ENERGY UTILIZATION IN SOUTH AFRICA

BY

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FOREWORD

This report on energy utilization in South Africa is the result of a two year survey carried out by the Energy Research Institute. Such work has never before been carried out in South Africa and the request for this survey by the Department of Planning indicates the growing interest in energy matters in South Africa. The data presented here will, in time, require updating and I hope that this report will form the foundation for further work, and will provide the incentive for the provision of adequate statistical information on the national use of energy, a lack of which has been highlighted by this survey.

This work has been a collaborative effort between the Department of Planning, Industry and the Energy Research Institute, and thanks must be given to the many people involved in this work, and especially to the members of Industry who gave of their time to the preparation of information for the survey.

Signed by candidate

Professor R.K. Dutkiewicz
Director
Energy Research Institute

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1. INTRODUCTION

1.1 Scope

The purpose of this study is to provide the Department of Planning and the Environment with the following information:

1) The quantities and forms of input and useful energy used by different sectors of the South African economy. (The terms input energy and useful energy are defined in section 1.2 of this chapter).

2) The efficiency of conversion of input energy to useful energy.

3) Current and expected trends in energy utilization within individual sectors of the economy.

The two year contract to carry out this study was awarded to the Energy Research Institute at the University of Cape Town.

The work was undertaken by one engineer assisted by a graduate engineer, supported by secretarial staff and supervised by a professor of the Department of Mechanical Engineering.

1.2 Definitions

Before discussing in detail the different energy analysis methods, it is necessary to define the different energy-related terms in common use.

1.2.1 Gross Energy is defined as the amount of energy required to carry out some activity and includes the energy required for the production of the energy used in the activity.

Strictly speaking, gross electricity requirements should include generation and transmission losses as well as the energy requirements for the mining, beneficiation and transport of the power station fuel and the energy requirements for the manufacture and erection of all plant, machinery and buildings of transmission systems, power stations and fuel processing plants.

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More commonly, the gross electricity requirements are related to the fuel usage in the power station and the secondary energy inputs are ignored. Consequently it is very important to define the system boundary and consequently the energy inputs that are being considered to prevent misunderstandings from arising.

1.2.2 Net Energy is defined as the portion of the gross energy that is available to do useful work. As such it excludes the direct energy required for the production of energy as well as the secondary inputs associated with the generation and distribution of the energy source.

The concept of net energy has led to a technique known as net energy analysis (NEA) (see 1.3.2.1). This technique is used to decide whether the energy-economics favour the development of new energy technologies and has been incorporated in American Law (1). However, the technique seems to have fallen out of favour recently (1), (2) and its future is uncertain.

1.2.3 Input Energy is defined as that energy which, in physical terms, crosses the boundary of the factory or establishment where it is utilized. In other words, it is the energy received by the user and excludes all losses associated with its prior winning,conversion or transport.

1.2.4 Useful Energy is defined as the energy that is utilized by the consumer after its final conversion. It excludes all losses up to the point of utilization and takes one of four forms : heat, light, mechanical energy or chemical energy.

1.2.5 Conversion Efficiency is defined as the efficiency of conversion of input energy to useful energy. As such, any conversion occurring in power stations or refineries remote from the point of utilization is excluded. However, if the user generates his own electricity, the losses associated with the process would be included.

1.2.6/........

1.2.6 Utilization Efficiency. The utilization efficiency arises from the fact that there are further losses associated with the utilization of useful energy. For example, electricity is converted to heat in a space heater at a conversion efficiency of practically 100%. A certain amount of the heat is utilized to heat up walls while a portion is lost through windows, doors etc. Therefore only a portion of the useful energy actually warms the room and it is this portion related to the input energy requirements that yields the utilization efficiency.

1.2.7 Summary. The flow of energy in an industrial society is highly complex. However, by the use of a simplified chart it is possible to highlight the terms defined above. This has been done in Figure 1 below.

