterprise	Net Present Value k KSh	Breakeven Constant	Locus Co-efficient	At expected wood price of 36	43	68
				Project is warranted if expected oil prices exceed the price below		
Panafrican Paper	123,783	11.18	1.07	50	57	84
Kenya Breweries	21,409	6.73	1.06	45	52	79
Rift Valley Textiles	10,254	7.65	1.06	46	53	80
Thika Cloth Mills	7,575	9.88	1.06	48	56	82
Kenya Canners Ltd	8,913	44.86	1.06	83	91	117
BAT - Project 1 (fuelwood)	-608	34.28	1.07	73	80	107
Clayworks Ltd	-52	26.56	1.06	65	72	99
BAT - Project 2 (tobacco)	253 wood breakeven 16.97 KSh/GJ					

TABLE 5.4: CATEGORY 2 - FUEL CONVERSIONS FROM FUEL OIL TO COAL

Prices in KSh/GJ

(a) Financial Evaluation

Enterprise	Net Present Value k KSh	Breakeven Constant	Locus Co-efficient	At expected coal price of 40	50	60
				Project is warranted if expected oil prices exceed the price below		
Bamburi Portland Cement	13,804	0.44	1.00	40	50	60

(b) Economic Evaluation

Enterprise	Net Present Value k KSh	Breakeven Constant	Locus Co-efficient	At expected coal price of 42	52	62
				Project is warranted if expected oil prices exceed the price below		
Bamburi Portland Cement	13,804	0.62	1.00	43	53	63

TABLE 5.5: CATEGORY 3 - WASTEHEAT BOILER AND TURBO ALTERNATOR

(a) Financial Evaluation

Enterprise	Net Present Value kKSh	Breakeven Electricity KSh/GJ
Bamburi Portland Cement	21,673	66.11
EA Sugar Industries *	6,169	64.78
Kenya Glass	3,306	94.13
EA Sugar Industries **	298	179.31

* Electricity exported at import tariff rate

** Same project without electricity export

(b) Economic Evaluation

Enterprise	Net Present Value kKSh	Breakeven Electricity KSh/GJ
Bamburi Portland Cement	79,616	107.60
EA Sugar Industries *	17,379	84.66
Kenya Glass	15,343	116.13
EA Sugar Industries **	2,448	234.36

* Electricity exported at import tariff rate

** Same project without electricity export

TABLE 5.6: CATEGORY 4 - RECOVER WASTEHEAT TO SAVE FUEL OIL OR FUELWOOD

(a) Financial Evaluation

Enterprise	Net Present Value kKSh	Breakeven Oil KSh/GJ
Bamburi Portland Cement, Project 1	12,270	10.75
Magadi Soda Co., Project 1	1,543	14.13
Bamburi Portland Cement, Project 3	497	2.97
Firestone East Africa Ltd	228	25.30
Kenya Co-op Creameries	212	5.15 *
Magadi Soda Co, Project 3	167	29.97
Kenya Canners Ltd	121	20.30
Emco Steelworks Ltd, Project 2	116	42.91
Thika Cloth Mills	108	9.98
Kenya Meat Commission	104	20.63
Emco Steelworks Ltd, Project 3	15	36.62

* Fuelwood - assumes conversion. Benefits greater if not converted

(b) Economic Evaluation

Enterprise	Net Present Value kKSh	Breakeven Oil KSh/GJ
Bamburi Portland Cement, Project 1	23,904	22.54
Magadi Soda Co, Project 1	2,945	19.96
Bamburi Portland Cement, Project 3		
Firestone East Africa Ltd	201	35.92
Kenya Co-op Creameries	1,486	7.20 *
Magadi Soda Co, project 3	219	39.84
Kenya Canners Ltd	155	28.65
Emco Steelworks Ltd, Project 2	147	45.88
Thika Cloth Mills	159	13.73
Kenya Meat Commission	150	28.88
Emco Steelworks Ltd, Project 3	13	52.79

* Wood fuel - assumes conversion. Benefits greater if not converted.

TABLE 5.7: CATEGORY 5 - ELECTRICITY AND STEAM CO-GENERATION FROM FUELWOOD OR FUEL OIL

Prices in KSh/GJ

(a) Financial Evaluation

Enterprise	Net Present Value k KSh	Breakeven Constant	Locus Co-efficient	At expected fuel price of: Fuelwood 18 / ** Fuel Oil 45	Fuelwood 38 / ** Fuel Oil 62	Fuelwood 65 / ** Fuel Oil 65
				Project is warranted if expected electricity prices exceed the price below		
Kenya Breweries	15,722	64.294	0.99	82	102	129
Kenya Meat Commission	8,073	58.07	1.41	83	112	150
Thika Cloth Mills	6,950	40.69	2.91	93	151	230
Pan African Paper	4,868	26.68	6.67	147	280	460
Rift Valley Textiles	4,612	74.66	2.98	128	188	268
Kenya Canners, Project 3b	1,671	105.36	1.96	141	180	233
Kenya Canners, Project 3a	-1,912	105.33	1.84 **	188	219	225
BAT (no export)	672	137.88	2.82	189	245	321
BAT (export)	1,055	108.73	2.60	156	208	278
Madhupaper International	- 202	35.60	8.60	190	362	595

** Fuel oil used

(b) Economic Evaluation

Enterprise	Net Present Value k KSh	Breakeven Constant	Locus Co-efficient	At expected fuel price of: Fuelwood 36 / ** Fuel Oil 35	Fuelwood 43 / ** Fuel Oil 41	Fuelwood 68 / ** Fuel Oil 71
				Project is warranted if expected electricity prices exceed the price below		
Kenya Breweries	62,829	79.84	0.99	116	123	147
Kenya Meat Commission	12,212	147.46	1.31	195	204	237
Thika Cloth Mills	27,589	50.24	2.91	155	175	248
Pan African Paper	29,899	33.36	6.67	273	320	487
Rift Valley Textiles	23,982	92.59	2.98	200	221	295
Kenya Canners, Project 3b	-1,493	230.65	1.96	351	365	414
Kenya Canners, Project 3a	-4,564	280.63	1.84 **	345	356	411
BAT (no export)	2,368	146.20	2.82	248	268	338
BAT (export)	3,184	134.61	2.60	228	246	311
Madhupaper International	-17,463	314.89	8.59	624	684	899

** Fuel oil used

TABLE 5.8: CATEGORY 6 - EFFICIENCY IMPROVEMENTS AND OTHER SUBSTITUTIONS

Prices in KSh/GJ

(a) Financial Evaluation

Enterprise	Net Present Value k KSh	Breakeven Constant	Locus Co-efficient	At expected fuel oil price of 45	62	65
				Project is warranted if expected I.D. oil prices exceed the price below		
Kenya Glass Works Ltd (Project 1)	6,214	Oil B/E *19.08				
Rift Valley Textiles	2,183	14.39	1.00	59	76	79
EA Sugar Industries	2,105	Wood B/E *13.74				
Kenya Glass Works Ltd (Project 3)	2,046	Oil B/E *4.13				
Thika Cloth Mills	1,243	4.62	1.00	50	67	70
Magadi Soda Co	821	Oil B/E *25.88				
Firestone East Africa Ltd	338	Oil B/E *41.58				
Kenya Calcium Products	162	Wood B/E *11.87				

* B/E = Breakeven price

(b) Economic Evaluation

Enterprise	Net Present Value k KSh	Breakeven Constant	Locus Co-efficient	At expected fuel oil price of 35	41	71
				Project is warranted if expected I.D. oil prices exceed the price below		
Kenya Glass Works Ltd (Project 1)	3,369	Oil B/E *19.08				
Rift Valley Textiles	1,264	20.16	1.00	55	61	91
EA Sugar Industries	8,403	Wood B/E *19.42				
Kenya Glass Works Ltd (Project 3)	7,468	Oil B/E *18.22				
Thika Cloth Mills	2,084	6.57	1.00	42	48	78
Magadi Soda Co	1,143	Oil B/E *36/57				
Firestone East Africa Ltd	57	Oil B/E *58.81				
Kenya Calcium Products	663	Wood B/E *16.16				

* B/E = Breakeven price

5.5 Implementation of Recommended Projects

Some of the organisations for which fundable projects have been identified would probably be able to carry out their own project management and engineering, but this would be unlikely for all 21 of the companies audited. It is not practical to leave each individual organisation to undertake the fundable projects on its own. The engineering and management skills are not equally available for all organisations in Kenya. In many cases the projects themselves, while not unduly complicated, are little known in Kenya except where provided under turnkey packages by suppliers who, all too often on completion of their work, retain negligible engineering presence or support facilities in Kenya. Clearly this is not an acceptable scenario; a number of instances of plant suppliers/contractors providing unsatisfactory port-commissioning support were identified. Furthermore, and more importantly, there is significant cross fertilisation of technology between a number of the fundable projects; this potential synergy should not be overlooked.

Accordingly, it is believed that the success of the Fundable Projects Programme may, in some instances, depend upon the addition of expatriate project management and engineering skills to work with Kenyan engineers to ensure that the appropriate technologies and experience are made available, and at the same time with the proviso that such overseas experience is transferred to Kenyan engineers as an investment in longer term national technology development.

In order to address adequately the vital issue of technology transfer it is proposed that a Fundable Project Group be formed within an appropriate Kenyan institution. It would be headed by an experienced Project Manager with a knowledge of the projects to be conducted, and with the requisite skills in financial and programme control, conditions of contract, procurement, site management and the like. The project management arrangements proposed would follow normal arrangements for small projects conducted using multi lateral sources of finance, but with the added complication of a considerably wider variety of clients and sites.

With such a Fundable Projects Group, established under the Kenya Industrial Energy Management Programme (Chapter 6) and using, desirably, counterpart engineers under training, it is probable that a substantial amount of the design, specification and procurement work could be undertaken and controlled from within Kenya by Kenyan nationals and Kenyan engineering organisations. This should certainly apply to site works, civil and structural engineering design and construction, and all mechanical and electrical services. Nevertheless specialist mechanical and electrical plant design and procurement work should be subcontracted to expatriate consulting organisations experienced in the technologies and with the ability to work them up from feasibility stage through to full demonstration projects. Such overseas organisations should, however, work wherever possible in close association with Kenyan engineering organisations.

Projects would be widely publicised and the results made available to all Kenyan industrialists. The object of the Fundable Projects Programme would be to catalyse energy conserving investment activity and to ensure that the relevant technology is transferred into the Kenyan engineering community in such a way that ongoing projects could, in time, be fully designed, engineered, and managed by Kenyan engineers and financed from Kenyan resources.

6. KENYA ENERGY MANAGEMENT PROGRAMME

6.1 Introduction

The Activity Initiation Brief for the project required the Consultants to define an Energy Demand Management Programme for Kenya.

As outlined in the earlier Chapters, there is a strong case for industrial energy management in Kenya, with scope for achieving significant results if steps are taken to overcome the psychological and other barriers outlined in Section 3.6.

However, industrial energy conservation in Kenya is relatively new - with one of the needs being, through a range of initiatives including this study itself, to heighten awareness and encourage the Government and industry towards the considerable rewards of energy conservation. In this connection the substantial efforts by the World Bank, the MOERD and others will need to be maintained for many years yet. It is therefore important to identify in this report the possible ongoing phases of progression towards full adoption nationally of good energy management practices. These 'phases' are in no sense clearcut steps related to any programme; rather they broadly define the elements of what could constitute a long term national plan.

Phase 1 Heightening of awareness at Government and industry management level using publicity, seminars and workshops. This phase is well under way under the leadership of the MOERD.

Phase 2 Preliminary audits, first aid actions and the commencement of management interest. Publishing of case studies to further heighten national interest. This phase has already been addressed by MOERD, and considerably added to by the Coal and Tea Energy Efficiency Studies.

Phase 3 Formal establishment of a Kenya Industrial Energy Management Programme, with firm commitment on the target savings from various industries. This phase has just started, in association with the Kenya Association of Manufacturers.

Phase 4 Fully management supported approaches to energy auditing in industry.

Phase 5 Implementation of energy conservation recommendations (fundable projects) which meet company investment criteria, both short and long term. Publication of more sophisticated case studies emphasising financial benefits.

Phase 6 Realisation of increasing profit and numerous associated benefits such as reduced maintenance, better working conditions, better product and environmental control, better management information, etc. in existing plants.

Phase 7 Establishment of demonstration projects and new plants, properly energy engineered and operated, not as the exception but as the rule.

For Kenya, Phases 1, 2, and 3 have begun well under the guidance and overview of the Kenyan MOERD. With appropriate policy setting the full scenario could be well in place by the early 90's, with increased levels of energy saving investment and of associated management and engineering training (recognising that notwithstanding the short term movements in oil prices, relative energy costs are likely to continue to grow, providing continuing economic justification at the corporate and national level for energy management).

An end objective is to have energy management regarded as an integral and normal part of general management, with energy reporting regarded as part of normal company reporting.

Following the award of the Contract for the Kenya Coal Conversion Action Plan to the Consultants, the Kenya/Canada Energy Advisory Project was also set up, and was responsible to the Planning Division of the Ministry of Energy and Regional Development to develop, inter alia, a Kenya Energy Management Programme (KEMP). Accordingly, this Chapter discusses elements of such a programme which the Consultants believe should be considered for inclusion in any strategy for the industrial sector. It is emphasised that the Consultants' proposals are put forward with a view to their being integrated into the overall Kenyan energy management strategy being developed by the Canadian Team.

It is clear that the Kenya (or National) Energy Management Programme (KEMP) will, in time, be developed to cover the needs of the five principal energy consuming sectors of the economy:

- Industrial
- Domestic
- Commercial
- Transport
- Agricultural

This report is limited to consideration of the industrial sector only, but several of the following proposals and action programmes, particularly those bearing upon incentives, training, demonstration and publicity, will be found to have relevance to all energy sectors. At the present time it is understood that the MOERD is concentrating on the energy intensive industrial and transport sectors, although as resources become available it is likely that the other sectors will be brought into the programme.

6.2 Management of the Kenya Energy Management Programme

6.2.1 Policy and Management

Before discussing the detailed content and function of the various sub-programmes, it is first necessary to consider the overall mechanisms necessary to set energy policy guidelines, as discussed in Chapter 3, and to supervise, control, monitor and develop the overall programme, and to ensure that it has effective executive powers.

It is accordingly proposed that the programme continue to develop and operate within the Ministry of Energy and Regional Development, using the existing executive powers entrusted to the Minister of Energy and Regional Development. These powers prescribe its authority, responsibilities, lines of accountability, and financing arrangements.

6.2.2 Policy Guidance - The Ministerial Energy Planning Committee

This important and vital Committee, which has been set up and is already working within the ambit of the MOERD, has the wide representation necessary to assist in formulating policy advice to the Minister for the KEMP. Its representation includes, in addition to the chairmanship, technical support and secretariat provided by the MOERD, the following bodies as and when required:

- Ministry of Finance
- Ministry of Planning and National Development
- Ministry of Commerce and Industry
- Ministry of Education, Science and Technology
- Ministry of Transport and Communications
- Ministry of Agriculture and Livestock Development
- Kenya Association of Manufacturers
- National Council of Science and Technology

The Committee's mandate is essentially to monitor and review various energy policy issues, programmes and projects, and to carry out any necessary changes as and when required. The Committee meets formally two or three times a year, and provides advice to the Minister upon all areas within its competence.

The MOERD must clearly continue to be the focal point for the national energy conservation effort, and as such must have as its primary responsibility the management and administration of the Kenya Energy Management Programme which includes, inter alia, the Kenya Industrial Energy Management Programme (KIEMP) described in the next section. Other programmes, whether existing or future, covering the domestic, commercial, transport and agricultural sectors are not however discussed further.

6.3 Kenya Industrial Energy Management Programme

The Kenya Industrial Energy Management Programme (KIEMP) was set up following the successful MOERD Workshop entitled "Commitment and Profit" and held on 5, 6 and 7 November 1985 in Mombasa. Management of KIEMP has been understandably been entrusted to the Kenya Association of Manufacturers (KAM) which has, from its members, the incentive and skills, given strong MOERD support, to undertake this task. Already a Steering Committee and five industrial sub-sector energy committees have been set up, with the secretariat and all necessary support infrastructure provided by KAM.

The sub-sector energy committees set up and working by the middle of 1986 were:

- Food and Beverages
- Textiles
- Wood, Pulp and Paper
- Chemical
- Plastics
- Tea

Further sub-sector energy committees will be formed to cover the balance of the overall industrial sector as the needs are identified and resources become available.

No nationally driven industrial energy management programme, however enthusiastic its individual members, can of itself save energy by its very presence. Fundamentally it must be a major exercise in raising awareness. Awareness may be raised or enhanced by promoting an understanding of energy conservation technologies, strengthening incentives necessary for their adoption and replication throughout industry. The elements of th programme will include:

- Training
- Seminars and workshops
- Consultant support schemes
- External consultant assistance
- Energy research projects
- Demonstration projects
- Establishing industry energy conservation targets in each sub-sector (Database)
- Award schemes
- Publicity via media outlets (press, television, radio)
- Technical publications
- Peer group conservation successes published (case studies)
- Commercial competition

Each of these elements is relevant to the proposed Kenya Industrial Energy Management Programme and many are already in hand within the MOERD. The Consultants commend the efforts made to date and recommend that they be supported and enhanced.

Each of the elements, which are discussed below, will require appropriate formulation, funding and administrative infrastructure. Maximum use will continue to be made of existing MOERD staff and functions working in association with the KAM; however positive identification of the proposals will heighten both the visibility and awareness of the GOK's growing efforts in the field of industrial energy management.

6.3.1 Industrial Energy Training

Training in the specific fields of energy management and related technologies is fundamental. Training, however, can take many forms and be addressed at many levels. There is no single simple solution.

Rather there is a hierarchy of solutions whose elements, and the levels at which they are relevant, may include but not be limited to the following; the target community being shown in brackets:

- Doctorate courses, both at home and overseas in thermodynamics, fuel technology, combustion, power and control engineering. (Post Graduates)
- Degree courses in the above areas. (Undergraduates)
- Technical college diplomas in the above areas, with the emphasis more on practical skills and applications. (Technical Officers and Trainees)
- General short courses, aimed specifically at Energy Manager and Foreman level, to develop particular and relevant skills in energy auditing, fuel technology, fuel preparation and handling, combustion, steam systems, electrical and control systems, lighting, maximum demand and power factor control, energy accounting, simple project economic evaluation, and the like. (Junior to Middle Management)
- Technical short courses, covering fundamentals of combustion control, steam systems, electrical systems and the like. (Plant Operating Staff)
- Seminars, which are case study oriented and designed to heighten management awareness of the financial benefits of energy conservation, and also the further development and analysis of fundable projects in energy conservation. (Middle to Senior Management)

All such initiatives would be coordinated by an appropriate officer of MOERD, possibly entitled Energy Training Officer. As the programme develops it is expected that this would be a new appointment.It is very good to note that several of the above initiatives are already in hand; the Consultants again commend these efforts and recommend that they be progressively supported and enhanced.

6.3.2 Industrial Energy Audit Programme

6.3.2.1 Objectives and Methodology

The Kenya Industrial Energy Audit Programme, now operating under the Planning Division of MOERD on small scale, should be strengthened to provide more widely the essential initial encouragement, support and technical guidance to companies and organisations wishing to set up energy management programmes. The Energy Audit Programme would approach these goals by:

- Conducting a continuing series of energy audits in Kenyan industry in the manner established by the Consultants;
- Providing follow-up for implementation until such time that adequate national capacity has been developed;

- Supporting and aiding as necessary the achievement of identified Target 1 and Target 2 energy intensities in audited industries (as now recorded in the Industrial Energy Utilisation Database for audited plants - Refer Appendix C and each individual Energy Audit Report).

- Establishing sector energy intensity targets based on nationally obtained data (as now recorded in the Industrial Energy Utilisation Database - refer Appendix C);

- Explaining to those audited and to others the national need for and financial benefits of good energy management;

- Promoting awareness of the opportunity areas for energy conservation (Refer for example, to technical appendices on steam systems, maximum demand control, power factor correction and lighting which appear in every individual Energy Audit Report;

- Pointing out the profitability of investing in energy saving techniques and equipment, particularly equipment for measurement and control;

- Providing information and practical assistance on more sophisticated energy management techniques;

- Seeking a commitment to better energy use in all areas of industrial enterprise.

To a large extent the Consultants have themselves already contributed to achievement of some of the above goals in the preparation of this report, the companion report on Energy Efficiency in the Tea Industry, and in all of the 40 individual Energy Audit Reports.

<u>6.3.2.2 Use of Energy Management Consultants</u>

The Kenya Industrial Energy Audit Programme would be an important field component of the Kenya Industrial Energy Management Programme. It would be devised to encourage industrial organisations to employ consultants, with the aim of reducing their energy consumption and therefore costs, and also with the aim of developing a locally based competent consultant community with energy management and auditing skills.

The MOERD would provide listing advice on energy management consultants qualified to carry out audits, although any such list maintained by MOERD would not imply any endorsement of the technical competence or suitability of any particular firm. Responsibility must always remain with the purchaser of any service for the selection of a consultant appropriate to, and with the necessary skills in, the plant and associated energy technology required.

It is believed that this programme, which is unlikely to prove particularly costly, should provide a catalyst for the development in Kenya of competent firms of energy management consultants.

6.3.2.3 Energy Audit Unit

At the present time it has to be recognised that a locally based energy management consultant community, with competence in conducting industrial energy audits, does not really exist in Kenya, although individual skills and skilled individuals are undoubtedly available. Accordingly it is proposed that, within the MOERD, an Energy Audit Unit be set up. The Consultants suggest it should be headed by the Energy Audit Unit Manager, and initially be staffed by say up to four Officers drawn as far as possible from the existing MOERD establishment. The Unit would include trained economists, engineers and technicians with experience in fuels, combustion and the energy consuming and converting mechanical and electrical plant typically found in industry. Initially expatriate candidates, suitably trained and experienced in industrial energy audit techniques and dedicated to training and technology transfer, might be recruited, possibly under an overseas aid programme.

The Unit would be equipped with all the instrumentation, measurement and auditing techniques used by the Consultants. As part of its monitoring functions, it would carry out yearly energy audits, or otherwise on demand, of each of the 21 enterprises already audited by the Consultants, reporting on progress made in a manner comparable to the model Energy Audit Reports. The Unit would also be available, on request, to carry out Energy Audits in any other plant making the request. To a large extent the Energy Audit Unit would be built upon the manpower and facilities existing at present in the MOERD, although external and perhaps, in the early years, expatriate industrial experience must also be sought. One possible scenario to this end is a scheme for the secondment of promising young engineers in the private sector to the Unit for say one or two years before returning to their own company.

The Energy Audit will clearly require additional funding provision, although the existing MOERD management, administrative support, transport facilities and some of the necessary audit instrumentation are already available. An approximate budget is likely to be as follows:

Unit Manager	- Salary	200 000 KSh/a
	- Overheads (75%)	150 000 KSh/a
Unit Engineers/ Economists (6)	- Salaries	160 000 KSh/a
	- Overheads (75%)	660 000 KSh/a
Instrumentation,	say	120 000 KSh
TOTAL FOR FIRST YEAR		2,090 000 KSh

As noted above, some or all of the estimated costs could possibly be supported, at least in the early years, under an overseas aid programme.

It is proposed that the audit service be provided by MOERD to customers at a fee set to recover the major part of the direct costs and expenses of the service provided. If this were not to be the case, then it would be unreasonable to expect that a private energy management consultant community could be established. The purpose of the Energy Audit Unit would be, as its first objective, to guide every factory towards achievement of its Target 1 savings, providing all necessary engineering advice to the purchasing departments and such supervision, project management support and guidance as necessary. As it gained experience, it would progress, again with external or expatriate assistance as required, to support and encourage the implementation of Target 2 projects and savings.

The Energy Audit Unit would be regarded as a catalyst or 'pump primer' for the creation of private sector consultants. In the longer term it is hoped that the initiative taken will sponsor the development of a healthy private sector team of Energy Management Consultants.

6.3.2.4 Industrial Energy Managers

Every company audited, and progressively all other energy users, should be encouraged to designate an Energy Manager, ideally from within the organisation itself, to set up its own Energy Management Programme. It is expected that the Energy Manager would, in most companies, be an existing member of the organisation, chosen for the task from the standpoint of suitability for the job. Indeed is likely that the Energy Manager's responsibility may reasonably be added to those of say the existing Works Manager, Plant Engineer or Maintenance Engineer, depending upon the staffing structure and resources of the company concerned.

With the development of the Industrial Energy Utilisation Database, and the bi-annual Energy Survey returns, not only will individual Energy Managers be able to have their performance monitored, but improvements will be quickly recognised by MOERD. Conversely, lapses in performance or failure to achieve identified Target 1 performance would, it is hoped, lead to positive support and action from the Energy Audit Unit.

6.3.2.5 Industrial Energy Utilisation Database and Energy Usage Surveys

The MOERD should continue to conduct its bi-annual (and in time preferably annual) energy usage survey for the purposes, inter alia, of raising awareness and of updating and reinforcing the Database prepared by the Consultants for this purpose. (Refer Appendix C). While based on the existing MOERD database, established from the 1981 and 1983 surveys, the Appendix C Database embodies a number of improvements. In using internationally accepted SI (Systeme Internationale) energy units (GJ and TJ) rather than physical units (litres, tonnes, toe, tce, etc), the data are consistently handled at national level. More importantly, the essential parameter of "energy intensity" i.e. energy per unit of output, typically GJ/t, has been included. This helps define Targets 1 and 2 for each organisation and each industry (ISIC) grouping.

While it is often postulated that works in the energy field should use units other than SI, for reasons of preceived familiarity, that is a short-sighted view. Most of the responsible literature on energy management is now clearly expressed in SI units, and virtually all international energy agencies use SI. In due course the index of energy usage per unit of constant GDP, an index which is used quite widely in industrialised countries, should be developed to monitor the effectiveness of energy management at the national level.

6.3.3 Industrial Energy Demonstration Projects

The demonstration programme is a logical extension of the fundable projects programme covered in Chapter 5. It is beyond the scope of this report to suggest how funding for demonstration projects is to be arranged. However, a number of appropriate models exist in other industrialised countries. Demonstration projects which are truly visible and well publicised are a most important element in the energy sector of any industrial community, as is well evidenced by the success of such projects in the United Kingdom, Canada and Australia, to name but three countries with established demonstration programmes.

In return for some degree of external funding and technical support the owner of the demonstration project would make available controlled access to the project, both to its technological and its financial features. The demonstration project could well be, for example, a cogeneration project (an area of particular interest in Kenya) or a fuelwood substitution project. Demonstration projects already exist informally in Kenya, for example the most interesting coffee husk combustion installations at East African Industries and East African Packaging Industries.

The objective of the demonstration programme is to ensure that scarce technological skills, some possibly imported from overseas, are visible to the widest possible market and so encourage technology transfer and project replication throughout industry. It would be naive to suggest that such visibility would itself immediately generate a wealth of engineering expertise, but it certainly acts to heighten awareness as to the prospects and potential of demonstrated technologies by making them available to all who have an interest. The Consultants have found that Kenya has a substantial engineering capability, both in design and manufacture, which can well be harnessed to and encouraged by the demonstration programme.

In time, it is hoped that the demonstration programme might be expanded to become a research, development and demonstration programme.

6.3.4 Industrial Energy Awards

Energy awards have been most successful in many countries which have set up national energy management programmes. Each year award entry forms are made available by the sponsoring organisation, in Kenya the MOERD, for an annual award in a number of categories. These categories might include:

- Industry
- Small Business
- Public Institutions
- Transport

Entries are submitted by a closing date to a review panel which judges them on aspects such as cost effectiveness, imagination, publicity potential, total savings, imported fuel substitution, relevance to other businesses, etc. Award criteria could be readily made available if such a programme were to be favoured.

The great value of the programme, which would run in parallel with all other elements of the Industrial Energy Management Programme, is that it gives the opportunity, say once per year, to have a full scale meeting and public presentation of award winners at a national level. Such functions are typically combined with speeches and presentations from the Minister and senior Ministry officials concerned, senior public servants, and leading business personalities. They are generally attended by all finalists and by invitees from the media. The peer group pressures generated and the positive and valuable publicity arising are particularly effective means of raising awareness.

Experience in other countries shows that winners of awards have used the honour effectively, both to enhance their own business' profile and to encourage others towards similar aspirations.

6.3.5 Industrial Energy Publications

Publicity and the publication of technical information is to a large extent embodied in each one of the foregoing recommendations. All publications, however, need to be well coordinated and issued as an overall planned and managed programme.

The Ministries responsible for energy in most of the industrialised countries issue ranges of excellent booklets dealing with energy utilisation and conservation in a wide variety of industries and processes. It is suggested that for Kenya such booklets and other publicity and informative material be developed, over a period of time, suitable for the national industry groups or sub-sectors, but that initially the maximum use be made of publications available from other countries. These would be coordinated and drawn together for Kenyan conditions within the MOERD. Outside assistance would be strongly encouraged, to say from the Kenya Association of Manufacturers or outside consultancy assistance if required, to ensure that each energy management booklet was suitably prepared and edited for use in Kenya within each industry group or sub-sector.

Attention is drawn particularly to the excellent publications of, amongst others, the United Kingdom, Canadian, and Australian Departments of Energy.

7. COAL CONVERSION

7.1 Potential for Coal Conversion

7.1.1 Introduction

The Kenya Coal Conversion Action Plan, by its name, inferred a coal substitution potential for fuel oil in Kenya. However, during the early months of the project, it was perceived by the World Bank, the Kenya Ministry of Energy and Regional Development, and the Consultants that limited opportunity existed for such substitution, and the emphasis was changed to a study of energy conservation and indigenous fuel substitution. The Consultants were requested to give an opinion of the capacity of the existing facilities to handle potential coal volumes.

7.1.2 Coal Resources

Around 110,000 to 130,000 t/a of Swaziland coal at 23.5 GJ/t is currently used by Bamburi Portland Cement in Mombasa. This is the only coal now used in Kenya. It is relatively cheap, but unsuitable for use in small boilers due to its low volatiles (14%), or in kilns and furnaces where product contamination is important. The source of supply is subject to interruption.

Thermal or steaming coal, typically around 28 GJ/t and 25% - 30% volatiles could be delivered from Australia, India, Canada or the U.S.A. However, shipments would necessarily be small and, for the foreseeable future, would be received over Bamburi's Mbaraki Wharf.

7.1.3 Coal Prices

Refer to Chapter 3 and to Appendix D - Supplies and Prices of Fuels. In summary: Coal imported to Kenya in 1985 was subject to import duty at the rate of 8 percent for coal sourced in the Preferential Trade Area (PTA) of Eastern and Southern African countries and 20 percent for other sources. Swaziland coal benefits from the PTA concession. CIF prices at Mombasa in 1985 for Swaziland coal were $US50/t ex duty, $US54/t with duty. Thermal coal prices (CIF Mombasa) would be expected to have had 1985 prices of $US55/t and $US66/t respectively.

In energy terms, the estimated 1985 Nairobi price ranges (including transport costs from Mombasa) for fuel oil and coal can be compared thus:

Fuel Oil	55 - 70 KSh/GJ
Coal (Swazi)	55 - 60 KSh/GJ
Thermal Coal	55 - 60 KSh/GJ

7.1.4 Substitution Potential for Coal in Industry

Analysis shows that the estimated 1985 delivered price of thermal coal in energy cost terms (KSh/GJ) is unlikely to provide a sufficient economic incentive to Kenyan industry to substitute coal for fuel oil for steam raising. Coal fired boilers and associated plant are considerably more costly than the equivalent rating of fuel oil or biomass boilers. A substantial energy price advantage, not now evident, would have to exist to drive any change to coal use in industry or power generation.

The drop in international crude oil prices in 1986, although not passed on to the Kenyan market, further negates any commercial advantage which might have been held by coal.

Conversion from fuel oil at East African Portland Cement (EAPC) at Athi River using Swazi coal is, however, likely to occur in time, but the project also would include the important prior energy conservation step of changing from the now little used energy intensive wet process to the dry process as at Bamburi. Detailed technical and economic studies have been carried out by EAPC's consultants, but it should be demonstrated that a more assured market for EAPC cement exists before any commitment is made to a major change to the use of coal in cement manufacture at that plant.

7.1.5 Substitution Potential for Coal in Power Generation

The development of Kenya's power generation system will continue to be based upon exploitation of the significant hydro and geothermal resources of the nation. However the long term planning of Kenya Power and Lighting Company Ltd (KPLC) includes a possible coal fired thermal plant at Mombasa. Two sets each of 60 MW are envisaged; and current planning suggests that the first set might be operational in the period 1995-2000, and the second at some later time as dictated by load growth and hydro and geothermal developments. Assuming an average 45% - 50% capacity factor, an ultimate coal demand of some 250,000 tpa is suggested; and this figure has been taken for the purposes of assessing possible coal handling requirements at the end of the study time frame of 1995.

The construction of a new coal fired power station, however, is thought likely to proceed only if and when the Dongo Kundu harbour development takes place, or if existing wharf capacity and developed land is made available. Both these possibilities appear unlikely before 1995.

In any event, coal fired power stations are not ideally suited for mid to low merit (peaking) duty. Given that there is significant identified hydro and geothermal potential in Kenya, and import hydro potential from Uganda, it seems likely that thermal power generation will be for low merit purposes (system peaks and plant or transmission system failures) or for drought years when hydro cannot meet all its planned load. Modern gas turbine plant (either open or combined cycle) is relatively cheap to install and well suited to peaking duty. The same is true of modern medium speed diesel engines which, though initially more expensive than gas turbines (though far cheaper than coal fired stations), are highly efficient and can burn low grade oil fuels.