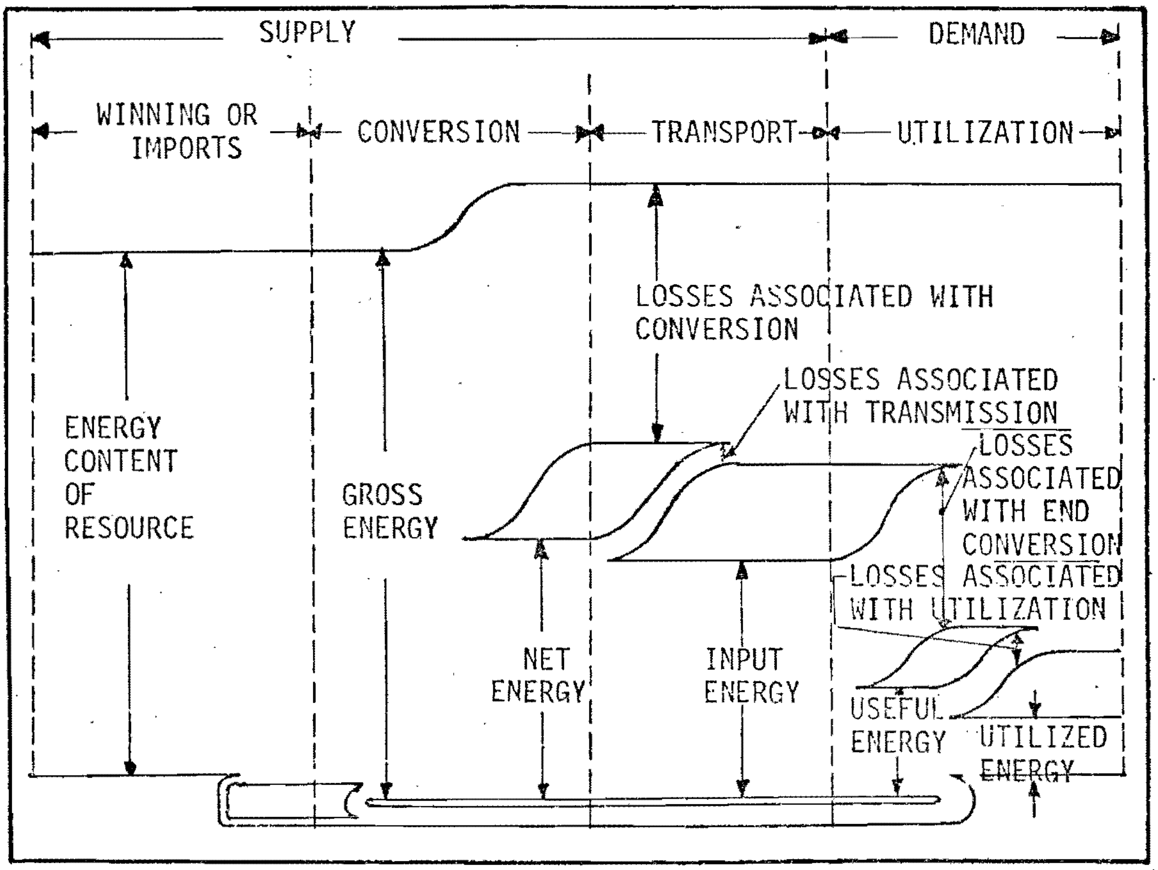

FIGURE 1 : THE FLOW OF ENERGY IN AN INDUSTRIALIZED SOCIETY

1.3 Energy Analysis Methods

Energy analysis techniques can be divided into two broad categories: input-output analyses and process analyses. Both techniques suffer from shortcomings and these should be remembered when the results of an energy analysis are considered.

1.3.1 Input - Output Analysis.

The input-out energy analysis is a development of the static input-output economic analysis. This affords a method of determining (in monetary terms) the interdependence of the various sectors of an economy. The results of an input-output economic analysis are usually presented in a matrix form, where the element A_{ij}, in the ith row and jth column, indicates the amount of commodity i (the money terms) required as a direct input to produce one unit of output of j (also in money terms). In other words, one complete column of an input-output table indicates the dependence of the industry represented in that column on all the other sectors of the economy.

Certain of the rows in such a table refer to the energy producers and by reference to these rows it is possible to determine the energy costs related to a particular product. Knowing the price of energy it is possible to determine the physical requirements (in terms of kWh or Megajoules) to produce one Rands worth of product. Knowing the price of the final product it is possible to determine the specific energy requirements (in terms of say Megajoules per tonne).

In this way it is possible to build up an energy-related input-output table. This has been cone by Hereendeen in America (3) and Wright in the United Kingdom (4).

Energy-related input-output tables enable the short-term effect of changes in the price of energy on the costs of commodities to be estimated as well as providing the specific energy requirements of various commodities.

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There are a number of disadvantages associated with the use of this type of analysis and these should be discussed.

Firstly, the analysis relies on the accuracy of the data contained within the economic input-output table. As can be imagined, the collection and collation of the data for such a table is a formidable task. Consequently the results are usually only published five to seven years after collection.

When the supplies of certain inputs are curtailed, as occurred as a result of the 1973 OPEC measures, it is difficult to estimate the effect on the table with the desired accuracy (5).

The enormity of the task of data collection can result in data being collected from different industries at different times with resultant errors. There is also little chance of feedback to ensure the accuracy of the supplied data. Inaccuracies in the data would be the result of errors or the reluctance to provide data of a confidential nature.

The division of the input-output table into the various sectors of an economy is done using economic considerations. Consequently, it is possible to combine in the same sector, two processes with widely differing energy-intensities. A second problem related to sectors producing more than one product results due to the definition of sectors within the input-output table. A factory producing primary steel as well as steel castings could be classified in either sub-group depending on the volume of sales of the products. If the sales of steel casting accounts for more than 50% of the total, then the factory would be classified as a steel casting establishment. The energy requirements for producing primary steel would therefore be included in the wrong sector.

The fact that the monetary values included in an economic input-output table are producers prices means that any purchaser who is able to get a special discount as a result of large volume purchases or other agreement actually uses more energy than is reflected by the energy costs as reported in the input-output table.

The input-output analysis assumes linearity of production and energy demand. This is a serious shortcoming when considering technological advances within a particular sector as one of the main incentives to introduce a new technology could be to reduce the energy requirements. Although adjustments can be made to individual coefficients contained in the input-output table to compensate for the expected changes in energy demand, the tables as they are commonly used do not allow for technological developments.

There are further problems associated with the use of input-output tables such as the energy content of imported goods but these and the other shortcomings described above, are not meant to imply that the technique is worthless. Applied correctly, the input-output analysis can provide valuable information, especially regarding the secondary energy requirements of industries.

The latest available input-output table for South Africa is for the year 1967 (6). Unfortunately, the energy inputs are only divided into two groups : (i) Other basic petroleum products, explosives and ammunition; and petroleum and coal products.

(ii) Electricity, gas and steam.

The input-output tables as they are at present structured are therefore not suited to energy analysis and it is suggested that consideration be given to a more detailed breakdown of energy inputs in in any forthcoming editions.

Due to the lack of detailed energy statistics it is not possible to carry outan accurate input-output energy analysis in South Africa and the study has therefore been confined to process analyses.

1.3.2. Process Analysis consists of the identification of all energy inputs required for an activity or process within a pre-defined sub-system. As such it implies a knowledge of the methods and processes used for the manufacture of the products under consideration. This knowledge is usually only obtained after an in-depth study of the industries involved and can entail personal visits by the researcher

to acquaint/.....

to acquaint himself with these methods and processes.

The method has the advantage that energy-intensive sub-sectors of a generally low-energy-intensive sector can be considered and is also well suited to predictions of energy requirements resulting from the introduction of new technologies.

However, one of the drawbacks of this technique centres around the definition of the sub-system. This problem can be broken down into two parts. Firstly, there is the problem of the energy content of machinery, plant and buildings. To estimate the energy costs of steel one should include the energy content of the steel used to construct and equip the steelplant as well. Luckily these energy requirements are usually small in comparison with the direct energy inputs obtained from commercial energy sources. Makhijani and Lichtenberg (7) quote figures of 6% for rolled steel, 1,5% for rolled aluminium, 2% for cement and 4,2% for glass (i.e. secondary energy requirements expressed as a percentage of the total).

Secondly, a decision must be made as to how far back along the chain of energy supply one wishes to travel. The energy content of electricity can either be considered in gross or net terms. As stated earlier, the gross requirements include the energy losses associated with the generation and transmission of the electricity to the point of utilization.

Process analysis does not lend itself to the determination of secondary energy inputs since these are in most cases derived from other sub-sectors of the economy. It should be mentioned though that it is possible to build up an energy-related input-output table using process analysis but due to the volume and confidentiality of the data, could probably only be successfully undertaken by somebody with enormous manpower resources. It is doubtful that such a project would be undertaken however, since the findings would only be of interest to a small body of persons. Two variations of process analysis should be mentioned here.