Industrial cogeneration too has its place, although it is unlikely to make a significant impact on the national level.

At this time, and at present landed fuel costs, coal fired power generation appears unlikely within the time frame of this study.

7.1.6 Substitution Potential for Coal in Other Sectors

There is no potential market in non-industrial sectors at present energy price differentials. This situation could change in the future if pressure on charcoal forces substantial price rises.

7.1.7 Conclusion

It is seen therefore that, apart from possible use in the cement industry, there is little or no potential for the conversion from existing fuels to coal as a source of energy. However, in the sections of this chapter which follow, the Consultants have reported briefly on the effect on the import and handling facilities at the port of Mombasa and on the Kenyan railway system, should the quantity of imported coal for whatever reason increase above the current 120,000 t/a.

7.2 Existing Coal Receival Facilities

As reported in Section 7.1, the only importer of coal into Kenya in 1985 was the Bamburi Portland Cement Co. Ltd. of Mombasa, which uses low volatile high ash coal currently imported from Swaziland. In 1984-85 coal was imported at the rate of approximately 120,000 t/a.

The coal is delivered in lots of 18,000t as back loading from the port of Maputo in Mozambique in the same ships used by Bamburi for delivery of bagged cement and clinker to their Indian Ocean customers. These ships are unloaded at either of the two berths at the Mbaraki complex in the Kilindini Harbour section of the Port of Mombasa. Coal is unloaded by grabs worked by the ship's gear dropping into a small hopper on the wharf whence trucks are loaded. The coal is temporarily stockpiled on the high level area behind the cement silos and is transferred to the Bamburi Plant by truck as quickly as possible.

A shipload of 18,000t of coal is usually unloaded in 3-1/2 days, working round the clock, or at an average rate at 215 tph.

7.3 Growth Projections

7.3.1 Industrial Energy

As noted in Appendix B, the demand for energy in industry is projected to increase at about 7.2% per annum or by 100% to 1995.

7.3.2 Port and Railways Traffic

7.3.2.1 Sources

For purposes of assessing the effects of coal importation on port and rail operations at 1995, the following sources were used:-

- National Transport Plan (JICS - August 1984)

  Clause 2.2.3 - Annual export and import growth rates of 4% are projected.

  Section 3.2 - Growth in land transport of 4.8% per annum is projected. However, without major investment in the railways, the capacity at the rail systems may be limited to 150% of the existing traffic.

- Dravo-Van Houten Report (Mombasa Port Expansion)

  Page 2.5 - Dry bulk cargoes are forecast to increase 8.1% per annum. Projections relating to specific products from this Report are referred to in the text.

7.3.2.2 Growth Rates Adopted

. Port Traffic

The handling of dry bulk cargoes can be expected to increase annually at a faster rate than the handling of all cargos represented by the JICS National Transport Plan figure of 4%. The Dravo-Van Houten figure of 8.1% is seen as being too optimistic, being based in part on the establishment of new industries in the Dongo Kundu area, however the Consultants have had no indication that the area will be developed in the foreseeable future.

A growth of dry bulk port traffic of 7.2% per annum or 100% to 1995 has been adopted, the same figure as has been projected for the demand for energy increase in industry (see 7.3.1.).

. Rail Traffic

The projected growth and limitation given by Section 3.2 of the JICS National Transport Plan has been accepted.

7.4 Projected Demand for Coal at 1995

7.4.1 General

The demand projections discussed below consist of the following three elements:

- Coal for Cement Production,

- Steaming (Thermal) Coal for Industry,
- Steaming Coal for a Thermal Power Station at Mombasa.

As instructed by the World Bank Mission on September 26th, 1985. possible demand for coal for domestic consumption has not been evaluated.

The following projections of demand cannot be precise, their purpose being to permit site selection and preliminary layout of the port, storage, and transportation facilities required for the various conditions.

7.4.2 Coal for Cement Production

7.4.2.1 Coal Type

Coal for this application is low volatile high ash and is thus considered separately from the steaming coals.

7.4.2.2 Bamburi Cement Co.

For Bamburi Cement, 1995 consumption would be the present figure of 120,000 tpa plus 100%, adopted as 240,000 t/a.

7.4.2.3 East African Portland Cement

Possible coal consumption by the Athi River Cement factory must be considered with regard to both the conversion from the wet to the dry process and conversion from oil to coal. The Energy Audit Report indicates that the plant currently uses 38,000 t/a of fuel oil. Assuming that the wet process requires 75% more energy that the dry process, conversion from wet to dry could be expected to reduce energy consumption to 22,000 t/a of oil.

Using energy contents of 42.9 and 23.5 GJ/t for fuel oil and low volatile coal respectively, conversion from oil to coal in 1995 would involve a demand for 40,200 t/a of coal, which would increase to 80,400 t/a after the demand growth of 100% to 1995, adopted at 80,000 t/pa.

7.4.2.4 Projected Maximum Demand at 1995

The projected demand for coal for cement production at 1995 has therefore been adopted as 320,000 t/a.

7.4.3 Steaming (Thermal) Coal for Industry

7.4.3.1 Energy Content

The calorific value of thermal coal is taken as typically 28 GJ/t.

7.4.3.2 Fuel Oil Consumption

Utilisation of fuel oil within Kenya in 1984 was:-

Item	Sector	'000t	Source
1	Commercial		
1a	Power Generation	52	(i)
1b	Other Commercial	72	(i)
2	Industrial		
2a	Tea Industry	25	(ii) (iii) (iv)
2b	Mining & Natural Resources	13	(i) (iv)
2c	Other Industry	196	(i)
3	Transport	42	(i)
4	Agriculture	12	(i)
5	Exports		
5a	Ships Bunkers	145	(i)
5b	Exports & Surplus	166	(i) (v)
6	TOTAL	725	(i)
7	From Kenya Petroleum Refineries Limited	767	(v)

Sources

(i) Ministry of Energy Tables entitled
- Energy Supply/Demand Balance 1984, and
- Oil Industry Sales Volumes, Jan - Dec 1984

(ii) Activity Initiation Brief - Energy Efficiency in the Tea Industry July 85, Clause 1.4

(iii) Energy Audits executed in response to (ii) above

(iv) Energy Use in Kenya Industry - 1983 by Ministry of Energy

(v) "Some Facts and Figures for Jan-Dec 1984 Operations" supplied by Kenya Petroleum Refineries Limited.

The difference of 6% between the totals derived from sources (i) and (v) is considered to be within the order of accuracy of the available data.

7.4.3.3 Conversion from Fuel Oil to Coal

. Introduction

Given the relative economic realities of fuel oil and coal consumption in Kenya, identified elsewhere in this report, it is recognised that it is unlikely that further conversion to coal will occur in the foreseeable future with the possible exception of EAPC at Athi River.

However, to present an action plan for the infrastructure requirements should a conversion programme ever eventuate, it is necessary for possible levels of future coal conversion to be identified.

Two levels of Coal Conversion are postulated and are denoted as the "Upper Limit of Coal Conversion" and the "Possible Extent of Coal Conversion".

. Upper Limit of Coal Conversion

Purely for the sake of examining the capacity of the infrastructure to cope with the greatest burden of coal importation which could be postulated, it is assumed under this scenario that most industrial fuel consumers and the most significant commercial consumers convert to coal.

Referring to the fuel oil consumption figures of the table contained in Section 7.4.3.2 :-

Item 1(a) Power Generation

See Section 7.4.4.

Item 1(b) Other Commercial

This item was not itemised in detail in source (i), though tourism (presumably hotel boilers - 3000t) and the Kenyatta National Hospital (3000t) are identified as possible candidates for conversion to coal.

Upper limit of possible convertible fuel oil consumption has been taken as 10,000 t/a.

Item 2(a) Tea Industry

If all factories converted, fuel oil replaced would be 25,000 t/a. This is highly unlikely as the only conversion would be to fuelwood or other biomass, not coal, and hence it has not been included in the coal usage calculations.

Item 2(b) Mining and Natural Resources

This sector consumes 13,000 t/a of fuel oil. As this is principally used by Magadi Soda, whose plant is unsuited to direct coal conversion due to contamination of the product, this item also has not been included in the coal usage calculations.

Item 2(c) Other Industry

Upper limit of fuel oil replacement has been taken as 190,000 t/a.

Total fuel oil consumption which could possibly be converted to coal is therefore 200,000 t/a which equates to 300,000 t/a of coal which would increase to 600,000 t/a after adding the demand growth of 100% to 1995.

The upper limit of possible consumption of steaming or thermal coal in Kenya's industry at 1995 has been taken to be 600,000 t/a.

. Possible Extent of Coal Conversion

As noted above the Upper Limit of Coal Conversion to approve 600,000 t/a consumption of steaming coal is notional only, being based on the total conversion of Kenya's industry.

Assessment of a more realistic level of possible conversion to coal over the decade to 1995 is highly conjectural, being dependent upon the age of existing factories and boilers and the Kenyan business community's perceptions of future trends in Kenya's economic health and, most significantly, on relative world prices for competing fuels.

To permit examination of the capacity of the infrastructure to handle likely levels of coal importation, the coal consumption figure for Possible Extent of Coal Conversion has been reduced to 200,000 t/a.

7.4.4 Steaming Coal for Thermal Power Station at Mombasa

Construction of coal-fired power station at Mombasa has been put forward as a long term option in various reports, 120MW being mentioned as a possible capacity.

Feasibility of construction of such a station before 1995 appears to be most improbable, given that hydro stations at Kiambere (140 MW) and Turkwell Gorge (110 MW) are scheduled for completion by 1988 and 1992 respectively. Even allowing for the possible supply at minimum cost to Kenya of some major items of thermal power station equipment from New South Wales, Australia, and transmission losses to Mombasa, these hydro stations would offer cheaper power than could be supplied from the coal-fired station. It must also be noted that the system operated during 1984 (a drought year) with only a minimal contribution from the existing 110 MW capacity oil-fired station at Kipevu, Mombasa. It must be assumed that, if the system's performance had been seen as being significantly unsatisfactory, greater efforts would have been made to return more of Kipevu's generating sets to operational condition.

However, for the sake of identifying the maximum possible demand for steaming coal, it can be assumed that a 120 MW power station would require coal imports at 250,000 t/a. Although such quantities would not be required before 1995, should the station proceed in accordance with current planning, then the port facilities at Mombasa would require to be planned for the full 250,000 t/a.

7.5 Port Facilities

7.5.1 General Requirements

There are no permanent facilities for the handling of imports of bulk materials existing within the port of Mombasa. The General Cargo Berths on Mombasa Island are not available, on a regular basis, for unloading of bulk materials. Imported coal is currently unloaded at Mbaraki by Bamburi Portland Cement Co.

This section of the report examines the feasibility, for the range of levels of coal importation identified, of the utilisation of the existing Mbaraki berths for unloading coal and the construction of permanent bulk unloading facilities for levels of coal importation above the capacity of the Mbaraki berths.

It would be necessary for a permanent bulk imports berth to be adjacent to adequate areas for coal storage, have good access to the road and rail systems, and be adjacent to a suitable site for a coal-fired power station, should future construction of that facility be accepted as a possible option.

7.5.2 Port Working Hours

Kenya Ports Authority advised that the port normally works 16.67 shifts per week. The number of available hours per year has thus been taken as 50 weeks x 16.67 shifts x 8 hours = 6668. 10% was then deducted for idle time due to weather, etc, leaving effective available time of 6000 hrs per annum.

7.5.3 Ship Sizes

7.5.3.1 Maximum Size

The largest ship which can currently enter the Port of Mombasa and use the berths at Mbaraki or possible future berths is 45,000 DWT. A ship of this size would carry approximately 40,000 t of coal.

7.5.3.2 Coal for Cement Production

It is assumed that coal for cement production will continue to be delivered in shipments of 18,000 t and that ships of this size would be equipped with gear suitable for operation of unloading grabs.

7.5.3.3 Steaming (Thermal) Coal

It is assumed that contracts for the supply of steaming (thermal) coal would be arranged utilising the competitive freights offered by the largest possible ships so that this type of coal would be delivered in lots of 40,000 t. Ships of this size would generally not be equipped with gear suitable for the operation of unloading grabs.

7.5.4 Required Stockpile Capacity

7.5.4.1 Criteria

In general, stockpile capacity should be such that the following criteria would be met :

(a) Proportion of Throughput

The minimum capacity of the stockpile should be such that stocks of coal could be built up in anticipation of an interruption of supply.

In the cases of coal for cement production and steaming coal for industrial boilers, the users of the coal should have some facility for storage of coal at their plants. Hence, 8% of annual throughput, or one month's supply, would be a reasonable storage capacity at the port.

The port stockpile area would provide the only storage of coal for the power station and, in this case, storage capacity equal to four months' average requirements or 33.3% of annual throughput would be appropriate.

(b) Relationship to Ship Size

To minimise the risk of ships being delayed while waiting for stockpile space to become available, it is desirable for the stockpile capacity to be at least 50% greater than the capacity of the largest ship to be unloaded.

It would be necessary in this instance to have separate stockpile areas for coal for cement production and for steaming coal so that this criterion must be applied to the total of ship capacities for the two coal types.

7.5.4.2 Derivation of Required Capacities

Required stockpile capacities are derived below for varying levels of coal importation.

(i) <u>Coal for Cement Production Only</u>

	(a)	8% of 320,000	=	25,600 t
or	(b)	1.5 x 18,000	=	27,000 t

<u>ADOPT 30,000 t</u>

(ii) <u>Coal for Cement Production Plus Steaming Coal for Industry at Possible Extent of Coal Conversion</u>

	(a)	8% (320,000 + 200,000)	=	41,600 t
or	(b)	1.5 (18,000 + 40,000)	=	87,000 t

<u>ADOPT 90,000 t</u>

(iii) <u>Coal for Cement Production Plus Steaming Coal for Industry at Upper Limit of Coal Conversion</u>

	(a)	8% (320,000 + 600,000)	=	73,600 t
or	(b)	1.5 (18,000 + 40,000)	=	87,000 t

<u>ADOPT 90,000 t</u>

(iv) <u>Steaming Coal for Industry</u>

	(a)	not more than 8% x 600,000	=	48,000 t
or	(b)	1.5 x 40,000	=	60,000 t

<u>ADOPT 60,000 t</u>

(v) <u>Power Station</u>

(Additional to any of the above options)

	(a)	33.3% of 250,000	=	83,000 t
or	(b)	1.5 x 40,000	=	60,000 t

<u>ADOPT 80,000 t Additional</u>

7.6 Transportation of Coal from the Port

7.6.1 Within Coast Province

No significant potential user of coal within Coast Province other than the Bamburi Cement Co.has been identified, and the requirements for delivery of coal to any other users would be the same as those applying to Bamburi but at a lower order of magnitude. The considerations of this section are therefore confined to Bamburi. The Bamburi Cement plant is not served by rail so that all transportation to and from that plant is by road.

Traffic to and from Mbaraki generated by Bamburi in 1984 consisted of 130,000t of bagged cement, 60,000t of clinker exports and 120,000t of coal imports. By 1995 it is projected that traffic to and from Mbaraki generated by Bamburi would consist of a maximum of 200,000t of bagged cement, 80,000t of cement clinker and 240,000t of coal. This would represent approximately 130 vehicle round trips per day.

This projected doubling of freight volume and the projected number of vehicles is consistent with the forecasts of the JICS National Transport Plan, 1984 - Part IV 3, and the Ministry of Transport has indicated that this traffic volume would be acceptable.

It is therefore assumed that all coal users within Coast Province would be supplied by road transport from any berth used. Rail was not considered a practical option due to higher construction costs for new rail lines which would have little traffic.

7.6.2 From Mombasa to Nairobi

7.6.2.1 Total Quantity to be Transported

The total quantity of coal to be transported up-country from Mombasa could be as follows:

Upper Limit of Coal Conversion:

Coal for Cement Production	80,000 t
Steaming Coal for Industry	600,000 t
Total	680,000 t

Possible Extent of Coal Conversion:

Coal for Cement Production	80,000 t
Steaming Coal for Industry	200,000 t
Total	280,000 t

7.6.2.2 Capacity of Railway

The following assessment of the potential for transport of coal by rail is based on discussions with Kenya Railways.

The limitation of the quantity of coal which would be transported by rail from Mombasa would be set by the capacity of the line from Changamwe to Nairobi rather than by traffic limitations on Mombasa Island or at Kipevu. Kenya Railways would attach main line locos to trains at Mbaraki or Kipevu if full length trains were available at those places.

There are currently 11 freight trains scheduled per day between Mombasa and Nairobi though only 9 are operated. If locos were available, Kenya Railways could operate a maximum of 13 freight trains per day from Mombasa to Nairobi on the existing track. A maximum of 3 trains per day could be devoted to transport of coal.

The maximum gross weight of trains hauled by a single Class 93 loco to Nairobi is 1000t. This could consist of 22 HLB wagons each loaded to struck volume capacity which would equal 30t of coal or a train capacity of 660t.

Should more powerful or double Class 93 locomotives be available in the future, trains of 1400t gross weight or 960t load capacity could be hauled. The wagons for such trains would need to have 40t capacity and be either covered or open with larger volume capacity than those existing. Given that locomotive availability is a major constraint on Kenya Railways' operations, it is not assumed at this stage that trains of this size could be operated.

It is assumed that the maximum quantity of coal which could be transported by rail from Mombasa at 1995 would be 600,000 t/a, consisting of 3 trains each containing 660t of coal on 300 days per year. The Ministry of Transport, Planning Section, has indicated that Kenya Railways would be able to transport the quantities of coal developed above.

However, should the quantity of rail transported coal ever reach this figure it would be because of industrial growth which would be coupled with an increase in volumes of traditional Kenya Railways traffic. Hence, at the very least, rolling stock and locomotives would be required to increase the number of daily freight trains from the current 9 to 10 (11% increase only) plus 3 trains for coal, 13 trains in all.

Using the possible extent of coal conversion figure of 280,000 t/a the coal transport requirements would be 2 trains per day with 1 train on alternate days (1-1/2 trains per day average), i.e. 11-1/2 trains for increased traditional traffic plus coal which is an increase of 28% over the present 9 trains per day. Any further increase in traditional traffic, coupled with the aforementioned coal traffic, would require investment in increased line capacity. While such investments would be justified they would have to be planned sufficiently well in advance. In summary, transport by rail of the higher volumes of coal would be conditional upon significant improvements in operational performance and selective investments to increase line capacity.

7.6.2.3 Capacity of Road Transport

The JICS National Transport Plan, 1984 - Part IV forecasts road freight volume between Mombasa and Nairobi in the year 2000 of at least 4.3 m t/a.

The projected coal transportation of 280,000 t/a corresponding to the possible Extent of Coal Conversion at 1995 represents only 7.5% of the forecast road freight volume. Therefore, if necessary, road transport could make a significant contribution to the transport of coal from Mombasa to Nairobi. The Ministry of Transport, Planning Section, has confirmed this assessment.

At 1985 prices road transport costs would be approximately 75% greater than rail.

7.6.2.4 Conclusion

Given the notional nature of the Upper Limit of Coal Conversion, it is concluded that Kenya Railways would be able to handle all coal required to be transported from Mombasa to Nairobi at 1995 without the need to use more powerful locomotives or larger wagons than those existing.

If necessary, road transport could make a significant contribution to the transportation of coal. However, this is considered a most undesirable option.

7.7 Existing Berths at Mbaraki

7.7.1 Products Other Than Coal

7.7.1.1 General

Materials which are handled over the existing two berths at Mbaraki, apart from the coal for cement production, are bagged cement, cement clinker, fluorspar, molasses and gypsum.

Projections have been made of the quantities of those commodities likely to be handled at 1995, of the probable handling rates, and hence the number of hours per year for which the berths would be likely to be occupied.

7.7.1.2 Bagged Cement

The 1983 Kenya Ports Authority Statistical Bulletin gave exports of bagged cement over the years 1979-1982 as 37,000t, 29,000t, 55,000t and 101,000t respectively. Bamburi Portland Cement advised that 130,000t of bagged cement were exported in 1983 and 1984 and that the envisaged increased in exports could reach a maximum of 200,000 tpa by 1995.

Three conditions have been set for the assessment of the effects of bagged cement on the capacity of the berth for handling coal:-

Condition 1: (Growth in exports)

> As noted above, growth of exports to a level of 200,000 t/a.

Condition 2: (Static exports)

Continuation of exports at the level of 130,000 t/a.

Condition 3: (Reduced exports)

A reduction in the level of exports to 65,000 t/a.

Bamburi advised that the existing bag handling equipment loads the cement at an average rate of 50 tph, hence loading of cement under the three conditions would thus occupy 4000, 2600, and 1300 hrs p.a. respectively.

7.7.1.3 Cement Clinker and Fluorspar

The 1983 Kenya Ports Authority Statistical Bulletin gave exports of cement clinker over the years 1979-1982 as 81,000t, 14,000t, 42,000t and 60,000t respectively and exports of fluorspar as 78,000t, 97,000t, 106,000t and 82,000t respectively. Bamburi Cement has advised that 60,000t of cement clinker were exported in 1983 and again in 1984 and that 54,000t of fluorspar were exported in 1983.

Dravo-Van Houten (Table T4-10) has forecast exports at 1995 of 80,000t of cement clinker and 110,000t of fluorospar. These materials would both be loaded with the Bamburi bulk loader of 185 tph peak capacity. (Dravo-Van Houten Clause 3.3.3 [A]).

Assuming that the average loading rate would be 70% of peak, loading of clinker and fluorspar at 1995 is projected to occupy

$$\frac{(80{,}000 + 110{,}000)}{0.7 \times 185} = 1470 \text{ hrs per annum}$$

7.7.1.4 Molasses

From Dravo-Van Houten (Table T3-4) exports of molasses in the years 1977-1982 have been 41, 38, 65, 79, 107 and 55 thousand tonnes respectively. Projections to 1995 are not given, but 100,000 t/a has been allowed. Assuming a loading rate of 200 tph, the berth requirement would be 500 hrs per annum.

7.7.1.5 Gypsum

Dravo-Van Houten (Table T4-10) forecast imports at 1995 of 25,000t. Assuming that this would be imported with ships gear at 200 tph, the berth requirement would be, say, 130 hrs per annum.

7.7.1.6 Berth Occupancy for Products Other Than Coal

The total number of hours per year at 1995 for which the two existing Mbaraki berths could be expected to be occupied under the three conditions of bagged cement exports would be:

Conditions	Hours per Year		
1 (Growth)	(4000 + 1470 + 500 + 130)	=	6100
2 (Static)	(2600 + 1470 + 500 + 130)	=	4700
3 (Reduction)	(1300 + 1470 + 500 + 130)	=	3400

7.7.2 Target Berth Occupancy Levels

At the berth occupancy levels sought, the range of ship sizes to be handled and the range of rates of loading and unloading for the various ships, it is considered that the application of queuing theory is appropriate.

In the queuing model:- (M/M/C): (FCFS/00/00), the value C (number of "servers") can be taken as 2.0 for the berths as existing because the loading of bagged cement, clinker or fluorspar can take place at either berth while the unloading of coal (with ships gear and possibly some minor additions of equipment to the berths) can take place at the other. Should an unloader be added to the berths, then C would reduce to 1.0 because it would not be possible for the existing loader and new unloader to pass.

The theoretical number of queued ships for these two conditions is:-

Berth Occupancy of each Berth	Theoretical Number of Queued Ships	
	C = 2	C = 1
75%	1.93	2.25
70%	1.34	1.67
65%	0.95	1.21
60%	0.68	0.90
55%	--	0.67

The berths are principally operated by Bamburi Cement Co. so that a high level of management control of the berths could be expected and there would presumably be scope for working additional shifts at critical periods. These factors, tending to improve throughput, could be expected to be more effective when Bamburi's levels of bagged cement exports were high.

Keeping the theoretical number of queued ships less than 1.0, the following target berth occupancy are available:

Bagged Cement	Unloading with Ships Gear (C = 2)		Unloading with Berth-Mounted Loader (C = 1)	
	Target Berth Occupancy	Theoretical Number of Queued Ships	Target Berth Occupancy	Theoretical Number of Queued Ships
1 (Growth)	65%	0.95	60%	0.90
2 (Static)	62.5%	0.82	57.5%	0.79
3 (Reduction)	60%	0.68	55%	0.67

7.7.3 Availability of Berths for Coal Imports

7.7.3.1 Using Ships Gear

The number of hours available at the two existing Mbaraki berths for unloading of coal with ships gear under the three conditions of cement exports would be:

Conditions	Hours per year available for coal imports		
1 (Growth)	(2 x 0.65 x 6000) - 6100	=	1700
2 (Static)	(2 x 0.625 x 6000) - 4700	=	2800
3 (Reduction)	(2 x 0.60 x 6000) - 3400	=	3800

Assuming that the unloading of coal with ship's gear at a handling rate of 215 tph would continue, these available times would permit unloading of 370,000 t/a; 600,000 t/a; and 820,000 t/a respectively.

7.7.3.2 Using a Berth-Mounted Unloader

With a westward extension of the existing berth rails a grab unloader could be mounted on the berth. The structural capacity of the existing berth is such that the size of this machine would be limited, hence a machine of only 400 tph maximum capacity has been allowed in the following assessment.

Should both berths be occupied, it would be necessary for the existing loader to work the east berth (No. 1) while the new unloader worked the west berth (No. 2). This situation corresponds to the single server model allowed in Section 7.7.2.

The number of hours available at the two existing Mbaraki berths for unloading of coal with a berth mounted travelling unloader under the three conditions of cement exports would be:

Conditions	Hours per year available for coal imports		
1 (Growth)	(2 x 0.60 x 6000) - 6100	=	1100
2 (Static)	(2 x 0.575 x 6000) - 4700	=	2200
3 (Reduction)	(2 x 0.55 x 6000) - 3400	=	3200

Assuming that the effective rate of unloading of ships would be 70% of the peak capacity of the unloader, or 280 tph, these available times would permit unloading of 310,000 t/a, 620,000 t/a and 900,000 t/a respectively.

7.7.4 Areas for Stockpile and Power Station at Mbaraki

There is sufficient space on the high level behind the Mbaraki berths for stockpiling of up to 90,000t and for construction of fixed facilities for loading of road trucks and rail wagons.

A conveyor system for transfer of coal from berths to stockpile could readily be installed to reduce costs and losses. The ship unloading rate of 215 tph with ship's gear would probably not increase, the capacity of the ship mounted unloading grabs being critical.

There would not be sufficient space in the Mbaraki area for construction of a coal-fired power station with the associated stockpiles and other facilities.

7.7.5 Utilisation of Existing Berths at Mbaraki - Summary

The throughput capacity of coal at 1995 of the two existing berths at Mbaraki is related to the conditions of bagged cement, as follows:-

(i) Bagged Cement Export Condition 1 (Growth to 200,000 t/a) -

- Capacity for coal importation would be 370,000 t/a, consisting of 320,000 t/a coal for cement production and 50,000 t/a of steaming coal, unloaded with ship's gear.

(ii) Bagged Cement Export Condition 2 (Static at 130,000 t/a) -

Capacity for coal importation would be 620,000 t/a, consisting of:-

- 300,000 t/a of steaming coal unloaded from 45,000 DWT ships with a new berth mounted unloader, and
- 320,000 t/a of coal for cement production unloaded with either ship's gear or the new berth mounted unloader.

(iii) Bagged Cement Export Condition 3 (Reduction to 65,000 t/a) -

- Capacity for coal importation would be up to 900,000 t/a, consisting of up to 580,000 t/a of steaming coal and 320,000 t/a of coal for cement production unloaded as in (ii) above.

Transportation of these annual quantities of coal away from Mbaraki would be as follows:-

- 240,000t of coal for cement production by road to Bamburi.
- 80,000t of coal for cement production by rail to Athi River.
- Up to 520,000t of steaming coal by rail as existing to Nairobi and beyond.

Although the storage area for coal at Mbaraki would be separate from the areas currently used for bagged cement, clinker, fluorspar and molasses (reference Drawing No. 1) a higher level of management control would be necessary. A condition for achieving the higher levels of throughput of steaming coal would clearly be that a greater emphasis than that currently in evidence would have to be given to good operational control of the whole operation. It is noted again that there is not sufficient space at Mbaraki for construction of a coal-fired power station.

7.8 Development of a New Importation Terminal

7.8.1 General

Given the high cost of construction of a new berth, a ship unloading rate of less than 700 tph peak (500 tph average) would not be contemplated for any new terminal. Operation over the effective available time at 6000 h/a derived in Section 7.5.2 would permit an average throughput of up to 3,000,000 t/a, a capacity greatly in excess of the maximum identified coal importation level at 1995.

Inclusion of the cost of construction of such an importation terminal as a capital cost component of the coal handling system would constitute a large penalty against that fuel. The interests of the port as a whole would therefore be best served by construction of a bulk materials unloading berth which could be used for coal, grain or other bulk commodities.

7.8.2 Possible Sites

7.8.2.1 Mbaraki (Drawing No. 1)

A third berth, to the west of the two existing berths, was designed in the 1960s by Bertlin & Partners for ships of 40,000 DWT and a 750 tph ship unloader. This berth has not been constructed.

The Consultants do not consider that a third berth of Mbaraki could be effectively utilised as an importation terminal with a capacity of up to 3.0 m tpa of coal and other bulk materials for the following reasons:-

- There is insufficient area available at Mbaraki for the construction of a coal-fired power station.

- It is improbable that the railway connecting Mbaraki to Changamwe and the road system on Mombasa Island could handle the generated traffic at a rate commensurate with the capacity of the berth itself.

7.8.2.2 Kipevu (Drawing No. 2)

A berth could be constructed to the west of the existing Kipevu oil berth, some dredging being required. The wharf would be approximately 500m offshore with a jetty roadway connecting to the land. A power station could be constructed on the adjacent shore, an area with reasonable foundation conditions and access to cooling water.

Part of the shallow area between the wharf and shore could be filled with dredged spoil and other filling to form the stockpile area. Stockpiles of low height served by rail-mounted stacker and reclaimer would not be adversely affected by the ground settlement which would probably occur in this area.

A rail siding and roadway could be constructed between the Chaani residential area and the Strategic Reserve Oil Tanks. The loading facilities constructed on this rail siding and roadway would be supplied with coal by means of an overland conveyor rising from the stockpile area to the west of the Kenya Petroleum Refineries Limited Tank Farm. The rail siding would connect to the track connecting the Changamwe Marshalling Yard to Berths 11 to 14 and the General Cargo Berths on Mombasa Island and thus give relatively direct access for trains loaded with coal to the rail line connecting Changamwe to Nairobi. The roadway from the truck loading point would have good access to the major roads radiating from the Changamwe Roundabout.

There is probably space available in the area between Chaani and the Strategic Reserve Oil Tanks for construction of storage for grain or any other imported bulk materials.

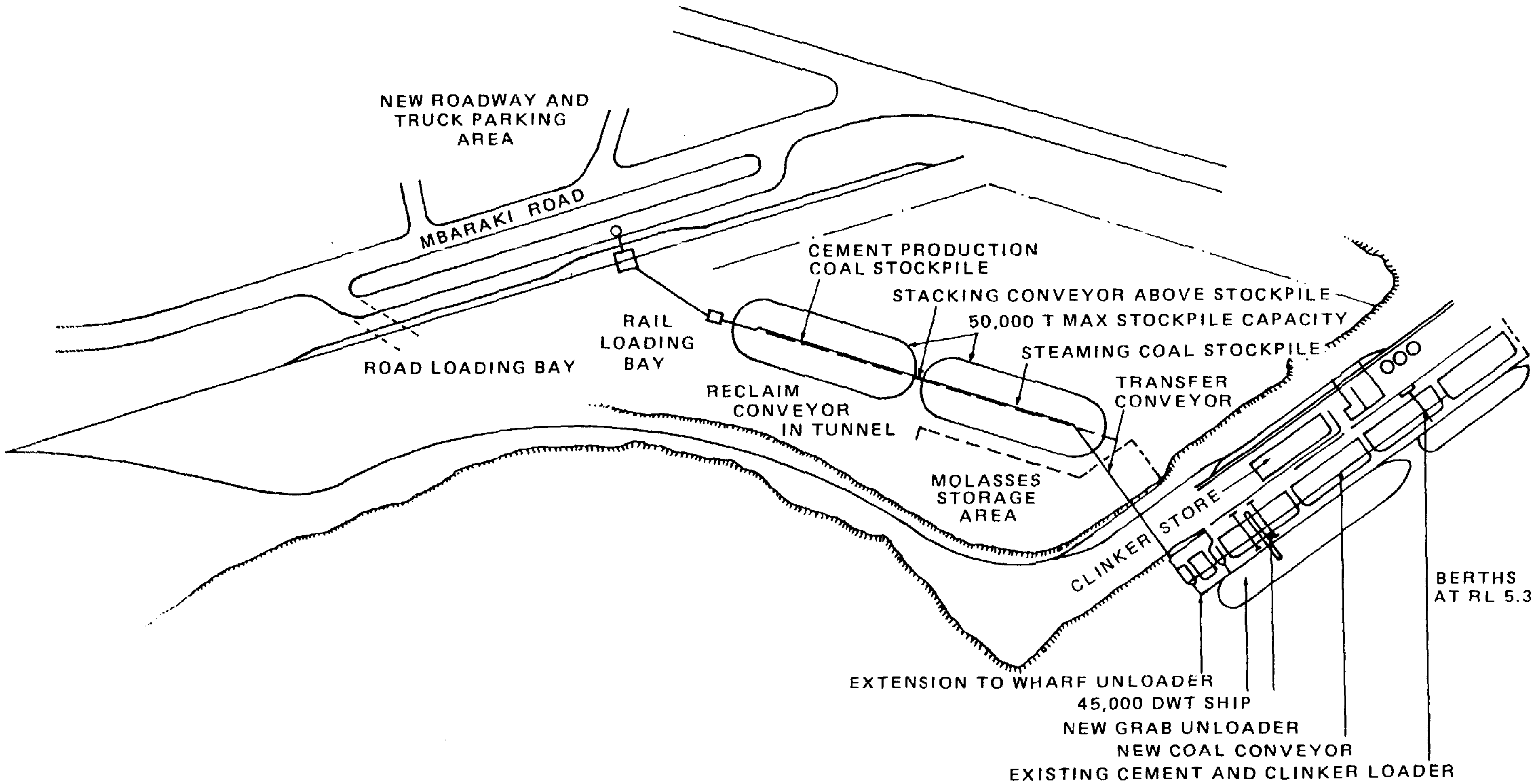
7.8.2.3 Dongo Kundu (Drawing No. 3)

Should a decision to be taken to develop the infrastructure and dredge the access channel to the Dongo Kundu area, then a bulk imports terminal and coal-fired power station could be constructed on that area.