1.3.2.1 Net Energy Analysis. This technique (1) is used to determine the viability of an energy technology. Using the technique one can estimate the efficiency of the energy industries. Basically, one compares all the energy inputs to the industry (primary and secondary inputs) with the energy delivered by the industry. A lot of work has been done in this field, especially in the United Kingdom (8), (9), (10), (11) although as mentioned earlier, some researchers are having doubts as to the value of this technique.

1.3.2.2 Statistical Analysis. Certain countries, notably the United States (Bureau of Census and Bureau of Mines) and the United Kingdom (Department of Energy) regularly publish comprehensive energy statistics. It is possible in the case of some industries to use this data directly to calculate specific energy requirements. This is an application of process analysis in its broadest sense. It is not usually possible to determine the end usage of the individual energy sources and the statistics often combine subsectors of varying energy intensities.

The only comparible statistics for South Africa are published by the Department of Planning and the Environment (12). These statistics are divided into four energy sources (electricity, gas, liquid fuels and solid fuels) and five economic sectors (domestic, industry, mining, transport and energy industries). In their present form, they are of little use to the energy analyst except in providing the overall energy requirements of the four groups of energy sources for the various sectors. i.e. domestic, industry, mining, transport and energy industries.

1.3.2.3 Other Methods. Variations of process analysis have been developed for particular applications such as the study of resource depletion, environmental impacts, energy conservation etc. The variations are derived by varying the definition of the sub-system being considered and the energy inputs into that sub-system.

1.4 The Application of the Results of this Energy Analysis

The primary object of this study, as stated in Section 1.1, is to determine energy conversion efficiencies as well as past, present and future energy usage patterns within selected sectors of the South African economy.

Since the statistics required for an input-output analysis are not available, the study has been confined to the use of process analysis techniques.

Only direct energy inputs have been considered i.e. the energy required to erect the factory initially, as well as the energy content of replacement machinery has not been considered.

Wherever possible energy inputs have been related to a common unit of output such as tonnes or litres of product. By obtaining data relating to past years from interviews, it is possible to identify trends in energy usage patterns and predict future energy requirements as well as energy conversion efficiencies.

2. METHOD OF DATA COLLECTION

A problem that was encountered very early on in the study was the lack of available data. Although the Department of Planning and the Environment has published details of the historical requirements of individual energy sources in South Africa (12), it is not possible to estimate the requirements of individual sectors of the economy.

It soon became apparent that the most reliable method of data collection would involve an extensive survey, preceeded by visits to as many large energy users as possible.

However, some estimation had to be made as to the sectors of the economy (especially in the manufacturing and mining industries) that warranted the most attention.

2.1 Breakdown of Sectors

All economic activities have been classified by the Department of Statistics (13) but this classification does not include the energy demands of one important sector, namely the domestic sector. For the purposes of this study the energy users have been re-classified into the following five major divisions:

1) The Industrial Sector
2) The Mining Sector
3) The Domestic Sector
4) The Transport Sector
5) Other

Within each of these major divisions there was a need for further sub-division since differences in energy usage patterns were expected. For example the industrial sector includes the manufacturing industries and it is necessary to look at the energy requirements of different manufacturing processes individually. Details regarding the final breakdown of the individual sectors investigated is contained in section 3.

2.2 Method of selection/......

2.2 Method of Selection of the Sample

It must be remembered that this study is not intended to provide a census of energy requirements but rather to obtain representative information regarding the present and future energy requirements of individual important energy-consuming sectors of the economy. As such it was not necessary to canvas every establishment within a particular sector, but a representative sample of the sector had to be obtained. The following methods were used to ensure that representative samples were obtained from the various sectors of the economy.

2.2.1 The Industrial Sector

The industrial sector of the economy is the largest energy user in the country. According to the Department of Planning and the Environment (11) this sector accounted for roughly 40% of the total energy requirements of the country during 1972.

The industrial sector is made up of a wide variety of manufacturing industries producing various products by different processes from a range of raw materials. Consequently it is more meaningful to consider trends within the energy-intensive industries before producing figures for the industrial sector as a whole.

Comprehensive data relating to the cost of energy to all the sub-sectors of the industrial sector are contained in the Manufacturing Census published periodically by the Department of Statistics. The latest available Census (14) was used to obtain an indication of the sub-sectors requiring intensive investigation. This data could only be treated as indicative of the energy-intensiveness of individual sub-sectors, since it reflects the cost rather than the quantity of energy used. If this distinction were ignored one might be led to the conclusion that a factory using small quantities of very expensive fuels would employ more energy-intensive processes than one using much larger quantities of relatively inexpensive fuel.