The Consultants have had no indication that the area will be developed in the foreseeable future, so this possibility is not considered further.

KENYA
MINISTRY OF ENERGY & REGIONAL DEVELOPMENT
COAL CONVERSION ACTION PLAN

MOMBASA - POSSIBLE COAL UNLOADING STOCKPILE & RAIL LOADING FACILITIES AT MBARAKI SITE



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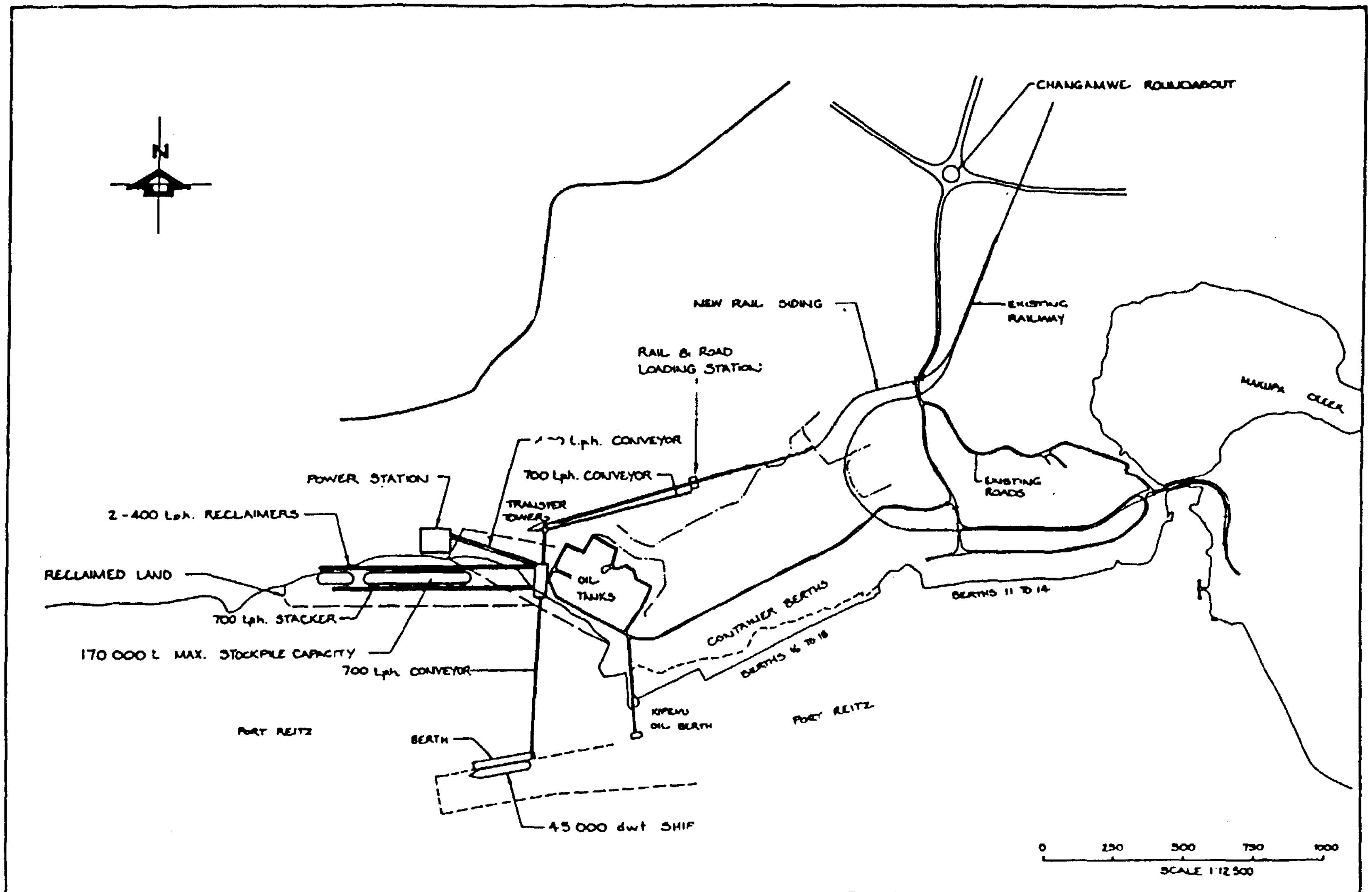
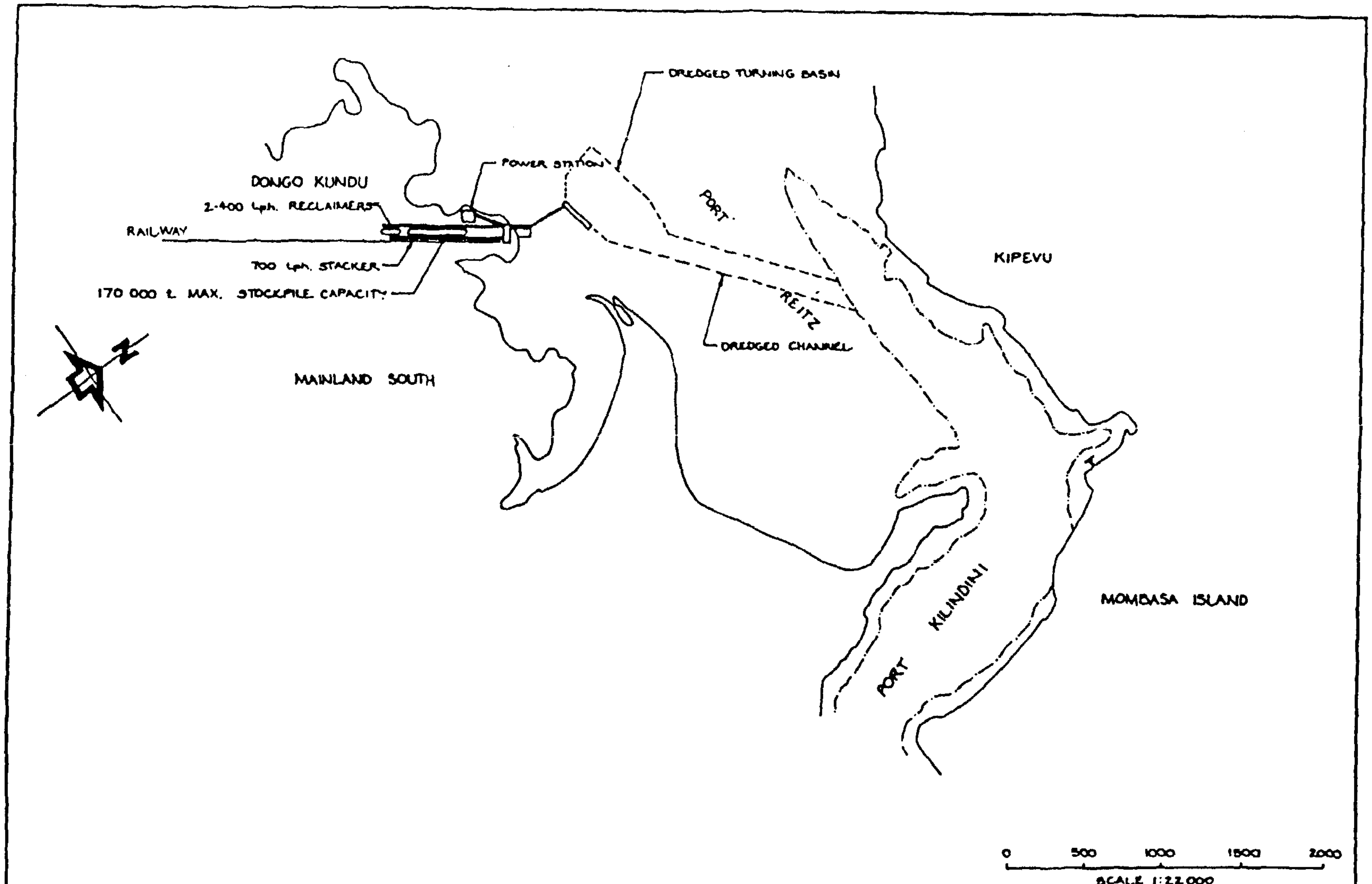


Macdonald Wagner

KENYA MINISTRY OF ENERGY & REGIONAL DEVELOPMENT	Designed P.J.B. / Drawn R.D.G. / Checked P.J.B. / Approved M.S.N.	MOMBASA - COAL UNLOADING, STOCKPILE & RAIL LOADING FACILITIES POSSIBLE KIPEVU SITE	WBK 101
KENYA COAL CONVERSION ACTION PLAN	Scale 1:12500		2.



Macdonald Wagner

KENYA MINISTRY OF ENERGY & REGIONAL DEVELOPMENT KENYA COAL CONVERSION ACTION PLAN	P.J.B. R.D.G. P.J.B. M.S.N. 1:22000	MOMBASA - COAL UNLOADING, STOCKPILE & RAIL LOADING FACILITIES POSSIBLE DONGO KUNDU SITE	WBK 101 3.

APPENDIX A

EXECUTIVE SUMMARIES FROM INDIVIDUAL AUDIT REPORTS

ENERGY AUDIT REPORT

Executive Summary

BAMBURI PORTLAND CEMENT COMPANY LTD
MOMBASA, KENYA

1.0 EXECUTIVE SUMMARY

1.1 Overview

Bamburi Portland Cement Company Limited (BPC) is situated at Mombasa, the principal Kenyan sea port and an important East African cargo transfer centre. BPC produce cement principally for export, but sell sufficient to service the local market. In CY 1984 BPC produced just over 840 000 tonnes of clinker, approximately 120 000 tonnes less than the previous years production. This reduction reflects the declining worldwide demand for cement rather than any problems with the plant or process. The plant is unique in Kenya in that it uses coal as its primary energy source while still using significant quantities of fuel oil and electricity.

BPC is a well engineered and operated plant with good process control and good access to overseas cement technology and engineering expertise. It is believed that opportunities do however exist for further improvement in energy conservation, and subsequent sections set out the target energy intensities (T1 and T2), and the savings that can be made in production costs if these targets are achieved. This report outlines those opportunities.

The energy consumptions for CY 1983 and 1984, utilisation and target energy intensities (T1 and T2) for BPC are summarised in Table 1.1. The percentage cost and consumption of the various energy forms, principally coal, fuel oil, and electricity, are shown pictorially in Figure 1.1. Gasoline, gas oil and LPG, being transport fuels, are not studied in this report or included in any derivation of energy intensity but are included in this summary to indicate their contribution to total energy costs. Coal, fuel oil and electricity in CY 1984 accounted for 56.3%, 14.6% and 24.5% respectively of all energy costs reported.

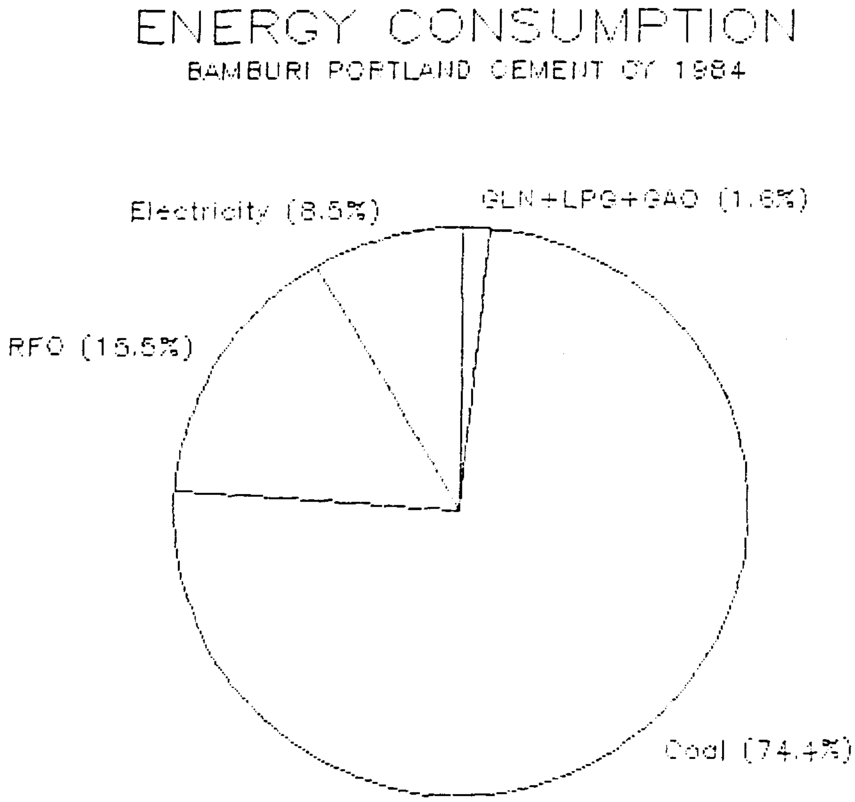
Energy intensity for CY 1984 at BPC as measured in gigajoules of energy consumed per tonne (kilocalories per kilogram) of clinker production was 4.97 GJ/t (1 187kCal/kg) at an energy cost of 264 KSh/t. The report shows how it is believed that this energy intensity and cost can be reduced, firstly to a Target 1 level of 4.41 GJ/t (1 053 kCal/kg) and 234.50 KSh/t and then, with some level of investment, to a Target 2 level of 4.00 GJ/t (955 kCal/kg), and 205 KSh/t. The cost reductions at present production levels extend to an annual savings of 25 184 000 KSh/a at Target 1 and a further 24 913 000 KSh/a at Target 2. Investments are only contemplated that show an internal rate of return (IRR) of over 15% after allowance for tax and depreciation.

The estimates for energy saving opportunities are based on actual measurements or engineering-economic judgement following the site visit. Cost and savings are approximate, and additional engineering and economic feasibility investigation, particularly to take account of continuing variations in energy costs, will be necessary before proceeding with any of the projects identified. Indeed it should be observed that since the time of the 1985 audit, international fuel oil prices have fallen dramatically, while the economic and market prices of both electricity and fuelwood have risen.

TABLE 1.1 - OVERALL ENERGY USAGE AND COST REPORT

Period:		1983	1984
Total Production:	t	964 402	842 845
Energy Consumption:	GJ	4 178 970	4 188 575
Energy Intensity:	GJ/t	4.33	4.97
	kCal/kg clinker	1 034	1 187
Energy Cost:	kKSh	213 924	222 848
Specific Energy Cost:	kKSh/t	221.82	264.40
Energy Intensity Targets:			
Target 1	GJ/t		4.41
	kCal/kg		1 053
Target 2	GJ/t		4.00
	kCal/kg		955
Potential Energy Savings:			
Target 1 Achieved	GJ/t		0.56
	kCal/kg		134
Target 2 Achieved	GJ/t		0.97
	kCal/kg		232
Potential Cost Savings:			
Target 1 Achieved	KSh/t		29.88
Target 2 Achieved	KSh/t		29.55

Note: Transport fuels are excluded from all analyses.


ENERGY CONSUMPTION
BAMBURI PORTLAND CEMENT CY 1984
Electricity (8.5%)
GLN+LPG+GAO (1.6%)
RFO (15.5%)
Coal (74.4%)

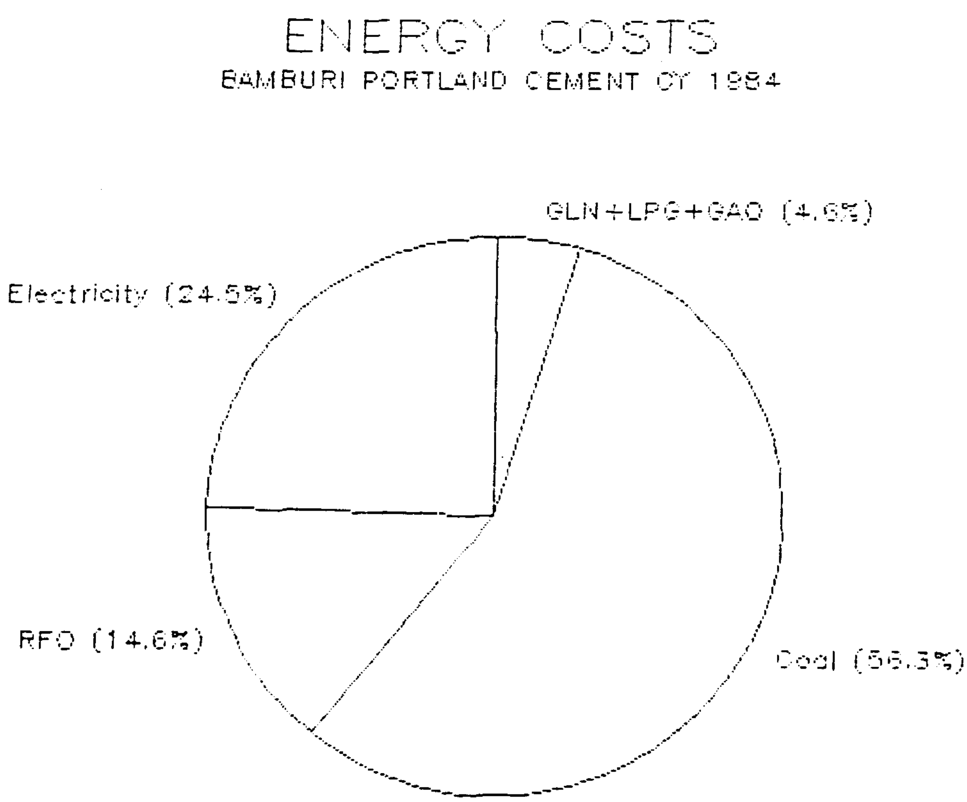

ENERGY COSTS
BAMBURI PORTLAND CEMENT CY 1984
GLN+LPG+GAO (4.6%)
Electricity (24.5%)
RFO (14.6%)
Coal (56.3%)

FIGURE 1.1

1.2 Target 1 - Short Term Energy Savings

By continuing the energy management programme and implementing the short term recommendations listed in Table 1.4 which, in general, require minimum investment levels, a Target 1 energy intensity of 4.41 GJ/t could be achieved. Plant energy consumption at current production levels would be reduced by 475 000 GJ/a or 11.3% of present process consumption, a saving of 25 180 000 KSh/a or 11.3% of 1984 process energy costs, as summarised in Table 1.2 below.

It is however understood that BPC already have a comprehensive system for recording and analysing energy consumptions, and thus the estimated capital cost of additional metering may be rather less than given in the report.

Section 1.4 following sets out in summary form the projects proposed to achieve Target 1 energy and cost savings.

TABLE 1.2 - TARGET 1 - SHORT TERM ENERGY SAVINGS*

Energy Form	SPECIFIC ENERGY Usage GJ/t	Target GJ/t	Savings GJ/t	Percent Savings %	ENERGY COSTS Current kKSh	Target kKSh	Savings kKSh	Percent Savings %
Electricity	0.43	0.41	0.02	4.9	57 286	54 486	2 800	5.4
Fossilfuel	4.54	4.00	0.54	11.9	165 562	143 178	22 384	13.5
Total	4.97	4.41	0.56	11.3	222 848	197 664	25 184	11.3

*Figures subject to rounding errors.

1.3 Target 2 - Long Term Energy Savings

By implementing the long term recommendations (including short term recommendations) listed in Table 1.4 which, in general, require some capital investment, and subject to further more detailed evaluation of engineering and economic feasibility, it is estimated that a Target 2 energy consumption will be 4.15 GJ/t, energy costs will be reduced by 24 913 kKSh/a or 11.1% of 1984 process energy costs, as summarised in Table 1.3 below.

Section 1.4 following sets out in summary form the projects proposed to achieve Target 2 energy cost savings.

TABLE 1.3 - TARGET 2 - LONG TERM ENERGY SAVINGS*

Energy form	SPECIFIC ENERGY Current GJ/t	T1 GJ/t	T2 GJ/t	ENERGY COSTS Current kKSh	T1 kKSh	T2 kKSh	Savings kKSh
Electricity	0.43	0.41	0.33	57 286	54 486	40 987	13 499
Fossil fuels	4.54	4.00	3.82	165 562	143 178	131 764	11 414
Total	4.97	4.41	4.15	222 848	197 664	172 751	24 913

*Figures subject to rounding errors.

1.4 Recommended Projects to achieve Target Energy Savings

Table 1.4 summarises the short term and long term projects identified to achieve the targeted energy savings at BPC Ltd. Reference is given to the report chapter in which a more detailed discussion of the proposal may be located.

TABLE 1.4 - RECOMMENDATIONS

Project Description	Energy Saving GJ/a	Cost Saving kKSh/a	Capital Cost kKSh	Payback Time Years	Reference Chapter Number
Target 1 - Short Term					
1. Monitor and control electricity consumption	17 800	2 800	1 400***	0.5	5
2. Lower MD target to 16MVA	-	300	-	N/A	5
3. Monitor and control fossil fuel utilisation	457 200	19 800	-	N/A	7
Target 2 - Long Term					
1. Extend precalcination time for RKI*	144 564	6 000	7 000	1.2	10
2. Install waste heat boilers on clinker cooler exhaust. Steam to drive T/A set	85 424	13 500	25 425	1.9	10
3. Steam heat RFO using waste heat**	3 682	191	50	0.3	10
4. Substitute coal for balance of RFO**	-	5 223	1 000	0.2	10

* BPCC have in hand.
** No.3 excluded if No.4 adopted.
Figures subject to rounding errors.
*** Estimate may be generous.

ENERGY AUDIT REPORT

Executive Summary

B.A.T. KENYA LIMITED
NAIROBI, KENYA

1.0 EXECUTIVE SUMMARY

1.1 Overview

BAT Kenya Ltd (BAT), situated just outside Nairobi, is Kenya's only cigarette manufacturer, producing several popular brands of cigarettes. Production in CY 1984 was 4 949 million cigarettes.

BAT is a well engineered and operated plant, with good process control and good access to parent company engineering expertise. It is good to note that the plant has a standing Energy Committee. It is believed that opportunities do however exist for further improvement in energy conservation, and subsequent sections set out the target energy intensities (T1 and T2) and the savings that can be made in production costs if these targets are achieved. This report also outlines the steps to realise these opportunities.

The energy consumption for CY 1982 to 1984, utilisation and target energy intensities (T1 and T2) for BAT are summarised in Table 1.1. The percentage cost and consumption of the various energy forms used at BAT, principally electricity, fuel oil, gas oil, LPG and gasoline, are shown pictorially in Figure 1.1. Gasoline, gas oil and LPG, being transport fuels, are not studied in this report or included in any derivation of energy intensity but are included in the summary to indicate their contribution to total energy costs. Fuel oil and electricity in CY 1984 account for 27.7% and 37.0% respectively of all energy costs reported, or 38.0% and 62.0% respectively when transport fuels are excluded.

The BAT Group have a world wide energy reporting system which usefully compares the energy performances of its many factories. BAT have developed the concept of the Energy Usage Ratio (EUR) for all factories which is reported in units of megawatt hours of energy per million cigarettes (MWh/M cigs). The EUR may be readily compared, and is dimensionally identical, with the Consultants' term Energy Intensity which is measured in gigajoules of energy per million cigarettes (GJ/Mcigs). Since 1 MWh = 3.6 GJ it follows that an EUR of 1 MWh/M cigs is equal to an Energy Intensity of 3.6 GJ/M cigs. To ensure that the Consultants' work may be readily used within the BAT Group as a whole, both ratios are used throughout the Executive Summary, but thereafter Energy Intensity alone is used.

Energy intensity at BAT for CY 1984 as measured in gigajoules of energy consumed per million cigarettes excluding transport fuels was 4.96 GJ/M cigs (EUR 1.38 MWh/M cigs). The current energy cost excluding transport fuels is 551 KSh/M cigs. The report shows how it is believed that this energy intensity and cost can be reduced, firstly to a Target 1 level of 4.13 GJ/M cigs (EUR 1.15) and 454 KSh/M cigs, and then, with some level of investment, to a Target 2 level of 4.94 GJ/M cigs (EUR 1.37) and 20 KSh/M cigs. It will be noted that the energy intensity has increased above the T1 value, while the specific energy cost has dropped substantially. This results from the proposed installation of a back pressure turbine to generate plant electricity and export surplus steam to a neighbouring site for a suitable return.

The cost reductions at present production levels extend to an annual savings of 480 000 KSh/a at Target 1 and a further 1 763 000 KSh/a at Target 2. Investments are only contemplated that show an internal rate of return (IRR) of over 15% after allowance for tax and depreciation.

The estimates for energy saving opportunities are based on actual measurements or engineering-economic judgement following the site visit. Cost and savings are approximate, and additional engineering and economic feasibility investigation, particularly to take account of continuing variations in energy costs, will be necessary before proceeding with any of the projects identified. Indeed it should be observed that since the time of the 1985 audit, international fuel oil prices have fallen dramatically, while the economic and market prices of both electricity and fuelwood have risen.

TABLE 1.1 - OVERALL ENERGY USAGE AND COST REPORT

CY :		1982	1983	1984
Total Production:	M cigs	4 649	4 976	4 949
Energy Consumption:	GJ	23 021	25 375	24 546
Energy Intensity:	GJ/M cigs	4.95	5.10	4.96
Energy Usage Ratio:	MWh/M cigs	1.37	1.42	1.38
Energy Cost:	kKSh	1 776	2 252	2 728
Specific Energy Cost:	KSh/M cigs	380	450	551
Energy Intensity Targets:				
Target 1	GJ/M cigs			4.13
Target 2	GJ/M cigs			4.94
Energy Usage Ratio Targets:				
Target 1	MWh/M cigs			1.15
Target 2	MWh/M cigs			1.37
Potential Energy Savings:				
Target 1 Achieved	GJ/M cigs			0.83
Target 2 Achieved	GJ/M cigs			(0.81)
Potential Cost Savings:				
Target 1 Achieved	KSh/M cigs			97
Target 2 Achieved	KSh/M cigs			434

Note: Transport fuels are excluded from all analyses.

ENERGY CONSUMPTION

B.A.T. KENYA CY 1984

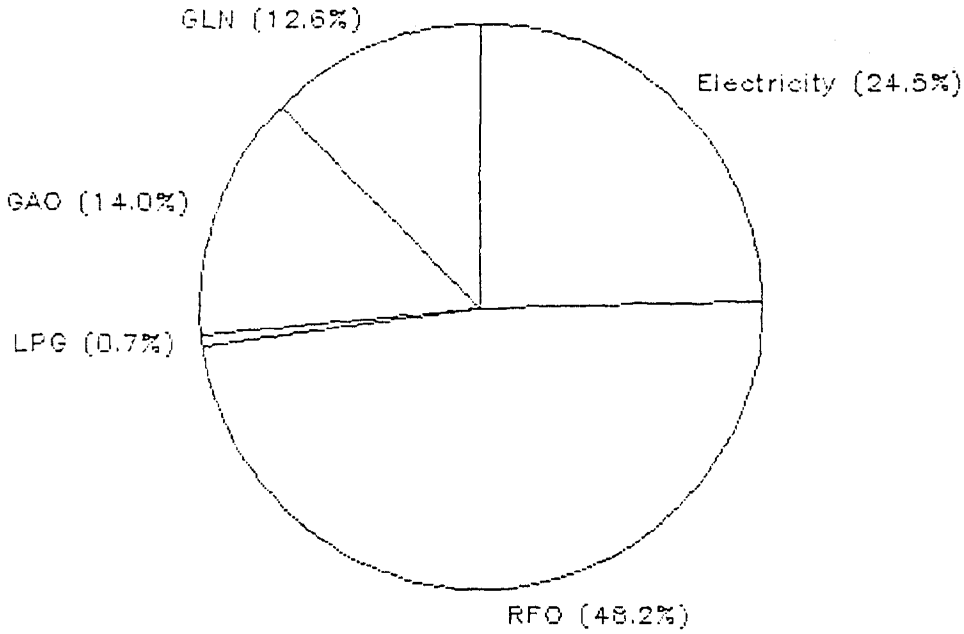


FIG 1.1a

ENERGY COSTS

B.A.T. KENYA CY 1984

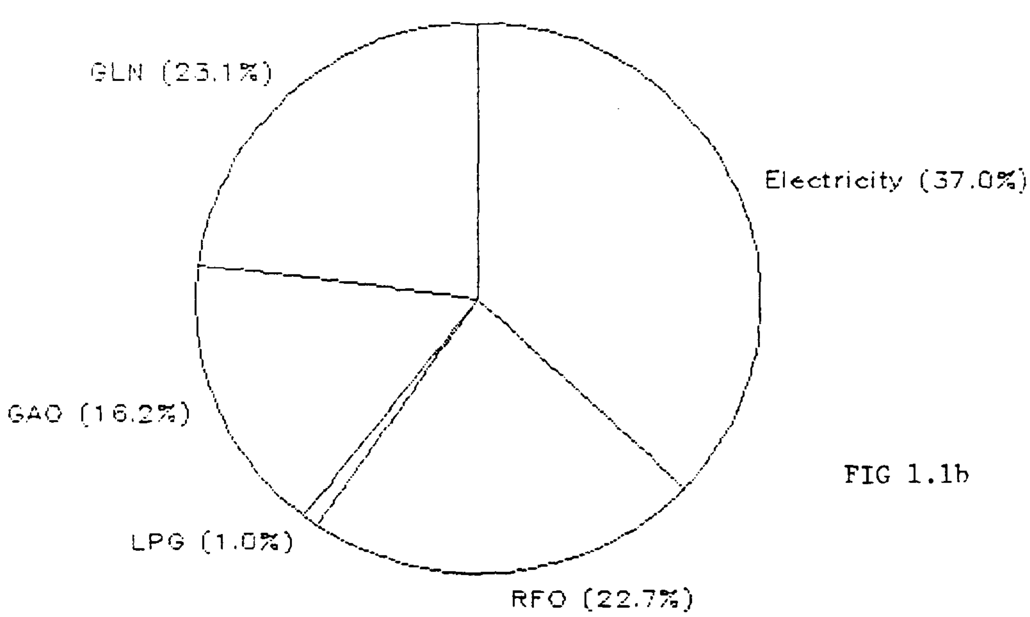


FIG 1.1b

1.2 Target 1 - Short Term Energy Savings

By adopting a vigorous energy management programme and implementing the short term T1 recommendations listed in Table 1.4 which, in general, require minimum investment levels, a Target 1 energy intensity of 4.13 GJ/M cigs (EUR 1.15 MWh/M cigs) could be achieved. Plant energy consumption at current production levels would be reduced by 4 160 GJ/a, around 17% of present process consumption, a saving of 480 000 KSh/a, or 18% of CY 1984 process energy costs, as summarised in Table 1.2 below.

Section 1.4 following sets out in summary form the projects proposed to achieve Target 1 energy and cost savings.

TABLE 1.2 - TARGET 1 - SHORT TERM ENERGY SAVINGS

	SPECIFIC ENERGY				ENERGY COSTS			
Energy Form	Usage GJ/M cigs	Target GJ/M cigs	Savings GJ/M cigs	Percent Savings %	Actual kKSh	Target kKSh	Savings kKSh	Percent Savings %
Electricity	1.67	1.38	0.29	17.4	1 691	1 381	310	18.3
Fuel Oil	3.29	2.75	0.54	16.4	1 037	867	170	16.4
Total	4.96	4.13	0.83	16.7	2 728	2 248	480	17.6
EUR (MWh/M cigs)	1.37	1.15	0.23					

1.3 Target 2 - Long Term Energy Savings

By implementing the long term T2 recommendations listed in Table 1.4 which, in general, require some capital investment, and subject to further more detailed evaluation of engineering and economic feasibility, and assuming all T1 recommendations have already been implemented, it is estimated that Target 2 energy consumption will be increased to 7.94 GJ/M cigs (EUR 2.21 MWh/M cigs). However energy costs will be reduced by a further 2 316 000 KSh/a or just over 53% of CY 1984 process energy costs as summarised in Table 1.3 below. Cost savings will be substantially increased if excess steam generated is exported.

Section 1.4 summarises the projects proposed to achieve Target 2 energy and cost savings.