Having obtained/......

Having obtained an indication of the energy-intensive sub-sectors from data contained in the Manufacturing Census, it was necessary to contact individual companies within these sub-sectors to ascertain details of their energy usage patterns.

The Bureau of Market Research at Unisa in Pretoria was contacted for assistance. A list comprising some thirteen thousand names and addresses of companies was obtained from the Bureau. The list, compiled by computer, was arranged according to industrial activity and company size. For example one portion of the list contained all South African cement producers arranged from the company having the largest number of staff to the one with the smallest number of staff. Since similar companies are being compared, it is reasonable to assume that the number of employees gives an indication of the output of the company. This approach was adopted since data relating to physical output was not obtainable.

Combining the data contained in the Manufacturing Census with that obtained from Unisa's Bureau of Market Research it was possible to select the largest companies in the most energy-intensive sub-sectors and approach them for assistance with the study.

2.2.2 The Mining Sector

According to the Department of Planning and the Environment, the mining sector accounted for some 16% of the country's total energy consumption during 1972 (11). One tends to associate mining in South Africa with gold and indeed gold mining accounts for the largest portion of the mining sector's energy requirements. It must not be forgotten though that South Africa has other extensive mining operations and the energy requirements associated with these cannot be ignored.

In general, electricity is an important energy input to the mining industry. While some industries (copper for instance, due to its geographic location) generate a portion of their requirements, most mines and beneficiation plants rely on Escom for their power. In their annual report (15), Escom gives details of the electricity requirements of individual sub-sectors of the mining industry. From these annual reports, it will be seen that gold (75%), platinum (11%), coal (4%) and copper (4%) collectively accounted for about 94% of the 1975 electricity requirements of the mining industry.

Attention was concentrated on the mining sub-sectors listed above. The aluminium industry has not been grouped under mining since South Africa's alumina requirements are imported. The only process carried out in South Africa, electrolytic refining of the alumina, has been grouped under the base metals, a sub-sector of the manufacturing industry.

Due to the confidential nature of the information relating to the platinum industry, it was decided that the Department of Planning and the Environment should liaise directly with the various producers. Consequently no information regarding this sector is included in the report.

2.2.3 The Domestic Sector

The domestic sector is unique in that is made up of a large number of relatively small energy users who in total account for a significant portion of the country's overall requirements (15% of the 1972 total energy requirements (11)).

Due to its composition the sector does not lend itself to data collection methods suited to specialized industries.

It was decided that the best method of data collection would be a postal survey, conducted on a nation-wide basis. The problem then arose of ensuring a representative sample. A number of methods were considered (16) and after consultations with a market research organization it was decided that the random selection of names from the Electoral Roll would supply a representative sample of the White population. (See Appendix 26)

The Department of Coloured Affairs and the Department of Bantu Administration was approached to supply names and thus obtain a representative sample of the non-White population. Although there was no guarantee that the names obtained from these government departments would provide a representative sample, the poor response obtained from the non-White sector precluded analysis of this particular sub-sector. Shortly after the survey was distributed, unrest erupted in a number of the Black and Coloured townships. As a result of the unrest, it was decided not to repeat the survey in these areas and the findings of the survey of the energy needs of the domestic sector are in the main, related to the White population.

The selection and transcribing of some 2 200 names and addresses from the Electoral Roll onto adhesive labels proved very time consuming and when it became obvious that, due to the poor response elicited from the public, a further wave of questionnaires would have to be distributed, a large international publishing and mail-order company was contacted for assistance. This company had previously purchased a computer tape containing all the information stored in the Electoral Roll and agreed to supply us with a list, selected at random, of 5000 of the names and addresses contained on this tape. The output was printed on adhesive labels and this facilitated easy transfer to envelopes.

The reasons for the poor response to the initial wave of questionnaires are discussed in section 2.4 of this chapter.

2.2.4 The Transport Sector

The transport sector of the South African economy can be conveniently divided into five sub-sectors:

1) South African Railways and Harbours (SAR&H)
2) Trolley and motorized buses
3) Pipelines
4) Road
5) Air

None of the above sub-sectors operate without some form of government restrictions and in the case of the SAR&H and pipelines a monopoly

exists/......

exists. This is virtually true for air transport as well, although private operators are permitted to operate within certain closely defined limits.