TABLE 1.3 - TARGET 2 - LONG TERM ENERGY SAVINGS*

Energy Form	SPECIFIC ENERGY Current GJ/M cigs	T1 GJ/M cigs	T2 GJ/M cigs	ENERGY COSTS Current kKSh	T1 kKSh	T2 kKSh	Savings kKSh
Electricity	1.67	1.38	- (1)	1 691	1 381	-	1 381
Fuel Oil	3.29	2.75	0	1 037	867	0	867
Fuel Wood	0	0	5.81	0	0	485	(485)
Tobacco Waste	0	0	1.09	0	0	0	-
Surplus Steam	-	0	- (1,2) (1.96) (3)	0	0	- (387) (2)	- 387
Total(1)	4.96	4.13	6.90	2 728	2 248	485	1 763
Total(2)	4.96	4.13	4.94	2 728	2 248	98	2 150
EUR(1)	1.38	1.15					
EUR(2)	1.38	1.15					

Notes:
(1) Included in fuel wood and tobacco energy contribution.
(2) Without surplus steam export - Project 3A implemented.
(3) With surplus steam export - Project 3B implemented.

*Figures subject to rounding errors.

1.4 Recommended Projects to achieve Target Energy Savings

Table 1.4 summarises the short term (T1) and long term (T2) projects identified to achieve the targeted energy savings at BAT. Reference is given to the report chapter in which a more detailed discussion of the proposal may be located.

TABLE 1.4 - RECOMMENDATIONS

Project Description	Energy Saving GJ/a	Cost Saving kKSh/a	Capital Cost kKSh	Payback Time Years	Reference Chapter
Target 1: Short Term Energy Savings					
Electricity:					
. Monitor and control consumption					5
. Repair leaks in compressed air system	1 500	310	-	N/A	8
. Repair leaks in vacuum system					9
. Further modernise lighting system					5
RFO:					
. Adjust fuel air ratio on burners	160	10	-	N/A	6
Steam:					
. Repair steam system leaks, traps, insulation and improve condensate return	2 500	160	160	1	7
. Monitor and control steam consumption					7
Target 2: Long Term Energy Savings					
1 Boiler conversion to burn woodfuel	(1 084)	625	1 424	2.3	11
2 Burn tobacco waste	-	92	-	N/A	11
3A Electricity and steam cogeneration without steam export	(12 627)	1 055	3 000	2.8	11
3B Electricity and steam cogeneration with steam export	(3 156)	1 194	3 000	2.5	11

ENERGY AUDIT REPORT

Executive Summary

CLAYWORKS LIMITED
NAIROBI, KENYA

1.0 EXECUTIVE SUMMARY

1.1 Overview

Clayworks Limited (Clayworks), situated just outside Nairobi, manufactures bricks, partition blocks, roof and floor tiles.

Clayworks do not appear to have appointed an Energy Manager or have in place an energy management programme. Energy costs are relatively low as the plant uses coffee husks for firing the Hoffman kilns. It is believed that opportunities do however exist for further improvement in energy conservation, and subsequent chapters set out the target energy intensities (T1 and T2) and the savings that can be made in production costs if these targets are achieved. This report outlines these opportunities.

The CY 1984 energy consumption, utilisation and target energy intensities (T1 and T2) for Clayworks plant are summarised in Table 1.1. The percentage cost and consumption of the various energy forms are shown pictorially in Figure 1.1. Gasoline and gas oil, being transport fuels, are not studied in this report or included in any derivation of energy intensity but are included in this summary to indicate their contribution to total energy costs.

Coffee husks, which are relatively cheap, comprise nearly 65% of all energy used, including transport. However, although small in terms of energy units, fuel oil and electricity account for about 19% and 44% respectively of all energy costs, or about 28% and 65% when transport fuels are excluded. This emphasises the very great importance of reducing fuel oil to the minimum and controlling electricity costs most carefully.

Energy intensity for CY 1984 at Clayworks as measured in gigajoules of energy consumed per tonne of product (GJ/t) excluding transport fuels was 2.74 GJ/t, equivalent to an energy cost of 44.1 KSh/t. The report shows how it is believed that this energy intensity and cost can be reduced, firstly to a Target 1 level of 2.48 GJ/t and 38.3 KSh/t, and then, with some level of investment, to a Target 2 level remaining at 2.48 GJ/t but at a greatly reduced energy cost of 26.2 KSh/t. The cost reductions at present production levels extend to an annual savings of 129 000 KSh/a at Target 1 and a further 270 000 KSh/a at Target 2 which are direct additions to profit. Investments are only contemplated that show an internal rate of return (IRR) of over 15% after allowance for tax and depreciation.

All estimates for energy saving opportunities are based on actual measurements or engineering-economic judgement following the site visits. Cost and savings are approximate and additional engineering and economic feasibility investigation, particularly to take account of continuing variations in energy costs, will be necessary before proceeding with any of the projects identified. Indeed it should be observed that since the time of the 1985 audit, international fuel oil prices have fallen dramatically, while the economic and market prices of both electricity and fuelwood have risen.

TABLE 1.1 - OVERALL ENERGY USAGE AND COST REPORT

		1984
Total Production:	t	22 332
Energy Consumption:	GJ	61 151
Energy Intensity:	GJ/t	2.74
Energy Cost:	kKSh	983
Specific Energy Cost:	KSh/t	44.1
Energy Intensity Targets:		
Target 1	GJ/t	2.48
Target 2	GJ/t	2.48
Potential Energy Savings:		
Target 1 Achieved	GJ/t	0.26
Target 2 Achieved	GJ/t	0
Potential Cost Savings:		
Target 1 Achieved	KSh/t	5.78
Target 2 Achieved	KSh/t	12.09

Note: Transport fuels are excluded from all analyses.

ENERGY CONSUMPTION
CLAYWORKS LTD CY 1984

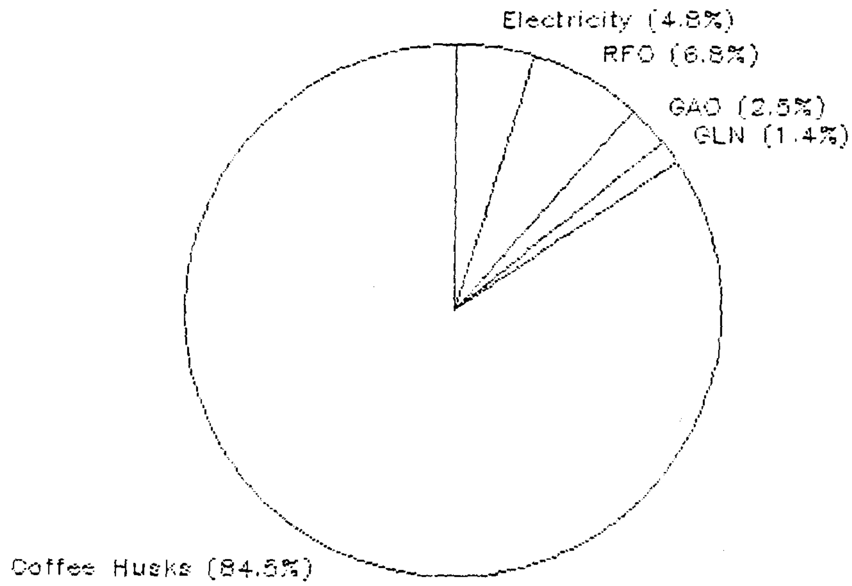


FIG 1.1a

ENERGY COSTS
CLAYWORKS LTD CY 1984

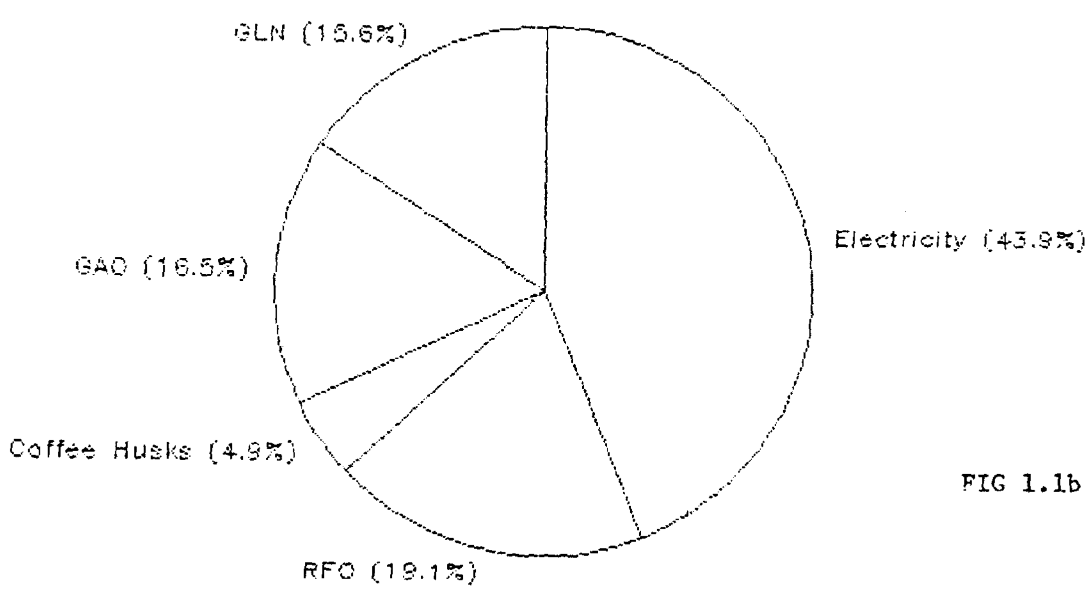


FIG 1.1b

1.2 Target 1 - Short Term Energy Savings

By adopting a vigorous energy management programme and in implementing the short term recommendations which, in general, require minimum investment levels, a Target 1 energy intensity of 2.48 GJ/t could be achieved, mainly by savings in electricity and coffee husk consumption. Plant overall energy consumption at current production levels would be reduced by around 5 700 GJ/a or 9% of present consumption, a saving of 129 000 KSh/a, or 13% of 1984 energy values, as summarised in Table 1.2.

TABLE 1.2 - TARGET 1 SHORT TERM ENERGY SAVINGS

Energy form	Specified Energy Usage GJ/t	Target GJ/t	Savings GJ/t	Percent Savings %	Energy Cost Actual kKSh	Target kKSh	Saving kKSh	Percent Savings %
Electricity	0.14	0.12	0.02	10	636	514	122	19
RFO	0.19	0.19	-	-	276	276	-	-
Cofee Husks	2.41	2.17	0.24	10	71	64	7	10
Total	2.74	2.48	0.26	9	983	854	129	13

1.3 Target 2 - Long Term Energy Savings

By implementing the long term T2 recommendations listed in Table 1.4 which, in general, require some capital investment, and subject to further more detailed evaluation of engineering and economic feasibility, it is estimated that whilst the Target 2 specific energy consumption would remain unchanged at 2.48 GJ/t, the energy cost would be reduced giving a further saving of around 270 000 KSh/a or a total saving of 41% of CY 1984 energy costs.

TABLE 1.3 - TARGET 2: LONG TERM ENERGY SAVINGS

Energy form	Specific Energy Current GJ/t	T1 GJ/t	T2 GJ/t	Energy Cost Current kKSh	T1 kKSh	T2 kKSh	Savings kKSh
Electricity	0.14	0.12	0.12	636	514	514	-
Fuel Oil	0.19	0.19	-	276	276	-	276
Coffee Husks	2.41	2.17	2.36	71	64	70	(6)
Total	2.74	2.48	2.48	983	854	584	270

Subject to rounding errors.

1.4 Recommended Projects to achieve Target Energy Savings

Table 1.4 summarises the projects identified to achieve the targeted energy savings at Clayworks Ltd. Reference is given to the report chapter in which a more detailed discussion of the proposal may be located.

TABLE 1.4 - RECOMMENDATIONS

Project	Energy Saving GJ/a	Cost Saving kKSh/a	Capital Cost kKSh	Payback Time Years	Reference Chapter
Target 1: Short Term Energy Savings					
1. Monitor and control electric energy consumption	310	64	64	1	5
2. Power factor control	-	48	-	N/A	5
3. MD control	-	10	25	2.5	5
4. Monitor and control coffee husk consumption	5400	7	-	N/A	7
Target 2: Long Term Energy Savings					
1. Replace heat exchanger RFO firing with coffee husks.	-	270	360	1.3	10

ENERGY AUDIT REPORT

Executive Summary

EAST AFRICAN PORTLAND CEMENT COMPANY LIMITED
ATHI RIVER, KENYA

1.0 EXECUTIVE SUMMARY

1.1 Overview

East African Portland Cement (EAPC) is situated at Athi River about 25 km south east of Nairobi, and is the smaller of Kenya's two cement producers. EAPC produced approximately 28% of total Kenyan production in 1984, all of which was sold into the local market, representing 57% of the cement actually used in Kenya.

EAPC is a well engineered and operated plant, with good process control and good access to international cement technology expertise. Due to the current high level of energy awareness, limited opportunities only exist for further improvement in energy conservation so long as the wet process is retained. Subsequent sections set out target energy intensities (T1 and T2) and the savings that can be made in production costs if these targets are achieved. This report outlines those opportunities and the means to secure them.

The energy consumption for CY 1982 to 1984, utilisation and target energy intensities (T1 and T2) for EAPC are summarised in Table 1.1. The percentage cost and consumption of the various energy forms used, principally electricity, fuel oil (RFO), gas oil (GAO) and gasoline (GLN), are shown pictorially in Figure 1.1. GNL, GAO, and LPG, being transport fuels, are not studied in this report or included in any derivation of energy intensity, but are included in the summary to indicate their contribution to total energy costs. Fuel oil and electricity account for 80.2% and 16.7% respectively of all energy costs when transport fuels are excluded.

Overall energy intensity at EAPC for 1984 excluding transport fuels is 5.37 GJ/t cement (1 283 kCal/kg), giving a current specific energy cost of 352 KSh/t. The report shows how this energy intensity and cost can be reduced, to a small extent, to a Target 1 level of 4.95 GJ/t cement (1 185 kCal/kg) and 318 KSh/t. No projects to significantly reduce consumption without process change were uncovered. The fuel oil (RFO) energy intensity for the manufacture of clinker is 6.1 GJ/t (1 456 kCal/kg) which compares reasonably with internationally accepted levels.

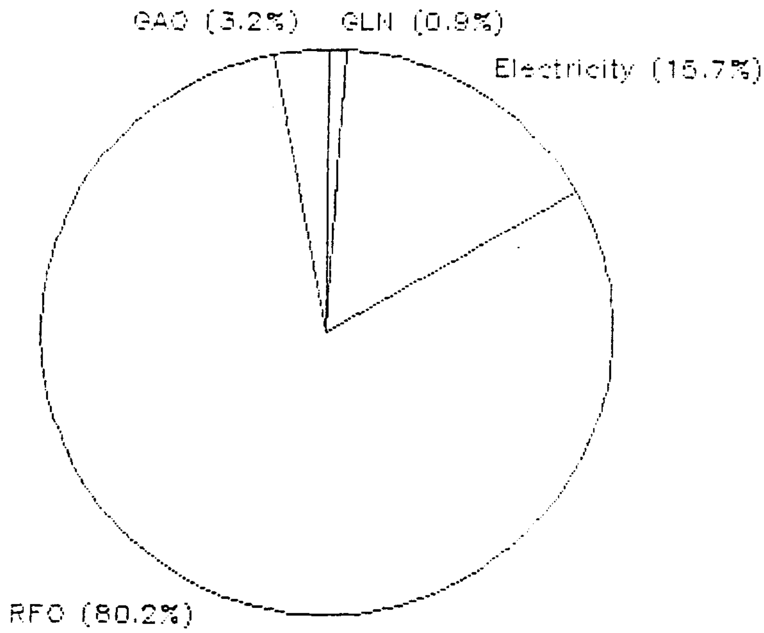
The estimates for energy saving opportunities are based on actual measurements or engineering-economic judgement following the site visit. Cost and savings are approximate, and additional engineering and economic feasibility investigation, particularly to take account of continuing variations in energy costs, will be necessary before proceeding with any of the projects identified. Indeed it should be observed that since the time of the 1985 audit, international fuel oil prices have fallen dramatically, while the economic and market prices of both electricity and fuelwood have risen.

TABLE 1.1 - OVERALL ENERGY USAGE AND COST REPORT

Period:	CY	1982	1983	1984
Total Production:	t	297 485	295 741	320 490
Energy Consumption:	GJ	1 654 881	1 783 668	1 722 562
Energy Intensity:	GJ/t	5.56	6.03	5.37
Overall	kCal/kg	1 329	1 441	1 284
Clinker only	kCal/kg	1 682	1 675	1 545
Energy Cost:	kKSh	89 542	105 600	112 694
Specific Energy Cost:	KSh/t	301	357	352
Energy Intensity Targets:				
Target 1	GJ/t			4.95
Target 2	GJ/t			
Potential Energy Savings:				
Target 1 Achieved	GJ/t			0.42
Target 2 Achieved	GJ/t			
Potential Cost Savings:				
Target 1 Achieved	KSh/t			34.0
Target 2 Achieved	KSh/t			

Note: Transport fuels are excluded from all analyses.

ENERGY COSTS
E.A.PORTLAND CEMENT CY 1984



ENERGY CONSUMPTION
E.A.PORTLAND CEMENT CY 1984

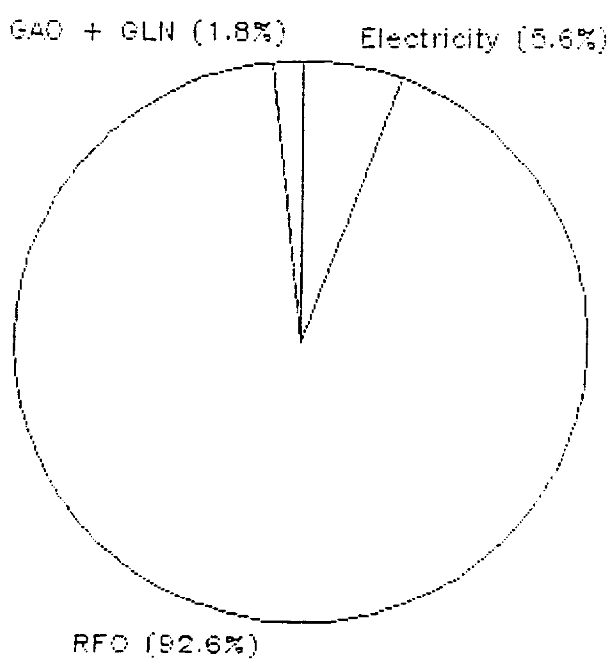


FIG 1.1

1.2 Target 1 - Short Term Energy Savings

By adopting a vigorous energy management programme and implementing the short term recommendations listed in Table 1.4 which, in general, require little investment, a Target 1 energy intensity of 4.95 GJ/t cement could be achieved. Plant energy consumption at current production levels would be reduced by 133 700 GJ/a or 7.8% of present process consumption, a saving of 10 795 000 KSh/a or 9.6% of 1984 process energy costs, as summarised in Table 1.2 below.

Section 1.4 following sets out in summary form the projects proposed to achieve Target 1 energy and cost savings.

TABLE 1.2 - TARGET 1 - SHORT TERM ENERGY SAVINGS

	SPECIFIC ENERGY				ENERGY COSTS			
Energy Form	Usage GJ/t	Target GJ/t	Savings GJ/t	Percent Savings %	Current kKSh	Target kKSh	Savings kKSh	Percent Savings %
Electricity	0.31	0.24	0.07	21.9	18 419	14 109	4 310	23.4
Fuel Oil	5.06	4.71	0.35	6.9	94 274	87 789	6 485	6.9
Total	5.37	4.95	0.42	7.8	112 693	101 898	10 795	9.6

Figures subject to rounding errors.
Figures given related to tonnes of cement.
Ratio of cement to clinker production taken as 1:0.83.

1.3 Target 2 - Long Term Energy Savings

No new projects to significantly reduce energy consumption or costs were uncovered which did not involve process change. Two avenues currently being investigated by EAPC and their consultants are:

- Conversion from wet to dry processing.
- Substitution from RFO to coal firing.

1.4 Recommended Projects to achieve Target Energy Savings

Table 1.4 summarises the short term and long term projects identified to achieve the targeted energy savings at EAPC. Reference is given to the report chapter in which a more detailed discussion of the proposal may be located.

TABLE 1.4 - RECOMMENDATIONS

Project Description	Energy Saving GJ/a	Cost Saving kKSh/a	Capital Cost kKSh	Payback Time Years	Reference Chapter Number
Target 1 -Short Term					
Electricity:					
. Monitor and control consumption	18 700	3 480	1 700	6 mths	5
. Further modernise lighting system	3 000	560	1 675	3 yrs	5
. MD control	-	270	90-150	4-7 mths	5
RFO:					
. Monitor and control consumption, including change from remote manual to automatic O_2 trim control	112 000	6 485	10	N/A	6

ENERGY AUDIT REPORT

Executive Summary

EAST AFRICAN SUGAR INDUSTRIES LTD
MUHORONI SUGAR MILL
MUHORONI, KENYA

1.0 EXECUTIVE SUMMARY

1.1 Overview

East Africa Sugar Industries Ltd (EASI), Muhoroni Sugar Mill, is one of Kenya's seven sugar mills. Process heating and electric drives are the major energy users in this plant. The mill also exports steam to the nearby Agro Chemical & Food Corporation plant where power alcohol and bakers yeast are made.

During 1984 fuel oil, fuelwood and electricity cost a total of 3 627 000 KSh, despite having available biomass waste from the process (bagasse) with an energy content of 1 894 546 GJ/a.

In general, for a given quantity of sugar cane with fibre contents in the region of 15% or greater, the energy required to extract and refine the sugar is exceeded by the energy available in the biomass waste from the process.

For the Muhoroni Sugar Mill, the primary aim should be total energy self sufficiency. To achieve this aim two areas should be addressed.

(i) Elimination of dependency upon KPL for electricity - the mill should in fact have an electricity export capability.

(ii) The efficiency of the boilers should be increased. By improving the combustion of the bagasse and so raising the boiler efficiency the mill will have a major energy surplus.

In the longer term the aim should be to become a major exporter of electricity. This may be achieved by reducing the energy intensity of the process and using the surplus steam to generate more electricity for export. This longer term aim is beyond the scope of this present report. The potential energy surplus based on the 1984 data is around 288 000 GJ/a, after meeting the entire energy needs of the mill and providing the present steam requirements of Agro Chemical Corporation.

This surplus would enable the mill to operate as a power station during the short off season, proving around 3 240 MWh of power worth around 2 750 000 KSh at current KPL rates during that period and still leaving a considerable surplus of bagasse.

Table 1.1 shows a summary of the energy consumption and cost for CY 1984. Figure 1.1 shows this data pictorially.

Although the process at EASI has not been studied in detail, a process flow diagram for a typical mill, Figure 1.2, has been included in the report. A detailed study of the plant would be necessary to determine the energy savings that could be made for the process as a whole. Based on experience in the Australian sugar industry it is considered that the present energy intensity could be significantly reduced.

All estimates for energy saving opportunities are based on actual measurements or engineering-economic judgement following the site visits. Cost and savings are approximate and additional engineering and economic feasibility investigation, particularly to take account of continuing variations in energy costs, will be necessary before proceeding with any of the projects identified. Indeed it should be observed that since the time of the 1985 audit, international fuel oil prices have fallen dramatically, while the economic and market prices of both electricity and fuelwood have risen.

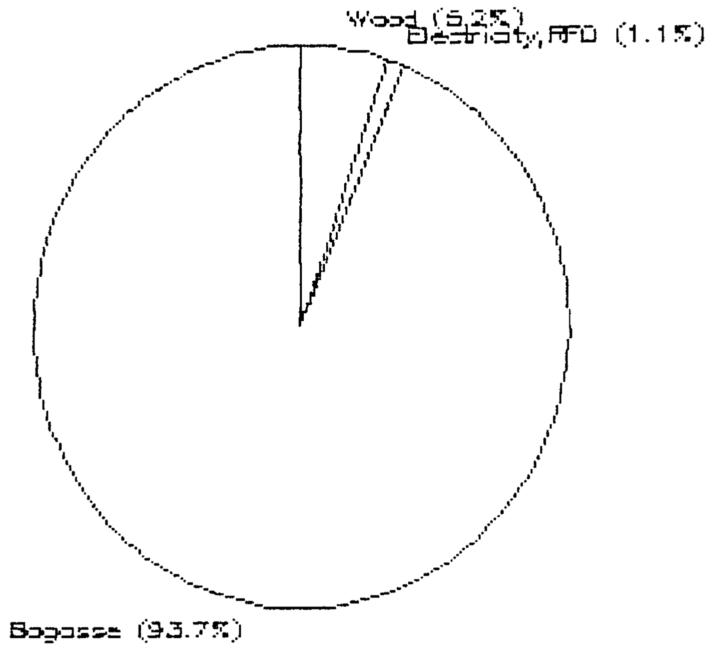
TABLE 1.1 - ENERGY SUMMARY FOR 1984

Cane Crushed	t/a	490 037
Sugar	t/a	42 231
Bagasse energy available	GJ	1 894 546
Bought in energy		
Fuelwood	GJ	104 982
Fuel oil	GJ	15 915
Electricity	GJ	6 107
Bought in energy cost	kKSh	3 627

FIGURE 1.1

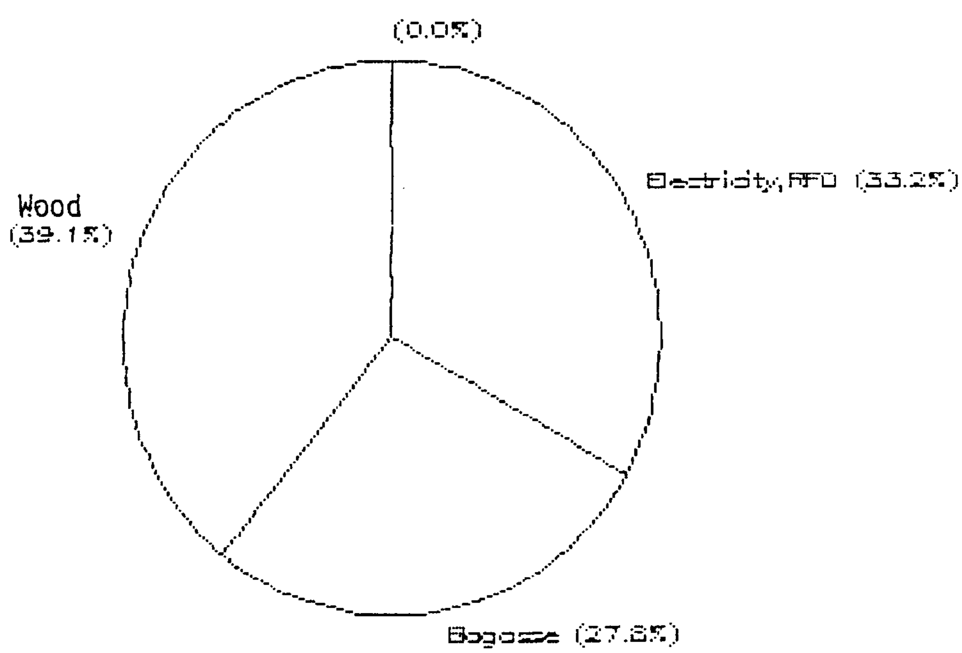
ENERGY CONSUMPTION

E.A. SUGAR INDUSTRIES CY 1984



ENERGY COSTS

E.A. SUGAR INDUSTRIES CY 1984



1.2 Recommended Projects to Achieve Self Sufficiency

Table 1.2 summarises the projects necessary to achieve energy self sufficiency at Muhoroni Sugar Mill. A more detailed discussion will be found in the Reference chapter.

TABLE 1.4 - RECOMMENDATIONS

Project Description	Energy Saving GJ/a	Cost Saving kKSh/a	Capital Cost kKSh	Payback Time Years	Reference Chapter Number
1. Retrofit cyclonic combustor to Boilers 1 & 2	120 897	2 424	6 480	3	8
2. Update Boiler 3 furnace controls			1 000		
3. Install T/A set in ACFC line	6 107	3 430	4 238	1.3	5

Subject to rounding errors.

ENERGY AUDIT REPORT

Executive Summary

EMCO STEEL WORKS (KENYA) LIMITED
NAIROBI, KENYA

1.0 EXECUTIVE SUMMARY

1.1 Present Energy Utilisation

Emco Steelworks Limited (ESW), situated in Nairobi, manufactures reinforcing rods for the building industry.

The plant is well laid out and management has access to international technology. It is believed however that opportunities do exist for improvement in energy conservation, and subsequent sections set out the target energy intensities (T1 and T2), and the savings that can be made in production costs if these targets are achieved. This report outlines those opportunities.

The CY 1984 energy consumption, utilisation and target energy intensities (T1 and T2) for ESW are summarised in Table 1.1. The percentage cost and consumption of the various energy forms are shown pictorially in Figure 1.1. Fuel oil and electricity in CY 1984 account for 32.4% and 67.6% respectively of all energy costs reported.

Energy intensity for CY 1984 at ESW as measured in gigajoules of energy consumed per tonne was 8.97 GJ/t. The current energy cost is 897 KSh/t. This report shows how it is believed that this energy intensity and cost can be reduced, firstly to a Target 1 level of 8.34 GJ/t and 819 KSh/t and then, with some level of investment, to a Target 2 level of 7.3 GJ/t and 751 KSh/t. The cost reductions at present production levels extend to an annual savings of 865 000 KSh/a at Target 1 and a further 486 000 KSh/a at Target 2. Investments are only contemplated that show an internal rate of return (IRR) of over 15% after allowance for tax and depreciation.

The estimates for energy saving opportunities are based on actual measurements or engineering-economic judgement following the site visit. Cost and savings are approximate, and additional engineering and economic feasibility investigation, particularly to take account of continuing variations in energy costs, will be necessary before proceeding with any of the projects identified. Indeed it should be observed that since the time of the 1985 audit, international fuel oil prices have fallen dramatically, while the economic and market prices of both electricity and fuelwood have risen.

TABLE 1.1 - OVERALL ENERGY USAGE AND COST REPORT

Plant: Emco Steelworks

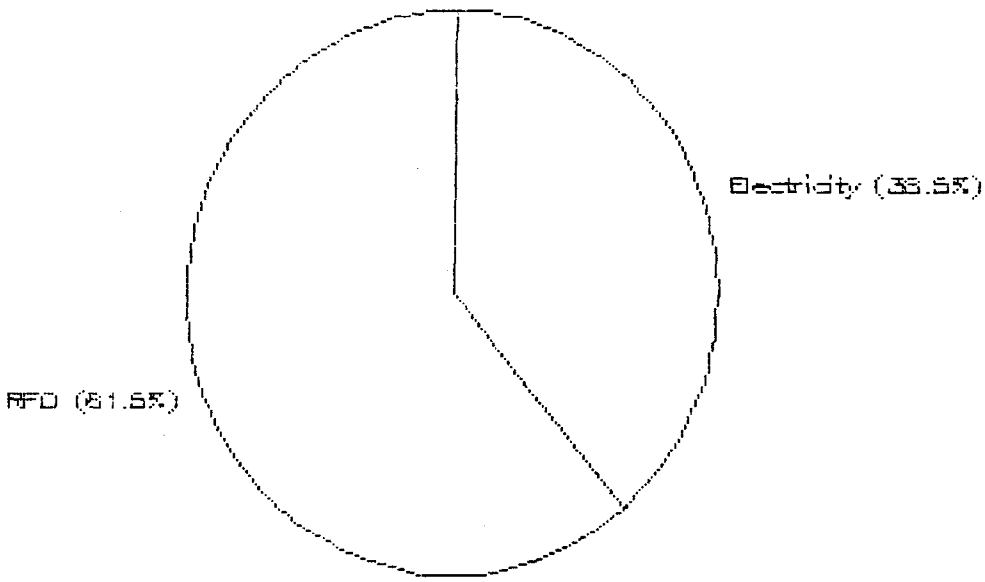
Period:	CY	1982	1983	1984
Total Production:	t	7 653	8 019	9 269
Energy Consumption:	GJ	72 168	69 801	83 175
Energy Intensity:	GJ/t	9.43	8.70	8.97
Energy Cost:	kKSh	7 192	7 404	8 313
Specific Energy Cost:	KSh/t	940	923	897
Energy Intensity Targets:				
Target 1	GJ/t			8.34
Target 2	GJ/t			7.3
Potential Energy Savings:				
Target 1 Achieved	GJ/t			0.64
Target 2 Achieved	GJ/t			1.04
Potential Cost Savings:				
Target 1 Achieved	KSh/t			78
Target 2 Achieved	KSh/t			68

Note: Transport fuels are excluded from all analyses.

Some figures subject to rounding errors.

ENERGY CONSUMPTION

EMCO STEEL WORKS KENYA CY 1984



ENERGY COSTS

EMCO STEEL WORKS KENYA CY 1984

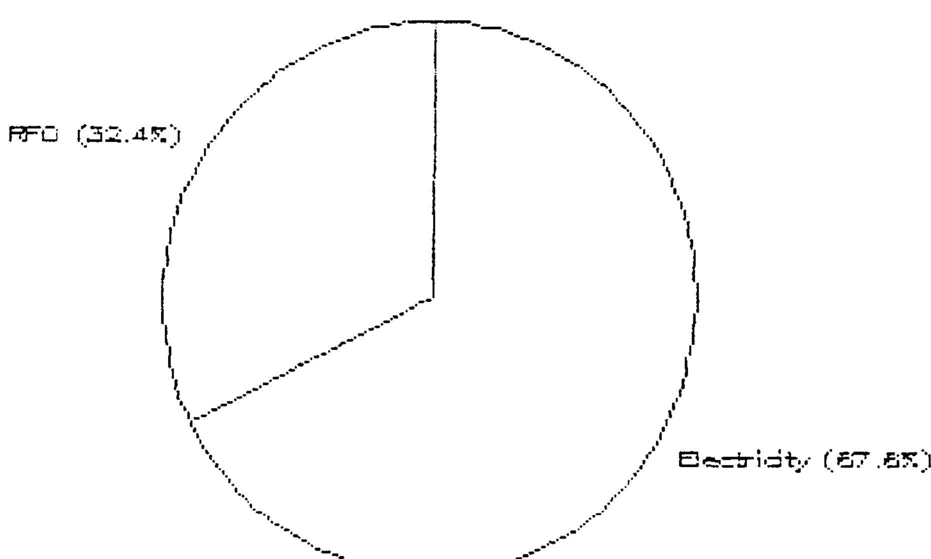


FIGURE 1.1

1.2 Target 1 - Short Term Energy Savings

By adopting a vigorous energy management programme and implementing the short term recommendations listed in Table 1.4 which, in general, require minimum investment levels, a Target 1 energy intensity of 8.34 GJ/t could be achieved. Plant energy consumption at current production levels would be reduced by 5 900 GJ/a or 7.1% of present consumption, a saving of 865 000 KSh/a, or 10.4% of 1984 energy costs, as summarised in Table 1.2 below.

TABLE 1.2 - TARGET 1 - SHORT TERM ENERGY SAVINGS

Energy Form	SPECIFIC ENERGY Usage GJ/t	Target GJ/t	Savings GJ/t	Percent Savings %	ENERGY COSTS Actual kKSh	Target kKSh	Savings kKSh	Percent Savings %
Electricity	3.46	3.10	0.36	10.4	5 622	4 892	730	13.0
Fuel Oil	5.52	5.24	0.28	5.1	2 691	2 556	135	5.0
Total	8.97	8.34	0.64	7.1	8 313	7 448	865	10.4

Some figures subject to rounding errors.

1.3 Target 2 - Long Term Energy Savings

By implementing the long term recommendations listed in Table 1.4 which, in general, require some capital investment, and subject to further more detailed evaluation of engineering and economic feasibility, it is estimated that a Target 2 energy consumption will fall to 7.3 GJ/t and energy costs will be reduced by a further 486 000 KSh/a or 5.8% of 1984 process energy costs, as summarised in Table 1.3 below.

TABLE 1.3 - TARGET 2 - LONG TERM ENERGY SAVINGS

Energy Form	SPECIFIC ENERGY Current GJ/t	T1 GJ/t	T2 GJ/t	ENERGY COSTS Current kKSh	T1 kKSh	T2 kKSh	Savings kKSh
Electricity	3.46	3.10	3.1	5 622	4 892	4 892	-
Fuel Oil	5.52	5.24	4.2	2 691	2 556	2 070	486
Total	8.97	8.34	7.3	8 313	7 448	6 962	486

Figures subject to rounding errors.

1.4 Recommended Projects to achieve Target Energy Savings

Table 1.4 summarises the short term (T1) and long term (T2) projects identified to achieve the targeted energy savings at ESW. Reference is given to the report chapter in which a more detailed discussion of the proposal may be located.

TABLE 1.4 - RECOMMENDATIONS

Project Description	Energy Saving GJ/a	Cost Saving kKSh/a	Capital Cost kKSh	Payback Time Years	Reference Chapter
Target 1: Short Term Energy Savings					
Electricity:					
. Monitor and control consumption) . Repair leaks in compressed air system) . Further modernise lighting system)	3 340	586	300-600	0.5-1	5
. Install MD control)	-	144	10*	1 mth	5
RFO:					
. Adjust fuel air ratio on burners by monitoring exhaust gases	2 560	135	10	1 mth	6
Target 2: Long Term Energy Savings					
1 Billet soaking pit and recuperator**	8 905	468	1 707	3.7	9
2 Billet soaking pit**	2 174	114	318	2.8	9
3 . RFO oil preheater	340	18	57	3.2	9

* Simplest system, other complex systems 9 to 15 times this cost.
** Either 1 or 2.

ENERGY AUDIT REPORT

Executive Summary

FIRESTONE EAST AFRICA (1969) LTD
NAIROBI, KENYA

1.0 EXECUTIVE SUMMARY

1.1 Overview

Firestone East Africa (1969) Ltd (FEA), situated just outside Nairobi, is Kenya's only tyre, tube and flap manufacturer, producing several popular lines for domestic and export markets as well as compound stock for the retread market.

FEA is a well engineered and operated plant, with good process control and good access to parent company engineering expertise. It is believed however that some opportunities do exist for further improvement in energy conservation, and subsequent sections set out the target energy intensities (T1 and T2), and the savings that can be made in production costs if these targets are achieved. This report outlines those opportunities.

The energy consumption for CY 1984, utilisation and target energy intensities (T1 and T2) for FEA are summarised in Table 1.1. The percentage cost and consumption of the various energy forms used at FEA, principally electricity, fuel oil, diesel oil (automotive), LPG and gasoline, are shown pictorially in Figure 1.1. Gasoline, diesel oil and LPG, being transport fuels, are not studied in this report or included in any derivation of energy intensity but are included in this summary to indicate their contribution to total energy costs. Fuel oil and electricity in CY 1984 account for 54.8% and 31.5% respectively of all energy costs reported, or 63.5% and 36.5% respectively if transport fuels are excluded.

Energy intensity for CY 1984 at FEA as measured in gigajoules of energy consumed per tonne of production was 20.4 GJ/t. The current energy cost is 1775 KSh/t. The report shows how it is believed that this energy intensity and cost can be reduced, firstly to a Target 1 level of 19.6 GJ/t and 1 710 KSh/t and then, with some level of investment, to a Target 2 level of 18.9 GJ/t and 1 642 KSh/t. The cost reductions at present production levels extend to an annual savings of 552 000 KSh/a at Target 1 and a further 572 000 KSh/a at Target 2. Only investments that show an internal rate of return (IRR) of over 15% after allowance for tax and depreciation are considered.

The estimates for energy saving opportunities are based on actual measurements or engineering-economic judgement following the site visits. Cost and savings are approximate and additional engineering and economic feasibility investigation, particularly to take account of continuing variations in energy costs, will be necessary before proceeding with any of the projects identified. Indeed it should be observed that since the time of the 1985 audit, international fuel oil prices have fallen dramatically, while the economic and market prices of both electricity and fuelwood have risen.

TABLE 1.1 - OVERALL ENERGY USAGE AND COST REPORT

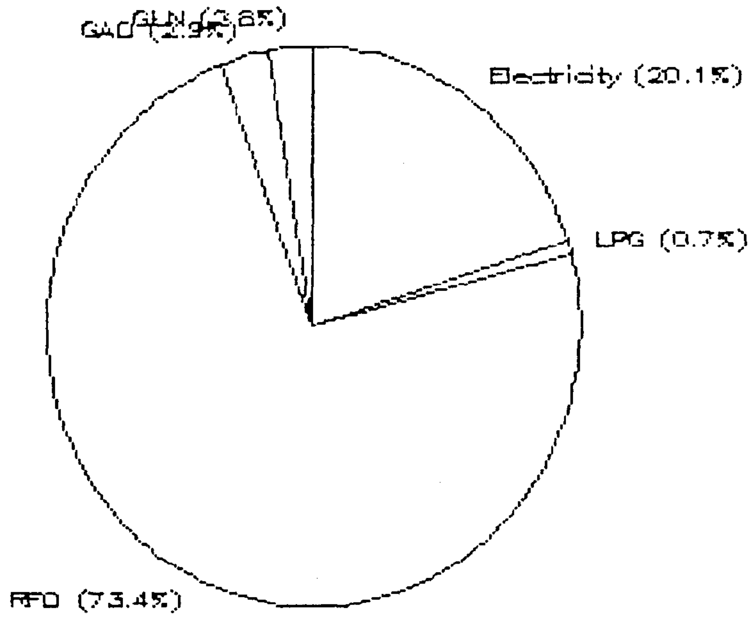
Period:	CY	1984
Total Production:	t	8 470
Energy Consumption:	GJ	172 947
Energy Intensity:	GJ/t	20.4
Energy Cost:	kKSh	15 033
Specific Energy Cost:	kKSh/t	1 775
Energy Intensity Targets:		
Target 1	GJ/t	19.6
Target 2	GJ/t	18.9
Potential Energy Savings:		
Target 1 Achieved	GJ/t	.8
Target 2 Achieved	GJ/t	.7
Potential Cost Savings:		
Target 1 Achieved	KSh/t	65
Target 2 Achieved	KSh/t	68

Note: Transport fuels are excluded from all analyses.

FIGURE 1.1

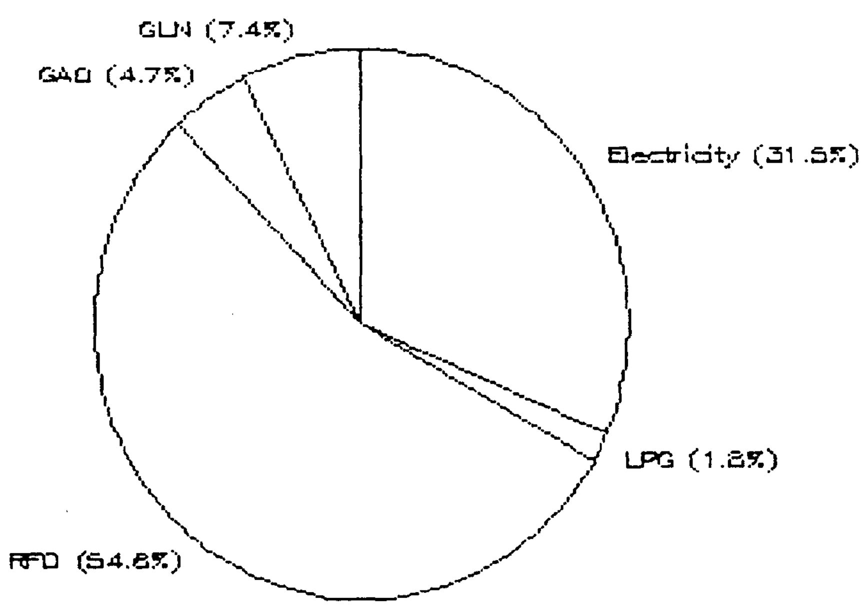
ENERGY CONSUMPTION

FIRESTONE E.A. LTD CY 1984



ENERGY COSTS

FIRESTONE E.A. LTD CY 1984



1.2 Target 1 - Short Term Energy Savings

By adopting a vigorous energy management programme and implementing the short term recommendations listed in Table 1.4 which, in general, require minimum investment levels, a Target 1 energy intensity of 19.6 GJ/t could be achieved. Plant energy consumption at current production levels would be reduced by 6 517 GJ/a or 4% of present process consumption, a saving of 1 552 000 KSh/a, or 4% of 1984 process energy costs, as summarised in Table 1.2 below.

Section 1.4 following sets out in summary form the projects proposed to achieve Target 1 energy and cost savings.

TABLE 1.2 - TARGET 1 - SHORT TERM ENERGY SAVINGS

	SPECIFIC ENERGY				ENERGY COSTS			
Energy Form	Usage GJ/t	Target GJ/t	Savings GJ/t	Percent Savings %	Current kKSh	Target kKSh	Savings kKSh	Percent Savings %
Electricity	4.4	4.4	-	-	5 498	5 396	102	2
Fuel Oil	16.0	15.2	.8	5	9 535	9 085	450	5
Total	20.4	19.6	.8	4	15 033	14 481	552	4

Some figures subject to rounding errors.

1.3 Target 2. Long Term Energy Savings

By implementing the long term T2 recommendations listed in Table 1.4 which, in general require some capital investment, and subject to further more detailed evaluation of engineering and economic feasibility and assuming all T1 recommendations have already been implemented, it is estimated that the Target 2 specific energy consumption would be reduced to 18.9 GJ/t and the energy cost would be reduced giving a further saving of around 572 000 KSh/a or a total saving of 7% of CY 1984 energy costs.

TABLE 1.3 - TARGET 2 - LONG TERM ENERGY SAVINGS

Energy form	SPECIFIC ENERGY Current GJ/t	T1 GJ/t	T2 GJ/t	ENERGY COSTS Current kKSh	T1 kKSh	T2 kKSh	Savings kKSh
Electricity	4.4	4.4	4.4	5 498	5 396	5 396	-
Fuelwood	16.0	15.2	14.5	9 535	9 085	8 513	572
Total	20.4	19.6	18.9	15 033	14 481	13 909	572

Figures subject to rounding errors.

1.4 Recommended Projects to achieve Target Energy Savings

Table 1.4 summarises the short term T1 and long term T2 projects identified to achieve the targeted energy savings. Reference is given to the report chapter in which a more detailed discussion of the proposal may be located.

TABLE 1.4 - RECOMMENDATIONS

Project Description	Energy Saving GJ/a	Cost Saving kKSh/a	Capital Cost kKSh	Payback Time Years	Reference Chapter Number
Target 1 -Short Term					
1. Maximum demand control	N/A	90	25	.3	5
2. Repair steam leaks	2 574	180	75	.4	7
3. Improve lagging	2 574	180	100	.6	7
4. Improve condensate return	1 287	90	30	.4	7
5. Repair compressed air leaks	82	12	-	N/A	8
Target 2 - Long Term					
1. Boiler oxygen trim	4 290	300	800	2.7	7
2. Recover heat of refrigeration	1 837	272	210	.8	9

ENERGY AUDIT REPORT

Executive Summary

KALUWORKS LIMITED
MOMBASA, KENYA

1.0 EXECUTIVE SUMMARY

1.1 Introduction

Kaluworks is the major manufacturer of enamelware, aluminiumware and plastic products in Kenya. Process heating is the major energy user in the plant. Overall energy usage and costs are summarised in Table 1.1. During 1984, electricity cost 1 248 000 KSh, RFO 732 000 KSh, IDP 644 000 KSh and LPG 278 000 KSh.

The estimates for energy saving opportunities are based on actual measurements or engineering-economic judgement following the site visits. Cost and savings are approximate and additional engineering and economic feasibility investigation, particularly to take account of continuing variations in energy costs, will be necessary before proceeding with any of the projects identified. Indeed it should be observed that since the time of the 1985 audit, international fuel oil prices have fallen dramatically, while the economic and market prices of both electricity and fuelwood have risen.

Figure 1.1 shows the energy consumption and cost pictorially.

TABLE 1.1 - ENERGY SUMMARY

		1984
Total production	t	1 769
Energy consumption	GJ	27 483
Energy intensity	GJ/t	15.5
Energy cost	kKSh	2 625
Specific energy cost	KSh/t	1 489
Energy intensity targets		
Target T1	GJ/t	12.1
Target T2	GJ/t	N/A
Potential energy savings		
Target T1	GJ/t	3.4
Target T2	GJ/t	N/A
Potential energy costs		
Target T1	KSh/t	1 188
Target T2	KSh/t	N/A

Notes: LPG excluded from all analyses.

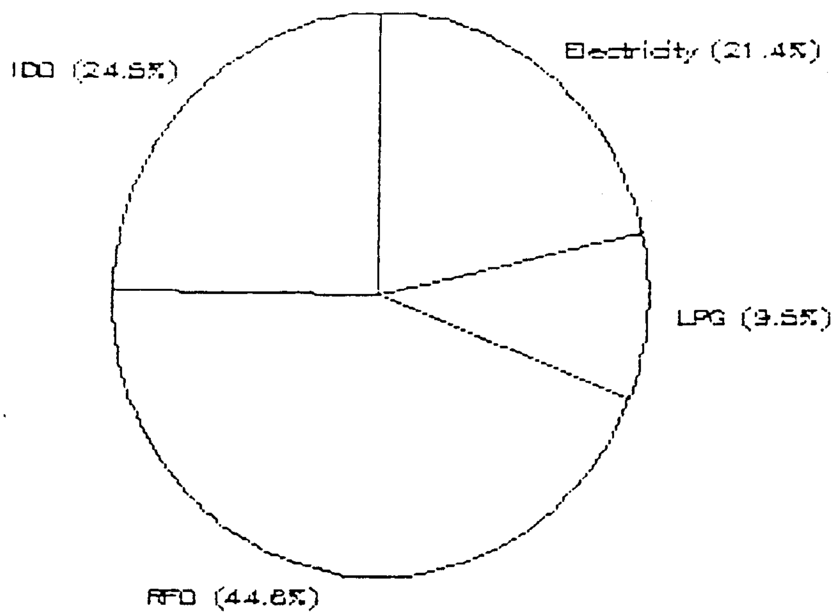
It is recommended that an Energy Manager be appointed, with responsibilities for execution of the projects below. He should also implement staff training and awareness activities.

Kaluworks has a number of major energy conservation and/or reduction opportunities. The estimates for such opportunities are based on actual measurements or engineering-economic judgement following the site visit. Cost and savings are approximate.

FIG 1.1

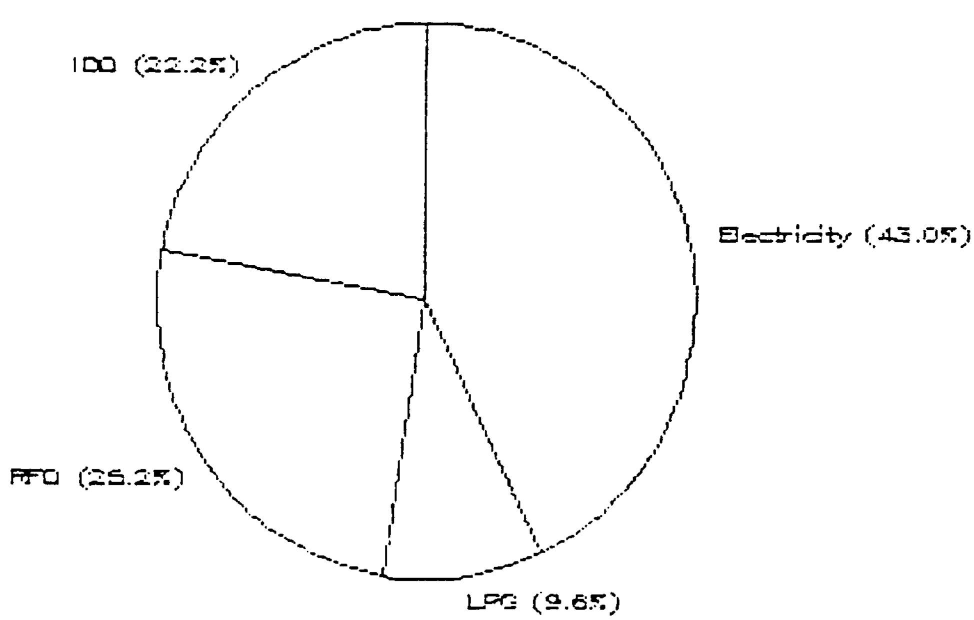
ENERGY CONSUMPTION

KALUWORKS LTD CY 1985



ENERGY COSTS

KALUWORKS LTD CY 1985



1.2 Recommended Projects to Achieve Target Energy Savings

Table 1.2 summarises the short term, T1, and long term, T2, projects identified to achieve the targeted energy savings at Kaluworks. A more detailed discussion of each proposal may be found in the reference chapter.

TABLE 1.2 - RECOMMENDATIONS

Project	Cost Saving kKSh/a	Capital Cost kKSh	Payback Time Years	Reference Chapter
Target 1: Short Term Energy Savings				
1 Insulate pickling vats (No. 1 line)	340	130	.4	6
2 Tune up enamel furnace	56	10	.2	6
3 Tariff switch	82	N/A	N/A	5

1.3 Target 1: Short Term Energy Savings

By adopting a vigorous energy management programme and implementing the short term T1 recommendations listed in Table 1.2, which in general require minimum investment levels, a Target 1 specific energy cost of 1 188 KSh/T could be achieved, giving a saving of around 522 000 KSh/a, or 20% of CY 1984 process energy costs as summarised in Table 1.3.

TABLE 1.3 - TARGET 1: SHORT TERM ENERGY SAVINGS

Energy form	Specific Energy Current GJ/T	Specific Energy Target GJ/T	Specific Energy Savings GJ/T	Energy Cost Current kKSh	Energy Cost Target kKSh	Energy Cost Savings kKSh	Percent Savings %
Electricity	3.7	3.7	N/A	1 248	1 166	82	7
Fuel oil	11.8	8.4	3.4	1 376	936	440	32
Total	15.5	12.1	3.4	2 624	2 102	522	20

1.4 Target 2: Long Term Energy Savings

In this somewhat unusual instance there are no long term T2 recommendations - the insulation of the pickling vats shows such quick returns that it has been treated as a T1 project.

ENERGY AUDIT REPORT

Executive Summary

KENYA BREWERIES LIMITED
TUSKER BREWERY
NAIROBI, KENYA

1.0 EXECUTIVE SUMMARY

1.1 Overview

Kenya Breweries Limited (KBL) Tusker Brewery, situated at Ruaraka just outside Nairobi, is one of the three breweries in Kenya. All are operated by KBL which belongs to East African Breweries Ltd. For the purposes of this report the abbreviation KBL is taken to refer to the Tusker Brewery only.

KBL is a well engineered and operated plant, with good process control and access to international brewing technology through Allied Lyons Ltd, and also a Mutual Technical Co-operation Agreement with Zimbabwe Breweries Ltd under which the two breweries exchange information and experience. It is believed that opportunities do however exist for further improvement of energy conservation, and subsequent sections set out the target energy intensities (T1 and T2) and the savings that can be made in production costs if these targets are achieved. This report outlines these opportunities.

The energy consumption for CY 1982 to 1984 , utilisation and target energy intensitites (T1 and T2) for KBL are summarised in Table 1.1. The percentage cost and consumption of the various energy forms used at KBL, principally fuel oil, electricity, diesel oil and LPG, are shown pictorially in Figure 1.1. Gasoline, automotive diesel and LPG, being transport fuels, are not studied in this report or included in any derivation of energy intensity but are included in this summary to indicate their substantial 'slice' of total energy costs. Fuel oil and electricity in CY 1984 account for 43.9% and 23.7% respectively of all energy costs reported, or 64.9% and 35.1% respectively when transport fuels are excluded.

Energy intensity at KBL for CY 1984 as measured in gigajoules of energy consumed per thousand litres excluding transport fuels was 2.97 GJ/kL. The current energy cost excluding transport fuels is 229 KSh/kL. The report shows how it is believed that this energy intensity and cost can be reduced, firstly to a Target 1 level of 2.25 GJ/kL and 217 KSh/kL, and then, with some level of investment, to a Target 2 level of 2.36 GJ/kL and 91 KSh/kL. It will be noted that the energy intensity has increased above the T1 value, while the specific energy cost has dropped substantially. This results from the proposed installation of a back pressure turbine to generate plant electricity using fuelwood as the energy source.

The cost reductions at present production levels extend to an annual savings of 8 458 000 KSh/a at Target 1 and a further 22 837 000 KSh/a at Target 2. Investments are only contemplated that show an internal rate of return (IRR) of over 15% after allowance for tax and depreciation.

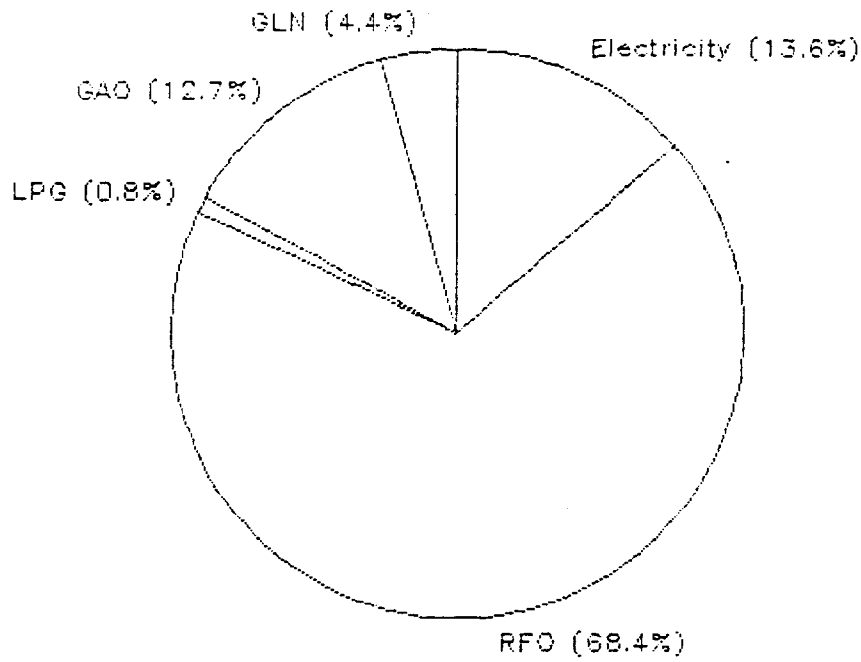
All estimates for energy saving opportunities are based on actual measurements or engineering-economic judgement following the site visits. Cost and savings are approximate and additional engineering and economic feasibility investigation, particularly to take account of continuing variations in energy costs, will be necessary before proceeding with any of the projects identified. Indeed it should be observed that since the time of the 1985 audit, international fuel oil prices have fallen dramatically, while the economic and market prices of both electricity and fuelwood have risen.

TABLE 1.1 - OVERALL ENERGY USAGE AND COST REPORT

Plant:				
Period:	CY	1982	1983	1984
Total Production:	ML	192	146	165
Energy Consumption:	GJ	611 329	513 723	491 532
Energy Intensity:	GJ/kL	3.185	3.553	2.972
Energy Cost:	kKSh	42 842	38 769	37 921
Specific Energy Cost:	KSh/kL	223	235	229
Energy Intensity Targets:				
Target 1	GJ/kL			2.25
Target 2	GJ/kL			2.36
Potential Energy Savings:				
Target 1 Achieved	GJ/kL			0.73
Target 2 Achieved	GJ/kL			(0.11)
Potential Cost Savings:				
Target 1 Achieved	KSh/kL			11.7
Target 2 Achieved	KSh/kL			138.4

Note: Transport fuels are excluded from all analyses.

ENERGY CONSUMPTION
KENYA BREWERIES LTD CY 1984



ENERGY COSTS
KENYA BREWERIES LTD CY 1984

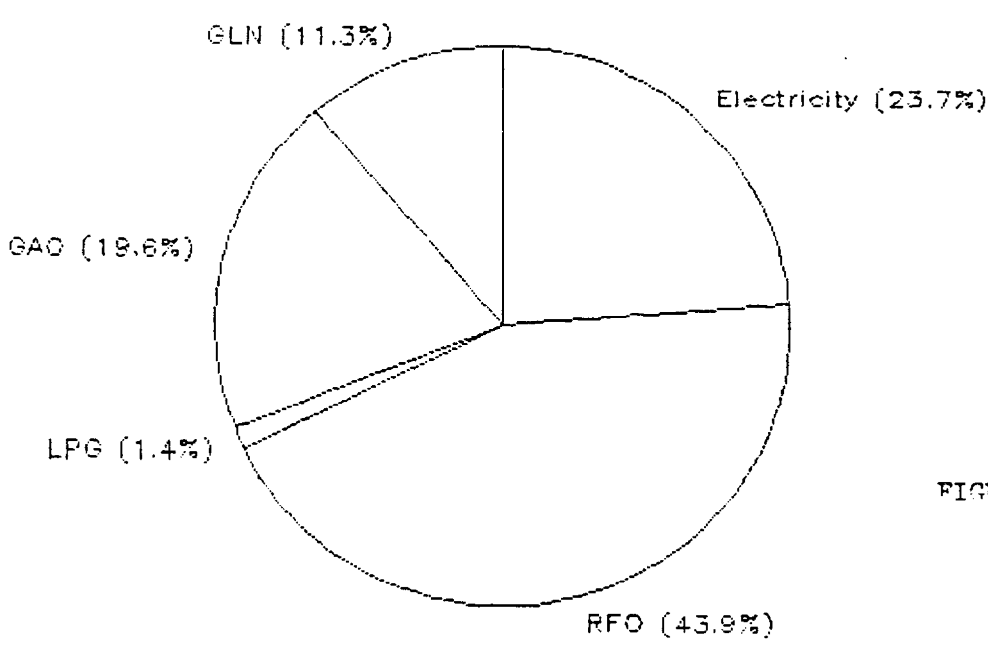


FIGURE 1.1

1.2 Target 1 - Short Term Energy Savings

By adopting a vigorous energy management programme and implementing the short term T1 recommendations listed in Table 1.4 which generally requires minimum investment levels, a Target 1 energy intensity of 2.25 GJ/kL can be achieved. Plant energy consumption at 1984 production levels would be reduced by 119 513 GJ/a or 24.3% of 1984 consumption, a saving of 8 458 000 KSh/a or over 22% of CY 1984 energy costs, as summarised in Table 1.2 below.

Section 1.4 following sets out in summary form the projects proposed to achieve Target 1 energy and cost savings.

TABLE 1.2 - TARGET 1 - SHORT TERM ENERGY SAVINGS

	SPECIFIC ENERGY				ENERGY COSTS			
Energy Form	Usage GJ/kL	Target GJ/kL	Savings GJ/kL	Percent Savings %	Actual kKSh	Target kKSh	Savings kKSh	Percent Savings %
Electricity	0.5	0.43	0.07	13.2	13 303	11 375	1 928	14.5
Fuel Oil	2.48	1.82	0.66	26.5	24 618	18 088	6 530	26.54
Total	2.98	2.25	0.73	24.3	37 921	29 463	8 458	22.3

Some figures subject to rounding errors.

1.3 Target 2 - Long Term Energy Savings

By implementing the long term T2 recommendations listed in Table 1.4 which, in general require some capital investment, and subject to further more detailed evaluation of engineering and economic feasibility, and assuming all T1 recommendations have already been implemented, it is estimated that Target 2 energy consumption will remain relatively constant. However energy costs will be reduced by a further 22 837 000 KSh/a or 60% of CY 1984 energy costs as summarised in Table 1.3 below.

TABLE 1.3 - TARGET 2 - LONG TERM ENERGY SAVINGS

Energy Form	SPECIFIC ENERGY Current GJ/ML	T1 GJ/ML	T2 GJ/ML	ENERGY COSTS Current kKSh	T1 kKSh	T2 kKSh	Savings kKSh
Electricity	0.5	0.43	-	13 303	11 375	-	11 375
Fuel Oil	2.48	1.82	-	24 618	18 088	-	18 088
Wood	-	-	2.36	-	-	6 626	(6 626)
Total	2.98	2.25	2.36	37 921	29 463	6 626	22 837

Figures subject to rounding errors.

1.4 Recommended Projects to achieve Target Energy Savings

Table 1.4 summarises the short term (T1) and long term (T2) projects identified to achieve the targeted energy savings at KBL. Reference is given to the report chapter in which a more detailed discussion of the proposal may be located.

TABLE 1.4 - RECOMMENDATIONS

Project Description	Energy Saving GJ/a	Cost Saving kKSh/a	Capital Cost kKSh	Payback Time Years	Reference Chapter Number
Target 1 - Short Term					
1. Optimise energy utilisation					
- electricity	10 700	1 740	900	6 mths	5
- RFO	46 200	2 774	4 800	2 mths	6
2. MD control	-	170	90-150	6-11 mths	5
3. Replace office air conditioning units with fans	113	18.3	40	2.2	5
4. Overhaul steam system	62 500	3 756	3 756	1	7
Target 2 - Long Term					
1. Fit cyclonic combustors to the existing boilers - use wood fuel	(34 550)	12 618	6 912	6 mths	11
2. Install a 4MW T/A set and generate electricity if No. 1 proceeds	93 087	10 208	16 730	1.7	11

ENERGY AUDIT REPORT

Executive Summary

KENYA CALCIUM PRODUCTS LIMITED
MOMBASA, KENYA

1.0 EXECUTIVE SUMMARY

1.1 Overview

Kenya Calcium Products (KCP) is situated just south of Mombasa and approximately 500 km from Nairobi. It is one of Kenya's lime manufacturing plants and part of the Homa Bay group.

KCP is a small plant mostly manually operated with little or no process control. It is believed that opportunities exist for improvement in energy utilisation, and subsequent sections of this report set out target energy intensities (T1 and T2), and the savings that can be made in production costs if these targets are achieved.

The energy consumption for CY 1984, utilisation and target energy intensities (T1 and T2) for KCP are summarised in Table 1.1. The percentage cost and consumption of the various energy forms used at KCP, principally electricity and wood, are shown pictorially in Figure 1.1. Diesel oil (GAO) being a transport fuel, is not studied in this report or included in any derivation of energy intensity but is included in the summary to indicate its contribution to total energy costs. Wood and electricity in CY 1984 account for 75% and 7% respectively of all energy costs reported.

Energy intensity for CY 1984 measured in gigajoules of energy consumed per tonne of product was 15.1 GJ/t. The current energy cost is 278 KSh/t. The report shows how it is believed that this energy intensity and cost can be reduced, firstly to a Target 1 level of 13.9 GJ/t and 252 KSh/t, and then, with some level of investment, to a Target 2 level of 12.5 GJ/t and 228 KSh/t. The cost reductions at present production levels extend to an annual savings of 192 000 KSh/a at Target 1 and a further 179 000 KSh/a at Target 2. Only investments that show an internal rate of return (IRR) of over 15% after allowance for tax and depreciation are considered.

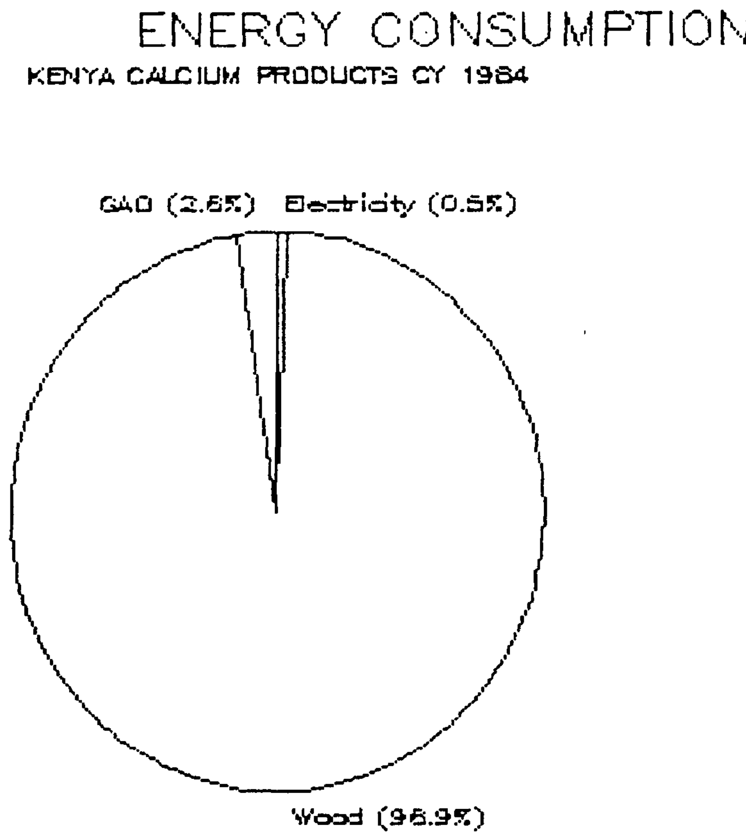
The estimates for energy saving opportunities are based on actual measurements or engineering-economic judgement following the site visits. Cost and savings are approximate and additional engineering and economic feasibility investigation, particularly to take account of continuing variations in energy costs, will be necessary before proceeding with any of the projects identified. Indeed it should be observed that since the time of the 1985 audit, international fuel oil prices have fallen dramatically, while the economic and market prices of both electricity and fuelwood have risen.

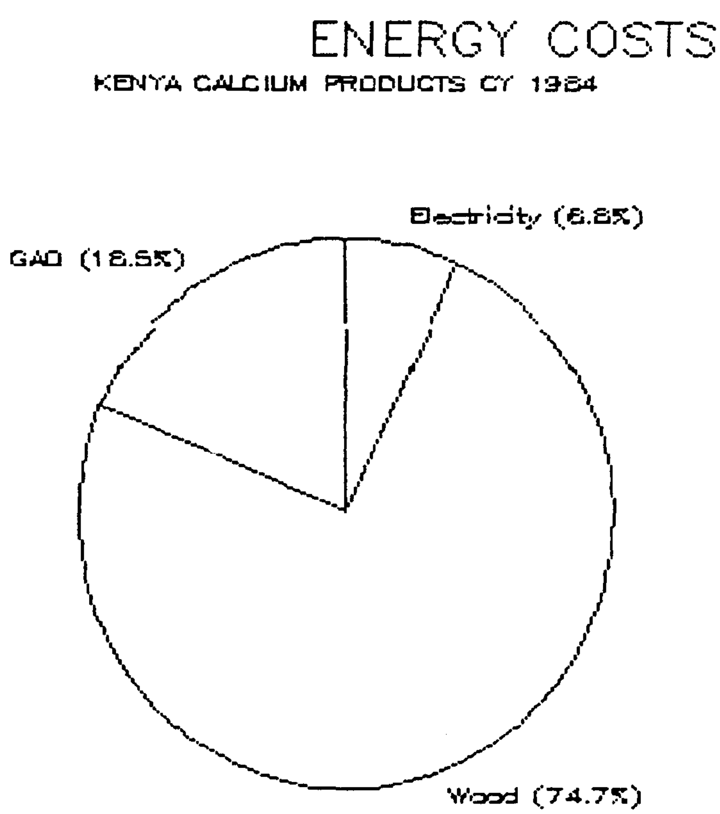
TABLE 1.1 - OVERALL ENERGY USAGE AND COST REPORT

Plant:		
CY :		1984
Total Production:	tonnes	7 637
Energy Consumption:	GJ	114 960
Energy Intensity:	GJ/t	15.1
Energy Cost:	kKSh	2 126
Specific Energy Cost:	KSh/t	278
Energy Intensity Targets:		
Target 1	GJ/t	13.90
Target 2	GJ/t	12.5
Potential Energy Savings:		
Target 1 Achieved	GJ/t	1.2
Target 2 Achieved	GJ/t	1.4
Potential Cost:		
Target 1 Achieved	KSh/t	252
Target 2 Achieved	KSh/t	228

Note: Transport fuels are excluded from all analyses.

FIGURE 1.1


ENERGY CONSUMPTION
KENYA CALCIUM PRODUCTS CY 1984
GAO (2.6%)
Electricity (0.5%)
Wood (96.9%)


ENERGY COSTS
KENYA CALCIUM PRODUCTS CY 1984
Electricity (6.8%)
GAO (18.5%)
Wood (74.7%)

1.2 Target 1 - Short Term Energy Savings

By adopting a vigorous energy management programme and implementing the short term recommendations listed in Table 1.4 which, in general, require minimum investment levels, a Target 1 energy intensity of 13.9 GJ/t could be achieved. Plant energy consumption at current production levels would be reduced by 9 000 GJ/a or 8% of present process consumption, a saving of 192 000 KSh/a, or 9% of 1984 process energy costs, as summarised in Table 1.2 below.

Section 1.4 following sets out in summary form the projects proposed to achieve Target 1 energy and cost savings.

TABLE 1.2 - TARGET 1 - SHORT TERM ENERGY SAVINGS

	SPECIFIC ENERGY				ENERGY COSTS			
Energy Form	Usage GJ/t	Target GJ/t	Savings GJ/t	Percent Savings %	Current kKSh	Target kKSh	Savings kKSh	Percent Savings %
Electricity	.1	.1	-	-	177	141	36	20
Fuelwood	15.0	13.8	1.2	8	1 949	1 793	156	8
Total	15.1	13.9	1.2	8	2 126	1 934	192	9

Some figures subject to rounding errors.

1.3 Target 2: Long Term Energy Savings

By implementing the long term T2 recommendations listed in Table 1.4 which, in general require some capital investment, and subject to further more detailed evaluation of engineering and economic feasibility and assuming all T1 recommendations have already been implemented, it is estimated that the Target 2 specific energy consumption would be reduced to 12.5 GJ/t and the energy cost would be reduced giving a further saving of around 381 000 KSh/a or a total saving of 18% of CY 1984 energy costs.

TABLE 1.3 - TARGET 2 - LONG TERM ENERGY SAVINGS

Energy Form	SPECIFIC ENERGY Current GJ/t	T1 GJ/t	T2 GJ/t	ENERGY COSTS Current kKSh	T1 kKSh	T2 kKSh	Savings kKSh
Electricity	.1	.1	.1	177	141	141	-
Fuelwood	15.0	13.8	12.4	1 949	1 793	1 614	179
Total	15.1	13.9	12.5	2 126	1 934	1 755	179

Figures subject to rounding errors.

1.4 Recommended Projects to achieve Target Energy Savings

Table 1.4 summarises the short term and long term projects identified to achieve the targeted energy savings at KCP Ltd. Reference is given to the report chapter in which a more detailed discussion of the proposal may be located.

TABLE 1.4 - RECOMMENDATIONS

Project Description	Energy Saving GJ/a	Cost Saving kKSh/a	Capital Cost kKSh	Payback Time Years	Reference Chapter Number
Target 1 -Short Term					
1. Maximum demand control	N/A	36	25	.8	5
2. Optimised charging	9 000	156	N/A	N/A	4
Target 2 - Long Term					
1. Fluidised bed combustor	10 518	179	585	3.0	7

ENERGY AUDIT REPORT

Executive Summary

KENYA CANNERS LTD
THIKA, KENYA

1.0 EXECUTIVE SUMMARY

1.1 Overview

Kenya Canners Limited (KCL) is situated at Thika about 40 km north of Nairobi. It is Kenya's only pineapple cannery and markets several products under the Kengold brandname. These include slices, pieces, crushed fruit, juice and concentrate.

KCL is an excellently engineered, managed and operated plant, with good process control and good access to parent company engineering expertise from Del Monte Corporation, California, USA. It is believed that opportunities do exist however for further improvement in energy conservation, and subsequent sections set out the target energy intensities (denoted T1 and T2) and the savings that can be made in production costs if these targets are achieved. This report outlines those opportunities.

The energy consumption for FY 1982 to 1984, utilisation and target energy intensities (T1 and T2) for KCL are summarised in Table 1.1. The percentage cost and consumption of the various energy forms used at KCL, principally electricity, fuel oil, gas oil, LPG and gasoline, are shown pictorially in Figure 1.1. Gasoline (GLN), diesel oil (GAO) and LPG, being transport fuel, are not studied in this report or included in any derivation of energy intensity but are included in the summary to indicate their contribution to total energy costs. Fuel oil and electricity in FY 1984 account for 31.4% and 13.8% respectively of all energy costs reported, or 69.5% and 30.5% if transport fuels are excluded.

Energy intensity for FY 1984 at KCL as measured in gigajoules of energy consumed per tonne of product excluding transport fuels was 1.89 GJ/t. The current energy cost excluding transport fuels, is 142 KSh/t. The report shows how this energy intensity and cost can be reduced, firstly to a Target 1 level of 1.05 GJ/t and 80 KSh/t, and then, with some level of investment, to a Target 2 level of 1.23 GJ/t but a cost of 21 KSh/t. The cost reductions at present production levels extend to an annual savings of 6 983 000 KSh/a at Target 1 and a further 6 622 000 KSh/a at Target 2. Investments are only contemplated that show an internal rate of return (IRR) of over 15% after allowance for tax and depreciation, and also exceed KCL's requirement of a two year simple payback.

The above findings are subject to require verification of some anomalies in the data obtained. When these have been resolved, the savings indicated may be reduced.

All estimates for energy saving opportunities are based on actual measurements or engineering-economic judgement following the site visits. Cost and savings are approximate and additional engineering and economic feasibility investigation, particularly to take account of continuing variations in energy costs, will be necessary before proceeding with any of the projects identified. Indeed it should be observed that since the time of the 1985 audit, international fuel oil prices have fallen dramatically, while the economic and market prices of both electricity and fuelwood have risen.

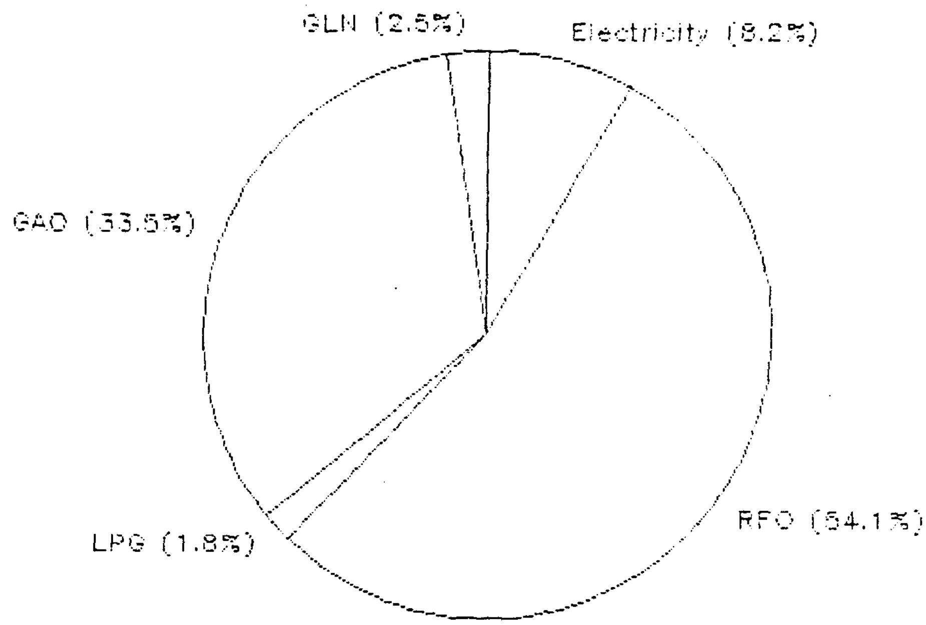
TABLE 1.1 - OVERALL ENERGY USAGE AND COST REPORT

Period:	CY	1982	1983	1984
Total Production:	t	86 966	105 450	112 195
Energy Consumption:	GJ	216 659	213 840	212 368
Energy Intensity:	GJ/t	2.49	2.03	1.89
Energy Cost:	kKSh	14 702	12 749	15 954
Specific Energy Cost:	kKSh/t	169	121	142
Energy Intensity Targets:				
Target 1	GJ/t			1.05
Target 2	GJ/t			1.23
Potential Energy Savings:				
Target 1 Achieved	GJ/t			0.84
Target 2 Achieved	GJ/t			(0.18)
Potential Cost Savings:				
Target 1 Achieved	KSh/t			62
Target 2 Achieved	KSh/t			41

Note: Transport fuels are excluded from all analyses.
Figures subject to rounding errors.

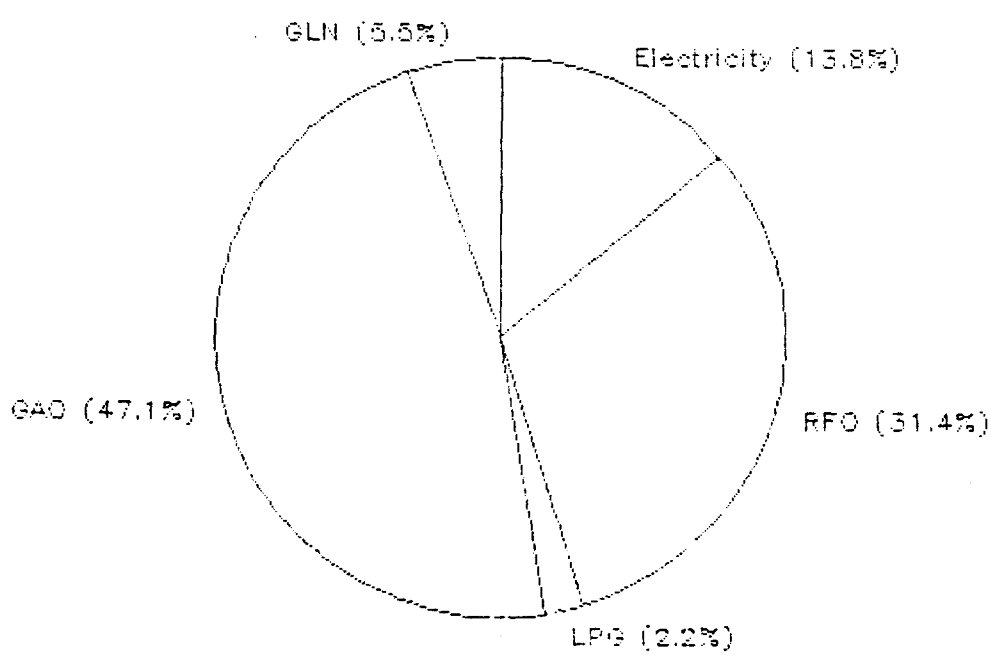
ENERGY CONSUMPTION

KENYA CANNERS LTD FY 1984



ENERGY COSTS

KENYA CANNERS LTD FY 1984



1.2 Target 1 - Short Term Energy Savings

By adopting a vigorous energy management programme and implementing the short term recommendations listed in Table 1.4 which, in general, require minimum investment levels, a Target 1 energy intensity of 1.05 GJ/t could be achieved. Plant energy consumption at current production levels would be reduced by 95 055 GJ/a or 44.4% of present process consumption, a saving of 6 983 000 MKSh/a, or 43.8% of 1984 process energy costs, as summarised in Table 1.2 below.

Section 1.4 following sets out in summary form the projects proposed to achieve Target 1 energy and cost savings.

TABLE 1.2 - TARGET 1 - SHORT TERM ENERGY SAVINGS

	SPECIFIC ENERGY				ENERGY COSTS			
Energy Form	Usage GJ/t	Target GJ/t	Savings GJ/t	Percent Savings %	Current kKSh	Target kKSh	Savings kKSh	Percent Savings %
Electricity	0.25	0.17	0.08	33.8	4 869	2 932	1 937	39.8
Fuel Oil	1.64	0.88	0.76	46.6	11 085	6 039	5 046	45.5
Total	1.89	1.05	0.84	44.4	15 954	8 971	6 983	43.8

Some figures subject to rounding errors.

1.3 Target 2 - Long Term Energy Savings

By implementing the long term recommendations (including short term recommendations) listed in Table 1.4 which, in general, require some capital investment, and subject to further more detailed evaluation of engineering and economic feasibility, it is estimated that a Target 2 energy consumption will be reduced to 1.23 GJ/t, while energy costs will be reduced by 6 622 000 KSh/a or 41.5% of 1984 process energy costs, as summarised in Table 1.3 below.

Section 1.4 following sets out in summary form the projects proposed to achieve Target 2 energy cost savings.

TABLE 1.3 - TARGET 2 - LONG TERM ENERGY SAVINGS*

Energy form	SPECIFIC ENERGY Current GJ/t	T1 GJ/t	T2 GJ/t	ENERGY COSTS Current kKSh	T1 kKSh	T2 kKSh	Savings kKSh
Electricity	0.25	0.17	-	4 869	2 932	-	2 932
Fuel oil	1.64	0.88	-	11 085	6 039	-	6 039
Fuelwood(1)	-	-	1.23	-	-	2 349	(2 349)
Total	1.89	1.05	1.23	15 954	8 971	2 349	6 622

*Figures subject to rounding errors.

(1) Assumes boiler converted to fuelwood firing and 2MWe t/a set installed.

1.4 Recommended Projects to achieve Target Energy Savings

Table 1.4 summarises the short term and long term projects identified to achieve the targeted energy savings at KCL Ltd. Reference is given to the report chapter in which a more detailed discussion of the proposal may be located.

TABLE 1.4 - RECOMMENDATIONS

Project Description	Energy Saving GJ/a	Cost Saving kKSh/a	Capital Cost kKSh	Payback Time Years	Reference Chapter Number
Target 1 - Short Term Energy Savings					
Electricity					
. Monitor and control consumption	8 470	1 480	74	0.5	5
. Progressively update lighting in factory	835	146	150	1	5
. Install MD alarm and control	-	311	90-150	0.3-0.5	5
RFO					
. Clean tubes and adjust air/fuel ratio	1 750	105	-	N/A	6
Steam					
. Monitor and control steam consumption; . Overhaul steam system as appropriate	84 000	5 046	2 085	0.5	7
Target 2 - Long Term Energy Savings					
1. Boiler conversion to burn woodfuel	(6 416)	4 213	8 000	1.9	10
2. Electricity and steam cogeneration	(19 103)	6 622	6 000	0.9	10
3. Recover heat of compression from refrigeration	1 102	66	100	1.5	10

ENERGY AUDIT REPORT

Executive Summary

KENYA CO-OPERATIVE CREAMERIES LTD
KITALE, KENYA

1.0 EXECUTIVE SUMMARY

1.1 Overview

Kenya Co-operative Creameries Limited (KCC) situated at Kitale, approximately 400km north west of Nairobi, is one of several creameries operated by KCC and others throughout the country. The Kitale creamery produces skim or standardised milk, butter and skim milk powder.

KCC Kitale is an excellently engineered and operated plant with good process control and good access to overseas dairy engineering expertise. It is believed that opportunities do exist however for further improvement in energy conservation, and subsequent chapters of the report set out the target energy intensities (T1 and T2) and the savings that can be made in production costs if these targets are achieved.

The energy consumption for CY 1983 and 1984, utilisation and target energy intensities (T1 and T2) for KCC are summarised in Table 1.1. The percentage cost and consumption of the various energy forms used at KCC, principally electricity and fuel oil, are shown pictorially in Figure 1.1. Fuel oil and electricity in CY 1984 account for around 50% each of all energy costs.

Energy intensity for CY 1983 at KCC as measured in gigajoules of energy consumed per tonne of production excluding transport fuels was 1.87 GJ/t at an energy cost of 131 KSh/t. The report shows how it is believed that this energy intensity and cost can be reduced, firstly to a Target 1 level of 1.76 GJ/t and 124 KSh/t, and then, with some level of investment, to a Target 2 level of 1.69 GJ/t and 61 KSh/t. The cost reductions at 1983 production levels extend to an annual savings of 256 000 KSh/a at Target 1 and a further 2 456 000 KSh/a at Target 2. Only investments that show an internal rate of return (IRR) of over 15% after allowance for tax and depreciation are considered.

The effect of intermittent production of powdered milk has a significant impact on the calculated energy levels. Savings have been based on a production regime that includes some powdered milk, that is the 1983 figures.

The estimates for energy saving opportunities are based on actual measurements or engineering-economic judgement following the site visit. Cost and savings are approximate, and additional engineering and economic feasibility investigation, particularly to take account of continuing variations in energy costs, will be necessary before proceeding with any of the projects identified. Indeed it should be observed that since the time of the 1985 audit, international fuel oil prices have fallen dramatically, while the economic and market prices of both electricity and fuelwood have risen.

TABLE 1.1 - OVERALL ENERGY USAGE AND COST REPORT

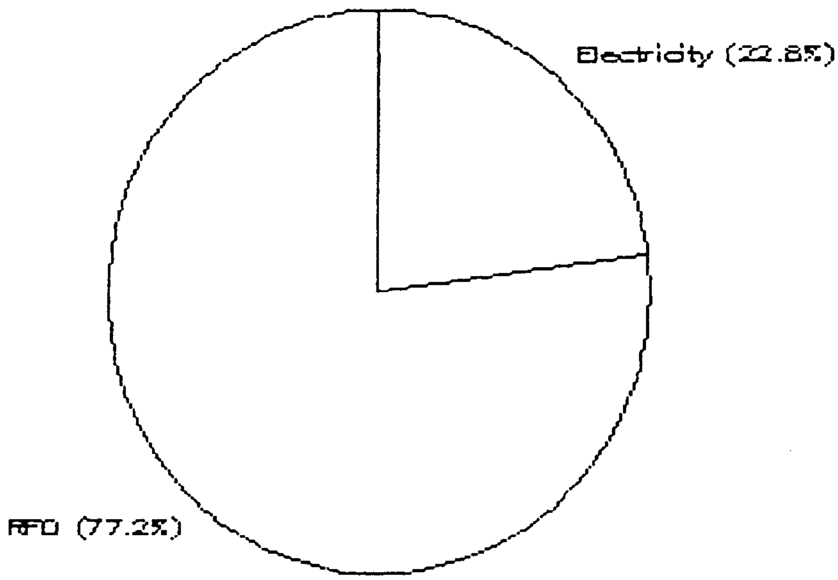
Period:	CY	1983	1984
Total Production: *	tonnes	39 155	31 359
Energy Consumption:	GJ	73 340	21 317
Energy Intensity:	GJ/t	1.87	0.68
Energy Cost:	kKSh	5 118	1 945
Specific Energy Cost:	KSh/t	131	62
Energy Intensity Targets:			
Target 1	GJ/t	1.76	
Target 2	GJ/t	1.69	
Potential Energy Savings:			
Target 1 Achieved	GJ/t	.11	
Target 2 Achieved	GJ/t	.07	
Potential Cost Savings:			
Target 1 Achieved	KSh/t	7	
Target 2 Achieved	KSh/t	63	

* Includes butter, milk and powdered milk.

FIGURE 1.1

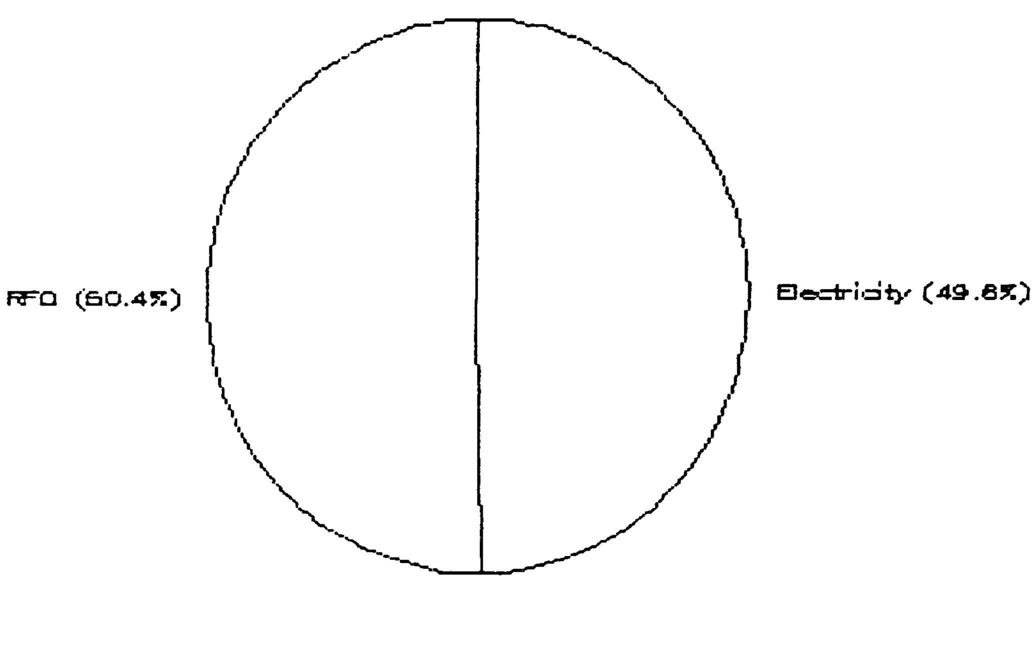
ENERGY CONSUMPTION

KENYA CO-OP CREAMERIES CY 1984



ENERGY COSTS

KENYA CO-OP CREAMERIES CY 1984



1.2 Target 1 - Short Term Energy Savings

By adopting a vigorous energy management programme and implementing the short term recommendations listed in Table 1.4 which, in general, require minimum investment levels, a Target 1 energy intensity of 1.76 GJ/t could be achieved. Plant energy consumption at current production levels would be reduced by 4 293 GJ/a or 6% of present process consumption, a saving of 256 000 KSh/a, or 5% of 1983 process energy costs, as summarised in Table 1.2 below. Note that 1984 was considered to be an atypical year due to the effects of drought.

Section 1.4 following sets out in summary form the projects proposed to achieve Target 1 energy and cost savings.

TABLE 1.2 - TARGET 1 - SHORT TERM ENERGY SAVINGS

	SPECIFIC ENERGY				ENERGY COSTS			
Energy Form	Usage GJ/t	Target GJ/t	Savings GJ/t	Percent Savings %	Current kKSh	Target kKSh	Savings kKSh	Percent Savings %
Electricity	.30	.30	-	-	1 464	1 464	-	-
Fuel oil	1.57	1.46	.11	7	3 654	3 398	256	7
Total	1.87	1.76	.11	6	5 118	4 862	256	5

Some figures subject to rounding errors.

1.3 Target 2: Long Term Energy Savings

By implementing the long term T2 recommendations listed in Table 1.4 which, in general require some capital investment, and subject to further more detailed evaluation of engineering and economic feasibility and assuming all T1 recommendations have already been implemented, it is estimated that the Target 2 specific energy consumption would be reduced to 1.69 GJ/t and the energy cost would be reduced giving a further saving of around 2 456 000 KSh/a or a total saving of 53% of CY 1983 energy costs.

TABLE 1.3 - TARGET 2 - LONG TERM ENERGY SAVINGS

Energy Form	SPECIFIC ENERGY Current GJ/t	T1 GJ/t	T2 GJ/t	ENERGY COSTS Current kKSh	T1 kKSh	T2 kKSh	Savings kKSh
Electricity	.30	.30	.30	1 464	1 464	1 464	-
Fuel oil	1.57	1.46	-	3 654	3 398	-	3 398
Fuelwood	-	-	1.39	-	-	942	(942)
Total	1.87	1.76	1.69	5 118	4 862	2 406	2 456

Figures subject to rounding errors.

1.4 Recommended Projects to achieve Target Energy Savings

Table 1.4 summarises the short term and long term projects identified to achieve the targeted energy savings at KCC. Reference is given to the report chapter in which a more detailed discussion of the proposal may be located.

TABLE 1.4 - RECOMMENDATIONS

Project Description	Cost Saving kKSh/a	Capital Cost kKSh	Payback Time Years	Reference Chapter Number
Target 1 -Short Term				
1. Improve combustion efficiency	73	50	.7	6
2. Modify steam supply system to reduce wetness and pressure drop	110	60	.6	7
3. Insulate condensate collection tank	73	30	.4	7
Target 2 - Long Term				
1. Boiler conversion to woodfuel	2 367	2 318	1	11
2. Recover heat of refrigeration	110	150	1.4	11

Figures subject to rounding errors.

Note: Cost savings for Project 2 increases from 100 kKSh/a to about 350 kKSh/a if boilers remain on RFO. Payback time reduces to 0.4 years.

ENERGY AUDIT REPORT

Executive Summary

KENYA GLASSWORKS LIMITED
MOMBASA, KENYA

1.0 EXECUTIVE SUMMARY

1.1 Overview

Kenya Glassworks Limited (KGL) is situated at Mombasa approximately 500 km from Nairobi and currently is Kenya's only glass container manufacturer.

KGL is a well engineered and operated plant, with good access to overseas glass making technology and engineering expertise. It is believed however that opportunities do exist for further improvement in energy conservation, and subsequent sections set out the target energy intensities (T1 and T2), and the savings that can be made in production costs if these targets are achieved. This report outlines those opportunities.

The energy consumption for CY 1984, utilisation and target energy intensities (T1 and T2) are summarised in Table 1.1. The percentage cost and consumption of the various energy forms used at KGL, principally electricity, fuel oil, and LPG are shown pictorially in Figure 1.1. Gas oil, being a transport fuel, is not studied in this report or included in any derivation of energy intensity but is included in this summary to indicate its contribution to total energy costs. Fuel oil and electricity in CY 1984 account for 64.1% and 21.2% respectively of all energy costs reported.

Energy intensity for CY 1984 at KGL as measured in gigajoules of energy consumed per tonne of product (GJ/t) excluding transport fuels was 18.8 GJ/t. The current energy cost is 1333 KSh/t. The report shows how it is believed that this energy intensity and cost can be reduced, firstly to a Target 1 level of 17.9 GJ/t and 1228 KSh/t, and then, with some level of investment, to a Target 2 level of 13.3 GJ/t and 878 KSh/t. The cost reductions at present production levels extend to an annual savings of 2.114 MKSh/a at Target 1 and a further 7 MKSh/a at Target 2. Investments are only contemplated that show an internal rate of return (ROR) of over 15% after allowance for tax and depreciation.

The estimates for energy saving opportunities are based on actual measurements or engineering-economic judgement following the site visits. Cost and savings are approximate and additional engineering and economic feasibility investigation, particularly to take account of continuing variations in energy costs, will be necessary before proceeding with any of the projects identified. Indeed it should be observed that since the time of the 1985 audit, international fuel oil prices have fallen dramatically, while the economic and market prices of both electricity and fuelwood have risen.

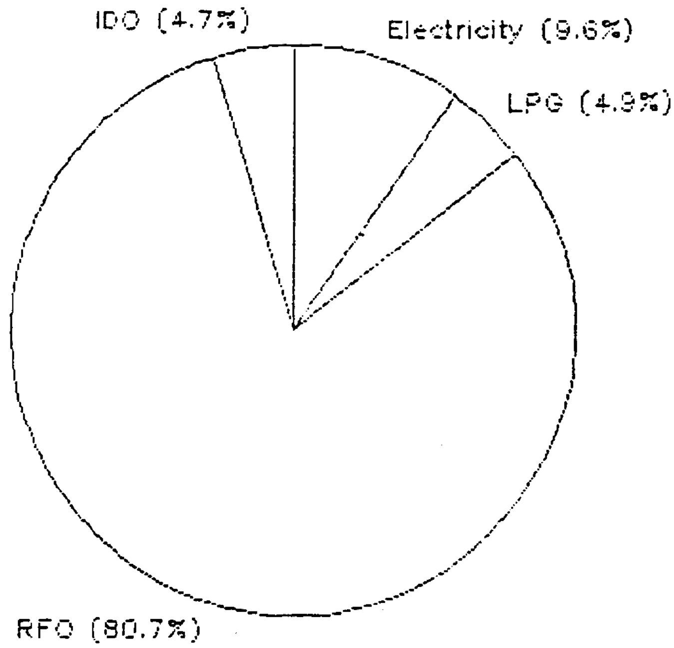
TABLE 1.1 - OVERALL ENERGY USAGE AND COST REPORT

Plant:		
CY :		1984
Total Production:	t	20 023
Energy Consumption:	GJ	374 401
Energy Intensity:	GJ	18.8
Energy Cost:	kKSh	26 699
Specific Energy Cost:	KSh/t	1 333
Energy Intensity Targets:		
Target 1	GJ/t	17.9
Target 2	GJ/t	13.3
Potential Energy Savings:		
Target 1 Achieved	GJ/t	0.9
Target 2 Achieved	GJ/t	4.6
Potential Cost Savings:		
Target 1 Achieved	KSh/t	105
Target 2 Achieved	KSh/t	350

Note: Transport fuels are excluded from all analyses.
Figures subject to rounding errors.

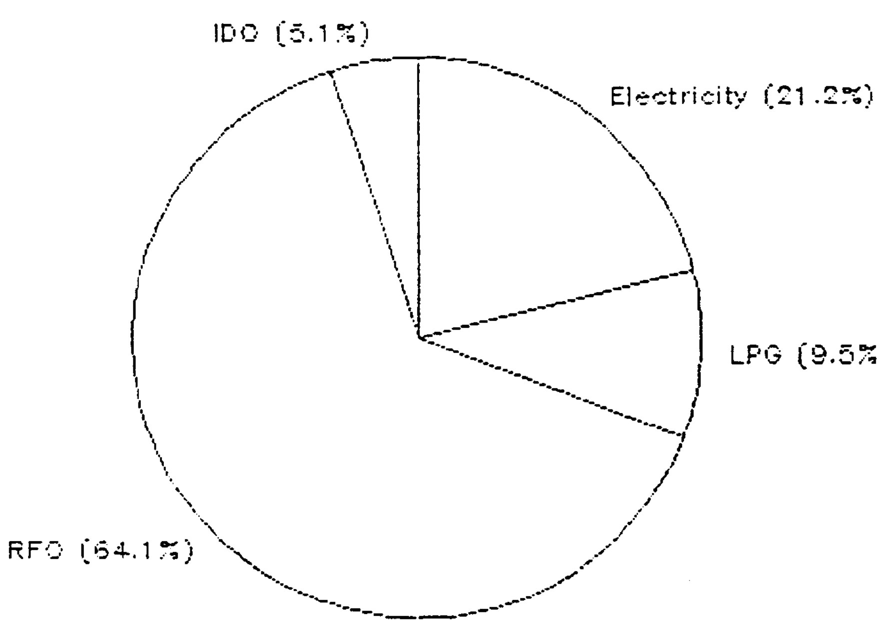
ENERGY CONSUMPTION

KENYA GLASSWORKS LTD CY 1984



ENERGY COSTS

KENYA GLASSWORKS LTD CY 1984



1.2 Target 1 - Short Term Energy Savings

By adopting a vigorous energy management programme and implementing the short term recommendations listed in Table 1.4 which, in general, require minimum investment levels, a Target 1 energy intensity of 17.9 GJ/t could be achieved. Plant energy consumption at current production levels would be reduced by 17 920 GJ/a or 4.8% of present process consumption, a saving of 2 114 000 KSh/a or 7.9% of 1984 process energy costs, as summarised in Table 1.2 below.

Section 1.4 following sets out in summary form the projects proposed to achieve Target 1 energy and cost savings.

TABLE 1.2 - TARGET 1 - SHORT TERM ENERGY SAVINGS

Energy Form	SPECIFIC ENERGY				ENERGY COSTS			
	Usage GJ/t	Target GJ/t	Savings GJ/t	Percent Savings %	Actual kKSh	Target kKSh	Savings kKSh	Percent Savings %
Electricity	1.88	1.69	0.19	10.1	5 665	4 987	678	12.1
Fuel Oil	15.10	14.51	0.59	3.9	17 112	15 992	1 120	6.5
LPG	0.92	0.81	0.11	12.0	2 547	2 231	316	12.4
IDO	0.89	0.89	-	-	1 374	1 374	-	-
Total	18.8	17.9	0.90	4.8	26 699	24 584	2 114	7.9

1.3 Target 2 - Long Term Energy Savings

By implementing the long term T2 recommendations listed in Table 1.4 which, in general, require some capital investment, and subject to further more detailed evaluation of engineering and economic feasibility, and assuming all T1 recommendations have already been implemented, it is estimated that Target 2 energy consumption will fall to 13.3 GJ/t. Energy costs will be reduced by a further 7 000 000 KSh/a or just over 26% of CY 1984 process energy costs as summarised in Table 1.3 below.

Section 1.4 summarises the projects proposed to achieve Target 2 energy and cost savings.

TABLE 1.3 - TARGET 2 - LONG TERM ENERGY SAVINGS*

Energy Form	SPECIFIC ENERGY Current GJ/t	T1 GJ/t	T2 GJ/t	ENERGY COSTS Current kKSh	T1 kKSh	T2 kKSh	Savings kKSh
Electricity	1.88	1.69	0.83	5 665	4 987	2 187	2 800
Fuel Oil	15.10	14.51	10.76	17 112	15 992	11 792	4 200
LPG	0.92	0.81	0.81	2 547	2 231	2 231	-
IDO	0.89	0.89	0.89	1 374	1 374	1 374	-
Total	18.8	17.9	13.3	26 699	24 584	17 584	7 000

*Figures subject to rounding errors.

1.4 Recommended Projects to achieve Target Energy Savings

Table 1.4 summarises the short term (T1) and long term (T2) projects identified to achieve the targeted energy savings at BAT. Reference is given to the report chapter in which a more detailed discussion of the proposal may be located.

TABLE 1.4 - RECOMMENDATIONS

Project Description	Energy Saving GJ/a	Cost Saving kKSh/a	Capital Cost kKSh	Payback Time Years	Reference Chapter
Target 1: Short Term Energy Savings					
Electricity:					
. Monitor and control consumption)	2640	415	200	0.6	5
. Power factor correction)	-	42	120	2.9	5
. MD control)	-	35	90	2.6	5
. Eliminate compressed air leaks)	1160	186	N/A	N/A	7 9
RFO:					
. Monitor and control consumption	11840	670	330	0.5	6
. Switch to 2500 sec oil	-	450	100	0.3	6
LPG:					
. Monitor and control consumption	2280	316	750	2.1	6
Target 2: Long Term Energy Savings					
1 Rebuild glass furnace and upgrade combustion control	60000	3400	3900	1.2	9
2 Install waste heat boiler and t/a generator	17120	2800	5500	2.0	9
3 Install oxygen trim control	15000	800	200	0.25	9

ENERGY AUDIT REPORT

Executive Summary

KENYA MEAT COMMISSION
ATHI RIVER, KENYA

1.0 EXECUTIVE SUMMARY

1.1 Overview

KMC situated at Athi River about 40kms south east of Nairobi, is Kenya's largest abattoir producing approximately 4588 tonnes of corned beef, 119 tonnes of beef extract and 2206 tonnes of meat and bone meal per year.

KMC is a well engineered abattoir and meat processing factory, but it is believed that significant opportunities exist for energy conservation. Subsequent sections set out target energy intensities (T1 and T2) together with the estimated savings in energy expenditure that will be realised once the targets are achieved.

The CY 1984 energy consumption, utilisation and target energy intensities (T1 and T2) for KMC are summarised in Table 1.1. Data for other years is presented where available. The percentage cost and consumption of the various energy forms used at KMC, principally electricity, fuel oil and diesel are shown pictorially in Figure 1.1. Fuel oil and electricity account for 69.4% and 28.5% respectively of all energy costs reported.

Energy intensity at KMC as measured in gigajoules per tonne of product was 35.2 GJ/t excluding transport fuels. The current reported specific energy cost was 2 507 KSh/t. The report shows how this energy intensity and cost can be reduced, firstly to a Target 1 level of 30 GJ/t and 2 189 KSh/t, and then, with some level of investment, to a Target 2 level of 34.3 GJ/t and 575 KSh/t.

The estimates for energy saving opportunities are based on actual measurements or engineering-economic judgement following the site visit. Cost and savings are approximate, and additional engineering and economic feasibility investigation, particularly to take account of continuing variations in energy costs, will be necessary before proceeding with any of the projects identified. Indeed it should be observed that since the time of the 1985 audit, international fuel oil prices have fallen dramatically, while the economic and market prices of both electricity and fuelwood have risen.

TABLE 1.1 - OVERALL ENERGY USAGE AND COST REPORT

Plant: Kenya Meat Commission - Athi River

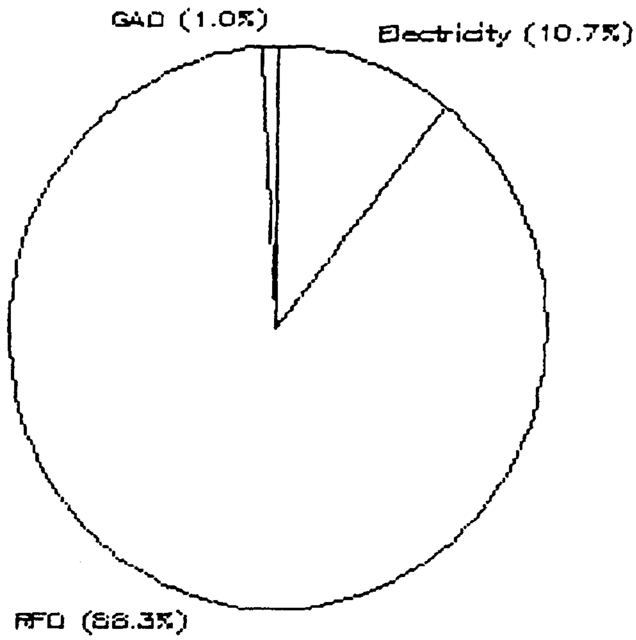
CY :		1983	1984
Total Production:	t	4 746	6 915
Energy Consumption:	GJ	180 675	243 439
Energy Intensity:	GJ/t	38.1	35.2
Energy Cost:	kKSh	12 864	17 334
Specific Energy Cost:	KSh/t	2 711	2 507
Energy Intensity Targets:			
Target 1	GJ/t		30.0
Target 2	GJ/t		34.3
Potential Energy Savings:			
Target 1 Achieved	GJ/t		5.2
Target 2 Achieved	GJ/t		-
Potential Cost			
Target 1 Achieved	KSh/t		2 189
Target 2 Achieved	KSh/t		575

Note: Transport fuels are excluded from all analyses. Production includes corned beef, beef extract and meat and bone meal.

FIGURE 1.1

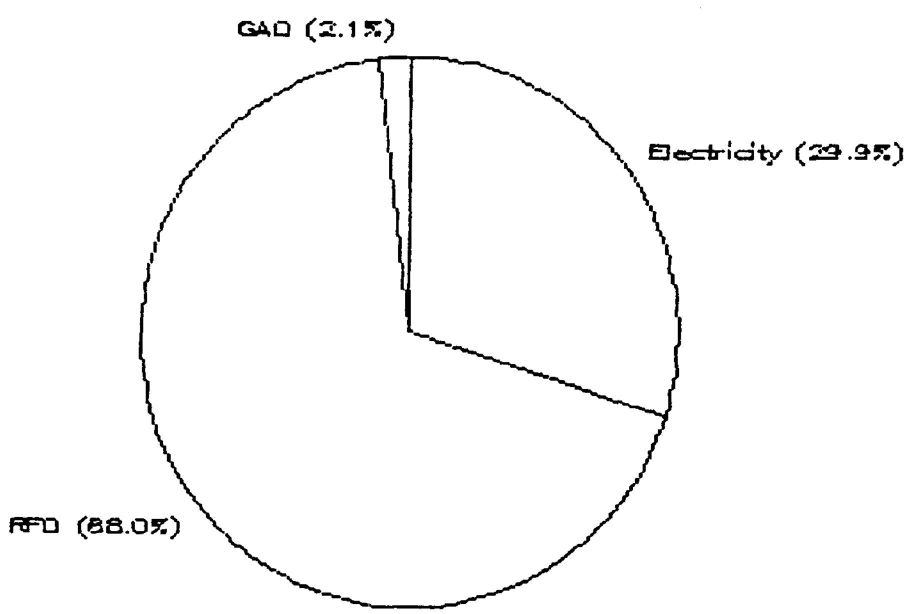
ENERGY CONSUMPTION

KENYA MEAT COMISSION CY 1984



ENERGY COSTS

KENYA MEAT COMISSION CY 1984



1.2 Recommended Projects to Achieve Target Energy Savings

Table 1.2 summarises the short term, T1, and long term, T2, projects identified to achieve the targeted energy savings at Kenya Meat Commission. A more detailed discussion of each proposal may be found in the reference chapter.

TABLE 1.2 - RECOMMENDATIONS

Project	Cost Saving kKSh/a	Capital Cost kKSh	Payback Time Years	Reference Chapter
Target 1: Short Term Energy Savings				
1 Steam leaks repair	240	80	.3	7
2 Insulation	864	160	.2	7
3 Steam trap maintenance/ replacement	240	150	.7	7
4 Boiler maintenance/cleaning	361	90	.3	6
5 Rectify cold room door seal leaks) 6 Rectify air leaks)	490	89	.2	5
Target 2: Long Term Energy Savings				
1 Boiler conversion to woodfuel	6 809	4 945	.7	9
2 Electricity & steam cogeneration	4 344	6 390	1.5	10
3 Recover heat of refrigeration	60	100	1.7	8

1.3 Target 1: Short Term Energy Savings

By adopting a vigorous energy management programme and implementing the short term T1 recommendations listed in Table 1.2, which in general require minimum investment levels, a Target 1 specific energy cost of 2 189 KSh/t could be achieved, giving a saving of around 219 5000 KSh/a, or 13% of CY 1984 process energy costs as summarised in Table 1.3.

TABLE 1.3 - TARGET 1: SHORT TERM ENERGY SAVINGS

Energy form	Specific Energy Current GJ/t	Specific Energy Target GJ/t	Specific Energy Savings GJ/t	Energy Cost Current kKSh	Energy Cost Target kKSh	Energy Cost Savings kKSh	Percent Savings %
Electricity	3.8	3.6	.2	5 300	5 021	279	5
Fuel oil	31.4	26.4	5.0	12 034	10 118	1 916	16
Total	35.2	30.0	5.2	17 334	15 139	2 195	13

1.4 Target 2: Long Term Energy Savings

By implementing the long term T2 recommendations listed in Table 1.2 which, in general require some capital investment, and subject to further more detailed evaluation of engineering and economic feasibility and assuming all T1 recommendations have already been implemented, it is estimated that whilst the Target 2 specific energy consumption would be increased to 34.3 GJ/t, the energy cost would be considerably reduced giving a further saving of around 3 973 KSh/a or a total saving of 77% of CY 1984 energy costs.

TABLE 1.4 - TARGET 2: LONG TERM ENERGY SAVINGS

Energy form	Specific Energy Current GJ/t	Specific Energy T1 GJ/t	Specific Energy T2 GJ/t	Energy Cost Current kKSh	Energy Cost T1 kKSh	Energy Cost T2 kKSh	Savings kKSh
Electricity	3.8	3.6	-	5 300	5 021	-	5 021
Fuel oil	31.4	26.4	-	12 034	10 118	-	10 118
Wood	-	-	34.3	-	-	3 973	(3 973)
Total	35.2	30	34.3	17 334	15 139	3 973	11 166

Subject to rounding errors.

ENERGY AUDIT REPORT

Executive Summary

KENYATTA NATIONAL HOSPITAL
NAIROBI, KENYA

1.0 EXECUTIVE SUMMARY

Kenyatta National Hospital is Kenya's premier health care establishment. Energy conservation opportunities are major and should be vigorously pursued to maximise savings.

The arrangements for funding by separate Ministries of operating and maintenance costs, as currently working, appear to the Consultants to be the main block to the expenditure of up to 1 000 000 KSh for essential repairs to the steam and condensate systems. This capital expenditure would be repaid within three (3) months by reduced expenditure on fuel oil, and these savings will continue and amount to well over 3 000 000 KSh each year; savings which can then be redirected to improved health care or any other worthwhile purpose.

At the present time the continuing waste of 3 500 000 KSh every year on fuel oil, waste of Kenya's scarce foreign exchange, is a situation that must not be allowed to continue. Indeed it should be the case that Kenya's major public institutions should set an example to all Kenyans in good energy management.

It is estimated that in 1984 RFO cost around 8 470 000 KSh and electricity around 3 750 000 KSh; however detailed records are not available.

To realise the potential savings available, an energy management system should be established. This should include energy consumption and cost monitoring and provision of an adequate maintenance budget.

1.1 Recommended Projects to Achieve Target Energy Savings

Table 1.1 summarises the short term, T1, and long term, T2, projects identified to achieve the targeted energy savings at Kenyatta National Hospital. A more detailed discussion of each proposal may be found in the reference chapter.

The estimates for energy saving opportunities are based on actual measurements or engineering-economic judgement following the site visits. Cost and savings are approximate and additional engineering and economic feasibility investigation, particularly to take account of continuing variations in energy costs, will be necessary before proceeding with any of the projects identified. Indeed it should be observed that since the time of the 1985 audit, international fuel oil prices have fallen dramatically, while the economic and market prices of both electricity and fuelwood have risen.

TABLE 1.1 - RECOMMENDATIONS

Project	Cost Saving kKSh/a	Capital Cost kKSh	Payback Time Years	Reference Chapter
Target 1: Short Term Energy Savings				
1 Insulation	1 250	400	.3	7
2 Condensate recovery & water savings	1 665	200	.2	7
3 Boiler	50	minimal	N/A	7
4 Repair of leaks	500	100	.2	7
5 Lighting control-outdoor	25	minimal	N/A	5
6 Temperature control and calorifier repairs	425	250	.6	7
Target 2: Long Term Energy Savings				
1 Boiler conversion to woodfuel	3 232	3 910	1.2	8

1.3 Target 1: Short Term Energy Savings

By adopting a vigorous energy management programme and implementing the short term T1 recommendations listed in Table 1.1, which in general require minimum investment levels, a Target 1 specific energy cost of .147 GJ/BD could be achieved, giving a saving of around 3 915 000 KSh/a, or 32% of CY 1984 process energy costs as summarised in Table 1.2.

TABLE 1.2 - TARGET 1: SHORT TERM ENERGY SAVINGS

Energy form	Specific Energy Current GJ/BD	Specific Energy Target GJ/BD	Specific Energy Savings GJ/BD	Energy Cost Current kKSh	Energy Cost Target kKSh	Energy Cost Savings kKSh	Percent Savings %
Electricity	.034	.034	-	3 750	3 725	25	-
Fuel oil	.209	.113	.096	8 465	4 575	3 890	46
Total	.243	.147	.096	12 215	8 300	3 915	32

1.3 Target 2: Long Term Energy Savings

By implementing the long term T2 recommendations listed in Table 1.2 which, in general require some capital investment, and subject to further more detailed evaluation of engineering and economic feasibility and assuming all T1 recommendations have already been implemented, it is estimated that whilst the Target 2 specific energy consumption would be increased to .154, the energy cost would be considerably reduced giving a further saving of around 3 228 000 KSh/a or a total saving of 58% of CY 1984 energy costs.

TABLE 1.3 - TARGET 2: LONG TERM ENERGY SAVINGS

Energy form	Specific Energy Current GJ/BD	T1 GJ/BD	T2 GJ/BD	Energy Cost Current kKSh	T1 kKSh	T2 kKSh	Savings kKSh
Electricity	.034	.034	.034	3 750	3 725	3 725	0
Fuel oil	.209	.113	-	8 465	4 575	-	4 575
Wood	-	-	.120	-	-	1 347	(1 347)
Total	.243	.147	.154	12 215	8 300	5 072	3 228

Subject to rounding errors.

ENERGY AUDIT REPORT

Executive Summary

MADHUPAPER INTERNATIONAL LIMITED
NAIROBI, KENYA

1.0 EXECUTIVE SUMMARY

1.1 Introduction

Madhupaper International Limited is one of Kenya's major manufacturers of paper products. Process heating and electric drives are the major energy users in this plant. Overall energy usage and costs are summarised in Table 1.1. During 1984 fuel oil cost 4 236 000 KSh, electricity 4 628 000 KSh.

Figure 1.1 shows the energy consumption and cost pictorially.

TABLE 1.1 - ENERGY SUMMARY

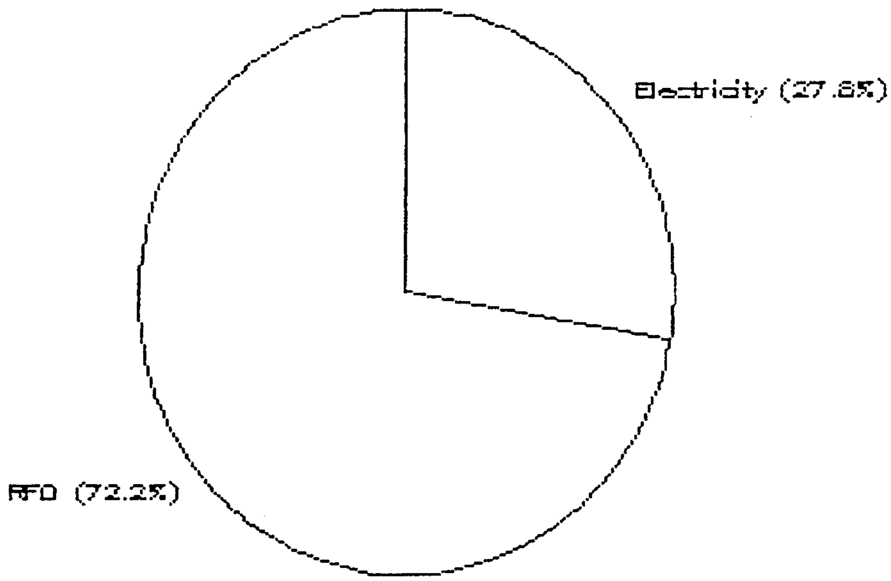
		1984
Total production	t	6 358
Energy consumption	GJ	94 174
Energy intensity	GJ/t	14.8
Energy cost	kKSh	8 864
Specific energy cost	KSh/t	1 394
Energy intensity targets		
Target T1	GJ/t	11.9
Target T2	GJ/t	27.5
Potential energy savings		
Target T1	GJ/t	2.9
Target T2	GJ/t	N/A
Potential energy costs		
Target T1	KSh/t	1 214
Target T2	KSh/t	467

The plant is well organised, data and records keeping are good. It is recommended that an energy manager be appointed, with responsibilities for execution of the projects below. He should also implement staff training and awareness activities.

Madhupaper has a number of major energy conservation and/or reduction opportunities. The estimates for energy saving opportunities are based on actual measurements or engineering-economic judgement following the site visit. Cost and savings are approximate, and additional engineering and economic feasibility investigation, particularly to take account of continuing variations in energy costs, will be necessary before proceeding with any of the projects identified. Indeed it should be observed that since the time of the 1985 audit, international fuel oil prices have fallen dramatically, while the economic and market prices of both electricity and fuelwood have risen.

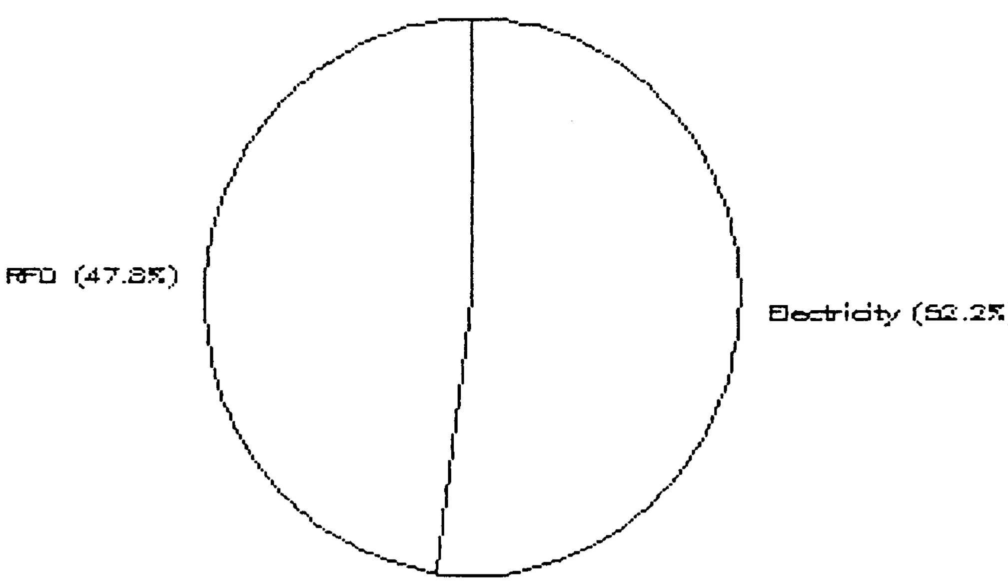
ENERGY CONSUMPTION

MADHUPAPER INT. LTD CY 1984



ENERGY COSTS

MADHUPAPER INT. LTD CY 1984



1.2 Recommended Projects to Achieve Target Energy Savings

Table 1.2 summarises the short term, T1, and long term, T2, projects identified to achieve the targeted energy savings at Madhupaper International. A more detailed discussion of each proposal may be found in the reference chapter.

TABLE 1.2 - RECOMMENDATIONS

Project	Cost Saving kKSh/a	Capital Cost kKSh	Payback Time Years	Reference Chapter
Target 1: Short Term Energy Savings				
1 Steam leaks repair	272	40	0.2	7
2 Insulation	255	100	0.4	7
3 Steam trap maintenance/ replacement	350	80	0.3	7
4 Boiler maintenance cleaning	265	25	0.2	6
Target 2: Long Term Energy Savings				
1 Boiler conversion to woodfuel	2 195	1 484	.7	9
2 Electricity & steam cogeneration	2 503	10 709	4.3	10

1.3 Target 1: Short Term Energy Savings

By adopting a vigorous energy management programme and implementing the short term T1 recommendations listed in Table 1.2, which in general require minimum investment levels, a Target 1 specific energy cost of 1 214 KSh/t could be achieved, giving a saving of around 1 142 000 KSh/a, or 13% of CY 1984 process energy costs as summarised in Table 1.3.

TABLE 1.3 - TARGET 1: SHORT TERM ENERGY SAVINGS

Energy form	Specific Energy Current GJ/t	Specific Energy Target GJ/t	Specific Energy Savings GJ/t	Energy Cost Current kKSh	Energy Cost Target kKSh	Energy Cost Savings kKSh	Percent Savings %
Electricity	4.1	4.1	N/A	4 628	4 628	N/A	N/A
Fuel oil	10.7	7.8	2.9	4 236	3 094	1 142	27
Total	14.8	11.9	2.9	8 864	7 722	1 142	13

1.4 Target 2: Long Term Energy Savings

By implementing the long term T2 recommendations listed in Table 1.2 which, in general require some capital investment, and subject to further more detailed evaluation of engineering and economic feasibility and assuming all T1 recommendations have already been implemented, it is estimated that whilst the Target 2 specific energy consumption would be increased to 27.5 GJ/t, the energy cost would be considerably reduced giving a further saving of around 4 753 000 KSh/a or a total saving of 67% of CY 1984 energy costs.

TABLE 1.4 - TARGET 2: LONG TERM ENERGY SAVINGS

Energy form	Specific Energy Current GJ/t	Specific Energy T1 GJ/t	Specific Energy T2 GJ/t	Energy Cost Current kKSh	Energy Cost T1 kKSh	Energy Cost T2 kKSh	Savings kKSh
Electricity	4.1	4.1	-	4 628	4 628	-	4 628
Fuel oil	10.7	7.8	-	4 236	3 094	-	3 094
Wood	-	-	27.5	-	-	2 969	(2 969)
Total	14.8	11.9	27.5	864	7 722	2 969	4 753

Subject to rounding errors.

ENERGY AUDIT REPORT

Executive Summary

MAGADI SODA CO P.L.C
MAGADI, KENYA

1.0 EXECUTIVE SUMMARY

1.1 Overview

Magadi Soda Co PLC (MSC) is situated at Magadi approximately 120 km by road from Nairobi, and is Kenya's only soda ash producer. The plant also produces coarse salt by solar evaporation.

MSC is a well engineered and operated plant, with good process control and access to overseas engineering expertise from ICI. It is believed however that opportunities do exist for further improvement in energy conservation, and subsequent sections set out the target energy intensities designated T1 and T2, and the savings that can be made in production costs if these targets are achieved.

The energy consumption for FY 1985, and target energy intensity for MSC are summarised in Table 1.1. The percentage cost and consumption of the various energy forms used at MSC, principally fuel oil and diesel oil, are shown pictorially in Figure 1.1. Fuel oil in FY 1985 accounts for 88.0% of all energy costs reported, with the balance due to diesel oil.

Energy intensity for FY 1985 measured in gigajoules of energy consumed per tonne of product was 2.71 GJ/t. The current energy cost is 156 KSh/t. The report shows how it is believed that this energy intensity and cost can be reduced, to a level ultimately approaching 2.3 GJ/t and 133 KSh/t. The cost reductions at present production levels extend to an annual savings of 5 210 000 KSh/a. Only investments that show an internal rate of return (IRR) of over 15% after allowance for tax and depreciation are considered.

Initially the savings would be around 3 310 000 KSh/a with an energy intensity of 2.45 GJ/t and an energy cost of 142 KSh/t, but as the proposed energy management scheme showed results the lower target would be not unrealistic.

The estimates for energy saving opportunities are based on actual measurements or engineering-economic judgement following the site visits. Cost and savings are approximate and additional engineering and economic feasibility investigation, particularly to take account of continuing variations in energy costs, will be necessary before proceeding with any of the projects identified. Indeed it should be observed that since the time of the 1985 audit, international fuel oil prices have fallen dramatically, while the economic and market prices of both electricity and fuelwood have risen.

TABLE 1.1 - OVERALL ENERGY USAGE AND COST REPORT

Plant: Magadi Soda

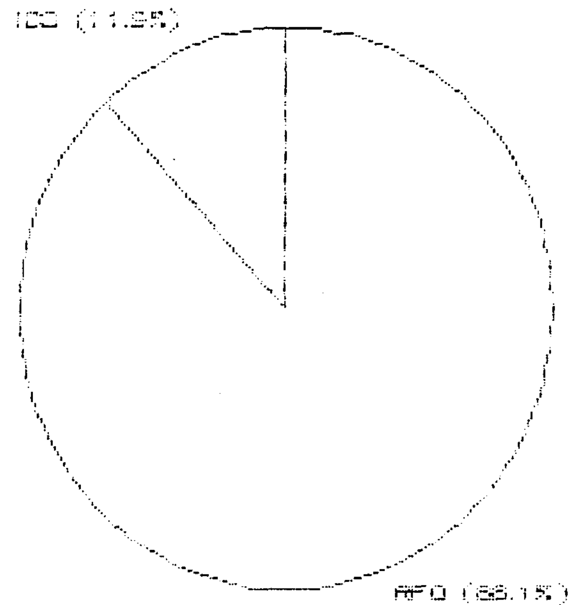
FY		1985
Total Production	t	224 860
Energy Consumption	GJ	609 389
Energy Intensity	GJ/t	2.71
Energy Cost	kKSh	35 167
Specific Energy Cost	kKSh/t	156.40
Energy Intensity Target	GJ/t	2.45
Potential Energy Saving	GJ/t	.26
Potential Cost Saving	KSh/t	14.7

Note: Transport fuels are excluded from all analyses.

FIG 1.1

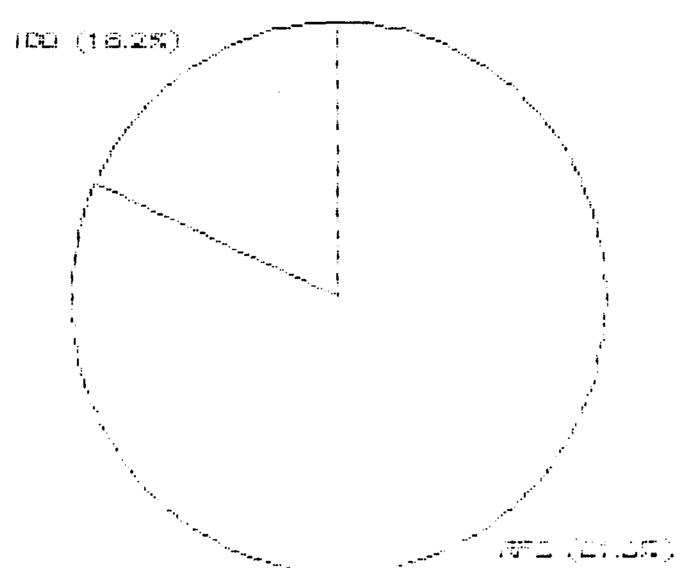
ENERGY CONSUMPTION

MAGADI SODA CO. CY 1984-85



ENERGY COSTS

MAGADI SODA CO. CY 1984-85



1.2 Recommended Projects to achieve Target Energy Savings

Table 1.2 summarises the short term and long term projects identified to achieve the targeted energy savings at Magadi Soda Co. Reference is given to the report chapter in which a more detailed discussion of the proposal may be located.

TABLE 1.2 - RECOMMENDATIONS

Project Description	Energy Saving GJ/a	Cost Saving kKSh/a	Capital Cost kKSh	Payback Time Years	Reference Chapter Number
Target 1 -Short Term					
1. Optimise moisture of trona	22 308	1 196	-	N/A	6
2. Repair air leaks in calciners	8 580	460	100	.2	6
3. Power factor correction	1 043	193	98	.5	5
Target 2 - Long Term					
1. Preheat combustion air	14 157	759	900	1.2	6
2. Improve combustion efficiency	10 725	575	1 250	2.2	6
3. Waste heat to heat RFO	2 360	127	300	2.4	6

1.3 Energy Savings

By adopting a vigorous energy management programme and implementing the recommendations listed in Table 1.2, an energy intensity of 2.43 GJ/t could be achieved. Plant energy consumption at current production levels would be reduced by 59 173 GJ/a or 10% of present process consumption, a saving of 3 310 000 KSh/a as summarised in Table 1.3 below.

TABLE 1.3 - ENERGY SAVINGS

	SPECIFIC ENERGY				ENERGY COSTS		
Energy Form	Usage GJ/t	Target GJ/t	Savings GJ/t	Percent Savings %	Current kKSh	Target kKSh	Savings kKSh
Fuel Oil	2.71	2.45	.26	10	35 167	31 857	3 310

Figures subject to rounding errors.

It should be noted that since both the Target 1 and Target 2 money savings are, in the main associated with non process changes, ie. improvements to the existing process only, they will be encompassed within the potential savings shown by the line of best performance superimposed on the energy intensity vs production linear regression, thus both Target 1 and Target 2 savings have been shown on the same table.

ENERGY AUDIT REPORT

Executive Summary

OIL EXTRACTION LIMITED
NAIROBI, KENYA

1.0 EXECUTIVE SUMMARY

1.1 Present Energy Utilisation

Oil Extraction Limited (OEL), situated in Nairobi, produces edible oil and fodder as a by-product from maize germ.

The CY 1984 energy consumption, utilisation and target energy intensities (T1 and T2) for OEL are summarised in Table 1.1. The percentage cost and consumption of the various energy forms are shown pictorially in Figure 1.1.

Fuel oil and electricity account for 89.3% and 10.7% respectively of process energy costs reported. It is believed that opportunities do however exist for improvement in energy conservation, and subsequent sections set out the target energy intensities (T1 and T2) and the savings that can be made in production costs if these targets are achieved. This report outlines those opportunities.

Energy intensity for Jan - Sep 1985 at OEL as measured in gigajoules of energy consumed per tonne of feed excluding transport fuels was 4.1 GJ/t. The current energy cost excluding transport fuels is 294 KSh/t. The report shows how this energy intensity and specific energy cost can be reduced, firstly to a Target 1 level of 3.0 GJ/t and 223 KSh/t, and then, with some level of investment, to a Target 2 level of 3.2 GJ/t and 84 KSh/t. The cost reductions at present production levels extend to an annual saving of 553 000 KSh/a at Target 1 and a further 1 027 000 at Target 2. It will be noted that the energy intensity has increased slightly (due to a proposed change in fuel source) but the cost of energy per tonne of product has dropped significantly. Investments are only contemplated that show an internal rate of return (IRR) of over 15% after allowance for tax and depreciation.

The estimates for energy saving opportunities are based on actual measurements or engineering-economic judgement following the site visit. Cost and savings are approximate, and additional engineering and economic feasibility investigation, particularly to take account of continuing variations in energy costs, will be necessary before proceeding with any of the projects identified. Indeed it should be observed that since the time of the 1985 audit, international fuel oil prices have fallen dramatically, while the economic and market prices of both electricity and fuelwood have risen.

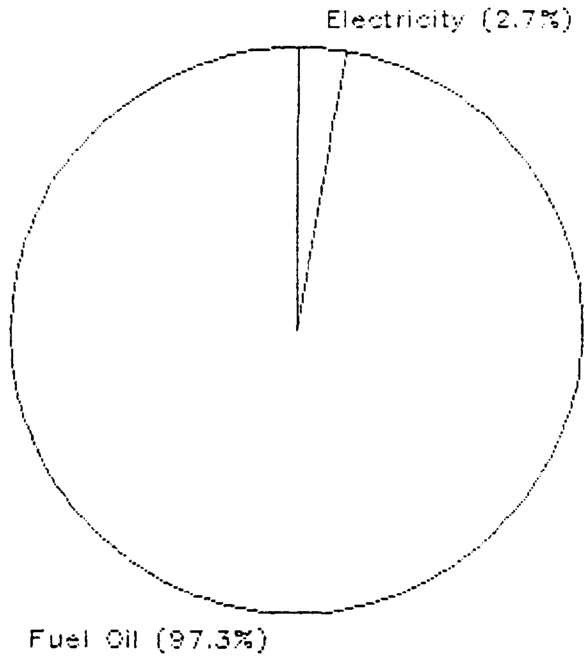
TABLE 1.1 - OVERALL ENERGY USAGE AND COST REPORT

Period	CY	1985 (Jan - Sep)
Total Production:	t	5 534
Energy Consumption:	GJ	22 689
Energy Intensity:	GJ/t	4.1
Energy Cost:	kKSh	1 625
Specific Energy Cost:	KSh/t	294
Energy Intensity Targets:		
Target 1	GJ/t	3.0
Target 2	GJ/t	3.2
Potential Energy Savings:		
Target 1 Achieved	GJ/t	1.1
Target 2 Achieved	GJ/t	(0.2)
Potential Cost Savings:		
Target 1 Achieved	KSh/t	71
Target 2 Achieved	KSh/t	139

Note: (1) Transport fuels are excluded from all analyses.
(2) Data covers a period of approximately 9 months only.

ENERGY CONSUMPTION

OIL EXTRACTION LTD CY 1985



ENERGY COSTS

OIL EXTRACTION LTD CY 1985

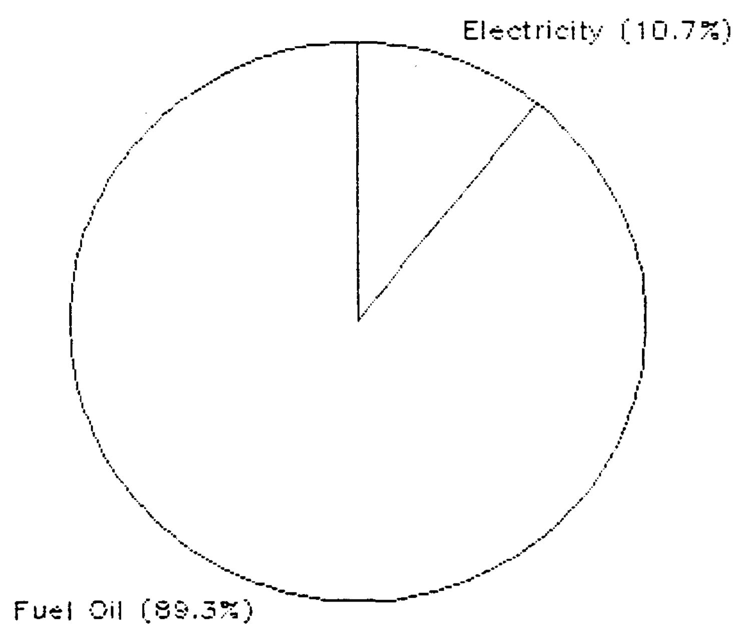


FIGURE 1.1

1.2 Target 1 - Short Term Energy Savings

By adopting a vigorous energy management programme and in implementing the short term T1 recommendations listed in Table 1.4 which, in general, require minimum investment levels, a Target 1 energy intensity of 3.0 GJ/t could be achieved. Plant energy consumption at current production levels would be reduced by 1.1 GJ/a or 26% of present process consumption, a saving of 553 000 KSh/a, or nearly 25% of CY 1984 energy costs, as summarised in Table 1.2 below.

Section 1.4 following sets out in summary form the projects proposed to achieve Target 1 energy cost savings.

TABLE 1.2 - TARGET 1 - SHORT TERM ENERGY SAVINGS*

Energy Form		SPECIFIC ENERGY			ENERGY COSTS			
	Usage GJ/t	Target GJ/t	Savings GJ/t	Percent Savings %	Actual kKSh	Target kKSh	Savings kKSh	Percent Savings %
Electricity	0.1	0.1	0.011	9.6	261	228	33	13
Fuel Oil	4.0	2.9	1.1	27	1 936	1 416	520	27
Total	4.1	3.0	1.1	26	2 197	1 644	553	25

*Figures subject to round-off errors

1.3 Target 2 - Long Term Energy Savings

By implementing the long term T2 recommendations listed in Table 1.4 which, in general, require some capital investment, and subject to further more detailed evaluation of engineering and economic feasibility, and assuming all T1 recommendations have already been implemented, it is estimated that Target 2 energy consumption will increase slightly to 3.2 GJ/t. However energy costs will be reduced by a further 1 027 000 KSh/a or 63% of 1985 process energy costs, as summarised in Table 1.3 below.

Section 1.4 following sets out in summary form the projects proposed to achieve Target 2 energy and cost savings.

TABLE 1.3 - TARGET 2 - LONG TERM ENERGY SAVINGS*

Energy Form	SPECIFIC ENERGY Current GJ/t	T1 GJ/t	T2 GJ/t	ENERGY COSTS Current kKSh	T1 kKSh	T2 kKSh	Savings kKSh
Electricity	0.1	0.1	0.1	261	228	228	0
Fuel Oil	4.0	2.9	0	1 936	1 416	0	1 416
Fuel Wood	0	0	3.1	0	0	389	389
Total	4.1	3.0	3.2	2 197	1 644	617	1 027

*Figures subject to rounding errors.

1.4 Recommended Projects to achieve Target Energy Savings

Table 1.4 summarises the short term (T1) and long term (T2) projects identified to achieve the targeted energy savings at OEL. Reference is given to the report chapter in which a more detailed discussion of the proposal may be located.

TABLE 1.4 - RECOMMENDATIONS

Project Description	Energy Saving GJ/a	Cost Saving kKSh/a	Capital Cost kKSh	Payback Time Years	Reference Chapter Number
Target 1 - Short Term					
1. Monitor and control electricity consumption	90	25	13-25	0.5-1.0	5
2. Maximum demand control	-	6	12	2	5
3. Power factor correction	-	2	0-6.4	0-2.8	5
4. Improve boiler efficiency	1 950	130	-	N/A	6
5. Overhaul steam system	6 000	390	400	1	7
TOTAL	8 040	553			
Target 2 - Long Term					
1. Boiler conversion to burn fuelwood	-	1 029	1 348	1.3	9
TOTAL		1 029	1 348		

ENERGY AUDIT REPORT

Executive Summary

PANAFRICAN PAPER MILLS (E.A.) LTD
WEBUYE, KENYA

1.0 EXECUTIVE SUMMARY

1.1 Overview

Pan African Paper Mills (EA) Ltd (PPM) is situated at Webuye approximately 400km from Nairobi, and is Kenya's largest paper manufacturer, producing a wide variety of grades for many diverse industrial, commercial and domestic uses on two paper machines. The FY 1985 production amounted to just over 65 000 tonnes.

PPM is a well engineered and operated plant, with good process control and good access to international paper technology and expertise. It is believed that opportunities do however exist for further improvement in energy conservation, and subsequent sections set out the target energy intensities (T1 and T2), and the savings that can be made in production costs if these targets are achieved.

The energy consumption for FY 1984 and 1985, utilisation and target energy intensities (T1 and T2) for PPM are summarised in Table 1.1. The percentage cost and consumption of the various energy forms used at the plant, principally electricity, fuel oil, gas oil, LPG and gasoline, are shown pictorially in Figure 1.1. Gasoline, LPG and diesel oil, being transport fuels, are not studied in this report or included in any derivation of energy intensity, but are included in this summary to indicate their contribution to total energy costs. Fuel oil and electricity in CY 1984 account for 86.8% and 11.6% respectively of all energy costs reported. Transport fuels accounted or only 1.6%.

Energy intensity for FY 1985 at PPM as measured in gigajoules of energy consumed per tonne of product excluding transport fuels was 39.3 GJ/t. The current energy cost excluding transport fuels is 2 579 KSh/t. The report shows how it is believed that this energy intensity and cost can be reduced to a Target 1 level of 37.8 GJ/t and 2 488 KSh/t. The cost reductions at present production levels extend to an annual savings of 5 865 000 KSh at Target 1. The Target 2 level proposals would involve a major change in philosophy and require further investigation.

The estimates for energy saving opportunities are based on actual measurements or engineering-economic judgement following the site visits. Cost and savings are approximate and additional engineering and economic feasibility investigation, particularly to take account of continuing variations in energy costs, will be necessary before proceeding with any of the projects identified. Indeed it should be observed that since the time of the 1985 audit, international fuel oil prices have fallen dramatically, while the economic and market prices of both electricity and fuelwood have risen.

TABLE 1.1 - OVERALL ENERGY USAGE AND COST REPORT

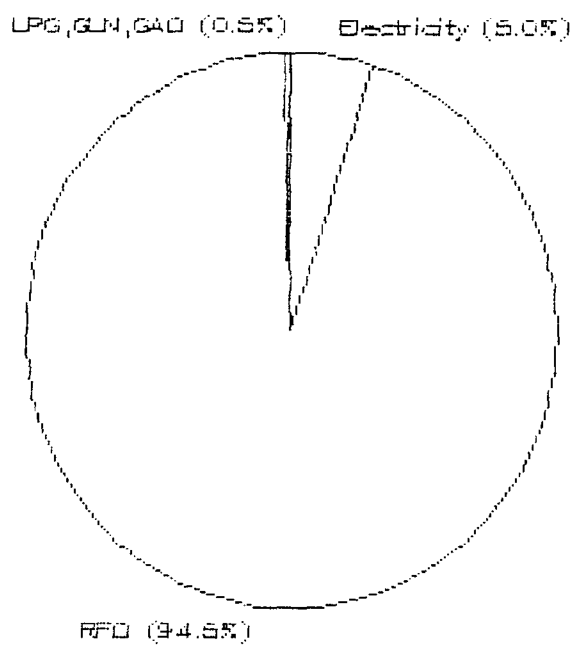
Period:	FY	1984	1985
Total Production:	tonnes	59 271	63 710
Energy Consumption:	GJ	2 372 795	2 504 560
Energy Intensity:	GJ/t	40.0	39.3
Energy Cost:	kKSh	137 847	164 327
Specific Energy Cost:	kKSh/t	2 329	2 579
Energy Intensity Targets:			
Target 1	GJ/t		37.8
Target 2	GJ/t		N/A
Potential Energy Savings:			
Target 1 Achieved	GJ/t		1.5
Target 2 Achieved	GJ/t		N/A
Potential Cost:			
Target 1 Achieved	KSh/t		2 488
Target 2 Achieved	KSh/t		N/A

Notes: Transport fuels are excluded from all analyses.
Subsequent to completion of the analysis, corrected machine paper production figures were advised for FY 1984 and 85. Machine Paper production figures for FY 1983-84 and 1984-85 should read of 60 078t and 65 319t respectively. These changes affect the derived ratios very slightly, but are of negligible significance in reading the conclusions stated.

FIGURE 1.1

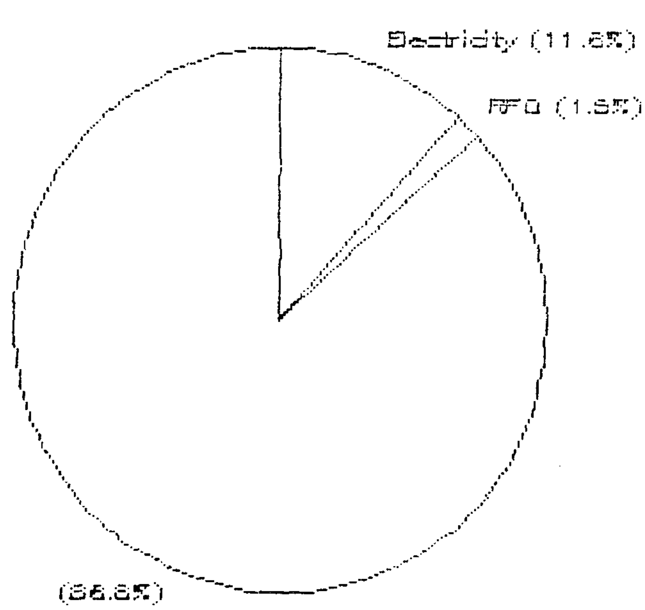
ENERGY CONSUMPTION

PAN AFRICAN PAPER MILLS FY 1984-85



ENERGY COSTS

PAN AFRICAN PAPER MILLS FY 1984-85



1.2 Recommended Projects to Achieve Target Energy Savings

Table 1.2 summarises the short term, T1, and long term, T2, projects identified to achieve the targeted energy savings at PPM. A more detailed discussion of each proposal may be found in the reference chapter.

TABLE 1.2 - RECOMMENDATIONS

Project	Cost Saving kKSh/a	Capital Cost kKSh	Payback Time Years	Reference Chapter
Target 1: Short Term Energy Savings				
1 Minor steam system repairs	3 258	350	.1	7
2 RFO fired boiler tune up and minor repair	2 607	100	.04	7
Target 2: Long Term Energy Savings				
1 Boiler conversion to woodfuel	) see Chapter 9			
2 Increased in plant electricity generation	) see Chapter 9			

1.3 Target 1: Short Term Energy Savings

By adopting a vigorous energy management programme and implementing the short term T1 recommendations listed in Table 1.2, which in general require minimum investment levels, a Target 1 specific energy cost of 2 488 KSh/t could be achieved, giving a saving of around 5 865 000 KSh/a, or 4% of CY 1984 process energy costs as summarised in Table 1.3.

TABLE 1.3 - TARGET 1: SHORT TERM ENERGY SAVINGS

Energy form	Specific Energy Current GJ/t	Specific Energy Target GJ/t	Specific Energy Savings GJ/t	Energy Cost Current kKSh	Energy Cost Target kKSh	Energy Cost Savings kKSh	Percent Savings %
Electricity*	2	2	-	19 401	19 401	-	-
Fuel oil	37.3	35.8	1.5	144 962	139 097	5 865	4
Total	39.3	37.8	1.5	164 327	158 498	5 865	4

*Note: Savings are based upon tariffs existing at the time of the audit.

1.4 Target 2: Long Term Energy Savings

By implementing the long term T2 recommendations listed in Table 1.2 which, in general require some capital investment, and subject to further more detailed evaluation of engineering and economic feasibility and assuming all T1 recommendations have already been implemented, it is estimated that whilst the Target 2 specific energy consumption would rise somewhat, but savings of around 100 000 000 KSh may accrue. Refer Chapter 9.0.

ENERGY AUDIT REPORT

Executive Summary

RIFT VALLEY TEXTILES LTD (RIVATEX)
ELDORET, KENYA

1.0 EXECUTIVE SUMMARY

1.1 Introduction

Rift Valley Textiles Ltd (Rivatex), a parastatal company, is one of Kenya's major textile producers. The company is also a major employer in Eldoret, with over 1 400 employees. Pr :ess heating and electric drives are the major energy users in this plant. Overall energy usage and costs are summarized in Table 1.1. During 1984 fuel oil cost 10.1 MKSh, electricity 7.4 MKSh and GAO 1.6 MKSh.

Figure 1.1 shows the energy consumption and cost pictorially.

TABLE 1.1 - ENERGY SUMMARY

		1984
Total production	km	10 625
Energy consumption	GJ	206 566
Energy intensity	GJ/km	19.4
Energy cost	kKSh	17 562
Specific energy cost	KSh/km	1 653
Energy intensity targets		
Target T1	GJ/km	18.4
Target T2	GJ/km	27.6
Potential energy savings		
Target T1	GJ/km	1.2
Target T2	GJ/km	N/A
Potential energy costs		
Target T1	KSh/km	1 578
Target T2	KSh/km	525

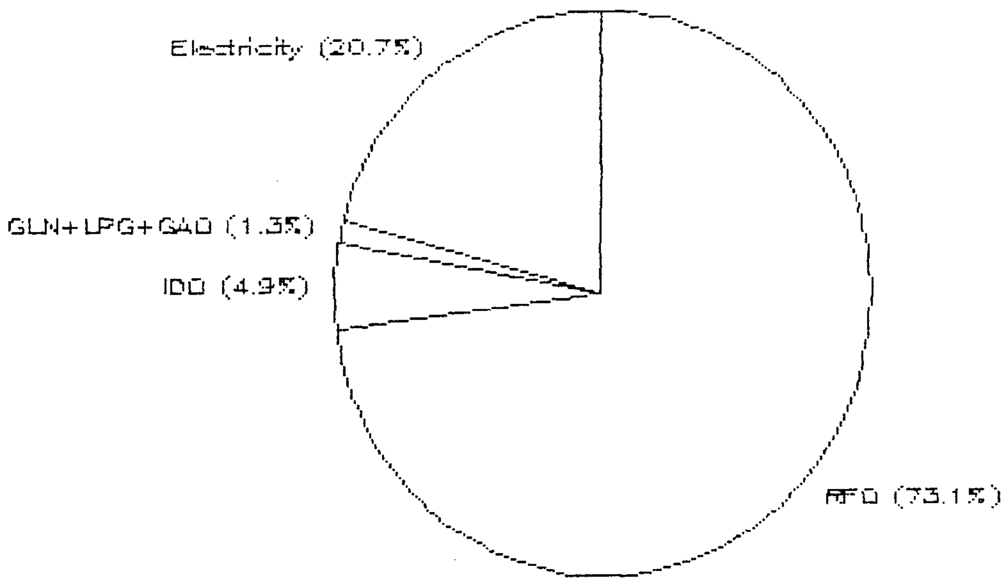
Notes: Transport fuels and IDO excluded from all analyses.

It is recommended that an energy manager be appointed, with responsibilities for execution of the projects below. He should also implement staff training and awareness activities.

Rivatex has a number of major energy conservation and/or reduction opportunities. The estimates for energy saving opportunities are based on actual measurements or engineering-economic judgement following the site visit. Cost and savings are approximate, and additional engineering and economic feasibility investigation, particularly to take account of continuing variations in energy costs, will be necessary before proceeding with any of the projects identified. Indeed it should be observed that since the time of the 1985 audit, international fuel oil prices have fallen dramatically, while the economic and market prices of both electricity and fuelwood have risen.

FIG 1.1 — ENERGY CONSUMPTION

RIVATEX CY 1984



ENERGY COSTS

RIVATEX CY 1984

1.2 Recommended Projects to Achieve Target Energy Savings

Table 1.2 summarises the short term, T1, and long term, T2, projects identified to achieve the targeted energy savings at Rivatex. A more detailed discussion of each proposal may be found in the Reference Chapter.

TABLE 1.2 - RECOMMENDATIONS

Project	Cost Saving kKSh/a	Capital Cost kKSh	Payback Time Years	Reference Chapter
Target 1: Short Term Energy Savings				
1 General improvements Steam system	229	200	.9	7
2 Insulation improvements	157	50	.3	7
3 Compressed air leakage	69	25	.4	8
4 Fan speed adjustments	186	120	.7	5
5 Flash steam recovery	154	50	.3	7
Target 2: Long Term Energy Savings				
1 Boiler conversion to woodfuel	6 521	3 560	.6	9
2 Electricity & steam cogeneration	4 511	12 180	2.7	10
3 Thermic heater fuel substitution	927	706	.8	6

1.3 Target 1: Short Term Energy Savings

By adopting a vigorous energy management programme and implementing the short term T1 recommendations listed in Table 1.2, which in general require minimum investment levels, a Target 1 specific energy cost of 1 578 KSh/km could be achieved, giving a saving of around 795 000 KSh/a, or 6% of CY 1984 process energy costs as summarised in Table 1.3.

TABLE 1.3 - TARGET 1: SHORT TERM ENERGY SAVINGS

Energy form	Specific Energy Current GJ/km	Target GJ/km	Savings GJ/km	Energy Cost Current kKSh	Target kKSh	Savings kKSh	Percent Savings %
Electricity	4.3	4.1	.2	7 445	7 190	255	3
Fuel oil	15.1	14.3	.8	10 117	9 577	540	5
Total	19.4	18.4	1.2	17 562	16 767	795	6

1.4 Target 2: Long Term Energy Savings

By implementing the long term T2 recommendations listed in Table 1.2 which, in general require some capital investment, and subject to further more detailed evaluation of engineering and economic feasibility and assuming all T1 recommendations have already been implemented, it is estimated that whilst the Target 2 specific energy consumption would be increased to 27.6 GJ/km, the energy cost would be considerably reduced giving a further saving of around 12 000 000 KSh/a or a total saving of 68% of CY 1984 energy costs.

TABLE 1.4 - TARGET 2: LONG TERM ENERGY SAVINGS

Energy form	Specific Energy Current GJ/km	T1 GJ/km	T2 GJ/km	Energy Cost Current kKSh	T1 kKSh	T2 kKSh	Savings kKSh
Electricity	4.3	4.1	-	7 445	7 190	-	7 190
Fuel oil	15.1	14.3	-	10 117	9 577	-	9 577
Wood	-	-	27.6	-	-	5 575	(5 575)
Total	19.4	18.4	27.6	17 562	16 767	5 575	11 192

Subject to rounding errors.

ENERGY AUDIT REPORT

Executive Summary

THIKA CLOTH MILLS
THIKA, KENYA

1.0 EXECUTIVE SUMMARY

1.1 Introduction

Thika Cloth Mills is one of Kenya's major textile producers. Process heating and electric drives are the major energy users in this plant. Overall energy usage and costs are summarized in Table 1.1. During 1984 fuel oil cost 7.3 mKSh, electricity 5.9 mKSh and industrial diesel oil 0.3 mKSh.

Figure 1.1 shows the energy consumption and cost pictorially.

TABLE 1.1 - ENERGY SUMMARY

		1984
Total production	km	11 344
Energy consumption	GJ	178 330
Energy intensity	GJ/km	15.7
Energy cost	kKSh	14 295
Specific energy cost	KSh/km	1 260
Energy intensity targets		
Target T1	GJ/km	14.8
Target T2	GJ/km	21.9
Potential energy savings		
Target T1	GJ/km	.9
Target T2	GJ/km	N/A
Potential energy costs		
Target T1	KSh/km	1 204
Target T2	KSh/km	372

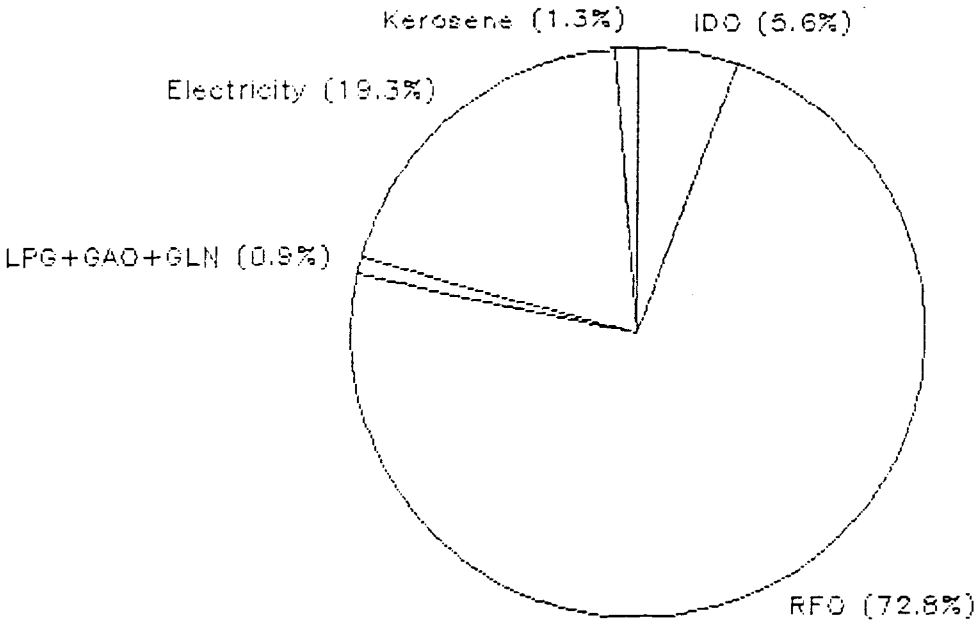
Notes: Transport fuels, kerosene and IDO excluded from all analyses.

The plant is highly organised, data and records keeping are exemplary. It is recommended that an energy manager be appointed, with responsibilities for execution of the projects below. He should also implement staff training and awareness activities.

Thika Cloth Mills has a number of major energy conservation and/or reduction opportunities. The estimates for energy saving opportunities are based on actual measurements or engineering-economic judgement following the site visit. Cost and savings are approximate, and additional engineering and economic feasibility investigation, particularly to take account of continuing variations in energy costs, will be necessary before proceeding with any of the projects identified. Indeed it should be observed that since the time of the 1985 audit, international fuel oil prices have fallen dramatically, while the economic and market prices of both electricity and fuelwood have risen.

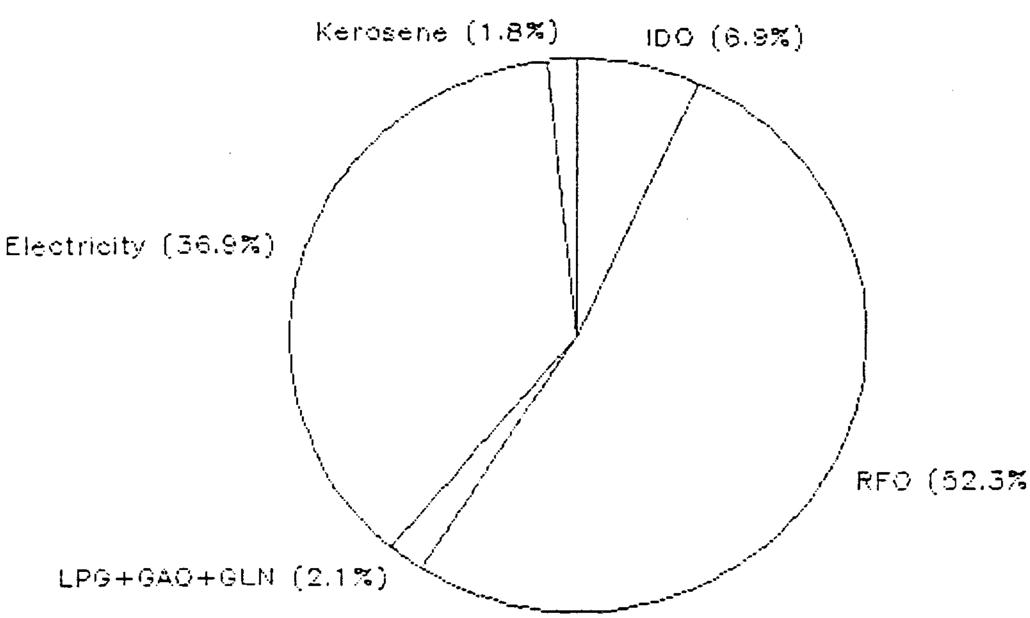
ENERGY CONSUMPTION

THIKA CLOTH MILLS CY 1984



ENERGY COSTS

THIKA CLOTH MILLS CY 1984



1.2 Recommended Projects to Achieve Target Energy Savings

Table 1.2 summarises the short term, T1, and long term, T2, projects identified to achieve the targeted energy savings at Thika Cloth Mills. A more detailed discussion of each proposal may be found in the reference chapter.

TABLE 1.2 - RECOMMENDATIONS

Project	Cost Saving kKSh/a	Capital Cost kKSh	Payback Time Years	Reference Chapter
Target 1: Short Term Energy Savings				
1 Boiler & boiler house maintenance/upgrading	110	50	.5	6
2 Steam system maintenance	298	155	.6	7
3 Caustic plant condensate/ feedwater upgrading	48	15	.5	7
4 Flash steam recovery	184	60	.3	7
Target 2: Long Term Energy Savings				
1 Boiler conversion to woodfuel	5 403	3 959	.7	9
2 Electricity & steam cogeneration	3 907	5 625	1.4	10
3 Thermic heater fuel substitution	608	250	.5	6
4 Jet dyer heat recovery	47	35 (presently in hand)	.7	7

1.3 Target 1: Short Term Energy Savings

By adopting a vigorous energy management programme and implementing the short term T1 recommendations listed in Table 1.2, which in general require minimum investment levels, a Target 1 specific energy cost of 1 204 KSh/km could be achieved, giving a saving of around 640 000 KSh/a, or 5% of CY 1984 process energy costs as summarised in Table 1.3.

TABLE 1.3 - TARGET 1: SHORT TERM ENERGY SAVINGS

Energy form	Specific Energy Current GJ/km	Specific Energy Target GJ/km	Specific Energy Savings GJ/km	Energy Cost Current kKSh	Energy Cost Target kKSh	Energy Cost Savings kKSh	Percent Savings %
Electricity	3.3	3.3	N/A	5 913	5 913	N/A	N/A
Fuel oil	12.4	11.5	.9	8 382	7 742	640	8
Total	15.7	14.8	.9	14 295	13 655	640	5

1.4 Target 2: Long Term Energy Savings

By implementing the long term T2 recommendations listed in Table 1.2 which, in general require some capital investment, and subject to further more detailed evaluation of engineering and economic feasibility and assuming all T1 recommendations have already been implemented, it is estimated that whilst the Target 2 specific energy consumption would be increased to 21.9 GJ/km, the energy cost would be considerably reduced giving a further saving of around 9 400 000 KSh/a or a total saving of 70% of CY 1984 energy costs.

TABLE 1.4 - TARGET 2: LONG TERM ENERGY SAVINGS

Energy form	Specific Energy Current GJ/km	Specific Energy T1 GJ/km	Specific Energy T2 GJ/km	Energy Cost Current kKSh	Energy Cost T1 kKSh	Energy Cost T2 kKSh	Savings kKSh
Electricity	3.3	3.3	-	5 913	5 913	-	5 913
Fuel oil	12.4	11.5	-	8 382	7 742	-	7 742
Wood	-	-	21.9	-	-	4 229	(4 229)
Total	15.7	14.8	21.9	14 295	13 655	4 229	9 426

Subject to rounding errors.