Trolley buses have in recent times lost support and are presently only in operation in Johannesburg.

Even road transport companies are required to work in close liaison with the Department of Transport and the licences granted are subject to restrictions.

As a result of the monopolistic nature of the transport sector, the collection of data was simplified. Relatively few organisations had to be contacted and the collation of data could be kept to a minimum.

2.2.5 Other

Besides the sectors of the economy already considered, there are a number of others that need mention in a study of this kind.

For example the energy requirements for municipal services, especially street lighting, need to be considered as well as state social services such as hospitals and nursing homes.

Hotels are fairly energy-intensive to operate, although in comparison with some of the large industrial sub-sectors, account for insignificant amounts of energy.

Other state-institutions, such as the Post Office, prisons as well as the various Government departments all require energy as do shops, offices, banks etc.

The stage is reached however where the amount of energy required by the sub-sector is so small that any change within the sub-sector will have insignificant effects on the energy demands of the country. It therefore becomes a purely academic exercise, of little practical merit, to ascertain the energy requirements of these sub-sectors.

While some of the abovementioned energy users are mentioned with respect to predicted trends in usage patterns in a later chapter of this report, the remarks have been kept brief as they are of little importance outside the particular sub-sectors in question.

A number of the low-energy intensive industries were surveyed by postal questionnaires. A general questionnaire, suitable for various industries was drawn up and distributed to these sectors. As might have been expected, the response to this survey was poor (about 10%) since no personal visits were involved and in most cases no follow up letters were sent.

2.3 Preparations for Data Collection

Having established the pattern for data collection it was necessary to contact the various large energy users in the industrial, mining and transport sectors.

It was obvious that meaningful results would not be obtained from the study unless an understanding of the needs and problems of the individual sub-sectors could be gauged.

To this end visits were arranged to representative companies of each of the energy-intensive industries. Meetings were arranged with members of staff of the individual companies, usually at the Senior to Chief Engineer level, and often with the Technical Directors. The aims of the study were discussed and wherever possible a visit to the factory was arranged. Assistance was sought from specialists employed by the companies in the compilation of questionnaires to ensure that meaningful data was obtained. In most cases, the questionnare, in draft form,would be shown to other companies operating in the same field and once all constructive criticism had been collated, a final version of the questionnaire was drawn up. This final questionnaire was then distributed (using Unisa's list of names and addresses) to as many companies producing the same commodities as was available.

The visits to upper managements had the dual role of ensuring co-operation at a later date from other employees in the company as well as allowing the author to familiarize himself with the various processes and techniques used.

As far as/.........

As far as the domestic sector was concerned, a draft questionnaire was compiled and a small pilot survey was carried out to pinpoint ambiguous questions. Once these had been isolated it was possible to finalise the format of the questionnaire, translate it and distribute it by post.

In certain sectors, the problem of the confidentiality of information arose. Since it was necessary to obtain production figures as well as other confidential data, some companies were worried that this would be presented in a form that would be of great value to competitors. To overcome this, the results have been presented in a form which makes the identification of individual company's figures impossible. Only in one case (the platinum industry) did the industry think that risk involved was too great and it was mutually decided that a detailed analysis of this sector would not be undertaken.

It is not felt that the inability to publish details of individual companies has detracted from the findings. The results as presented represent average values for the industries and as such allow individual companies to compare their figures with the average values and thus point out areas where measures could be adopted to reduce energy requirements.

2.4 Response and the Factors Affecting it

The response to the survey varied widely from sector to sector.

Within the industrial sector, certain sub-sectors readily supplied information while others were most reluctant and in some (isolated) cases refused outright. In most cases though, a reminder was sufficient to ensure that the questionnaires were returned.

Control of the mining sector is in the hands of relatively few but very large groups of companies. The inertia involved with large companies of this kind sometimes resulted in a poor response. This was particularly true when a number of companies within one group were requested to supply information. It was found in some cases that it was most important to ensure that one approached the correct person. Failure to do so would result in a total lack of co-operation from the correct man and his staff.

A number of other factors also affected the response obtained from the industrial and mining sectors.

Until comparatively recently, energy was not a matter that received a great deal of attention in most industries. It was a cost that had to be taken into account, but often it formed a relatively insignificant portion of the total cost of the final product. Management could institute greater cash savings by considering automation, improved utilization of labour and raw materials and a host of other changes rather than to install energy conservation equipment. As a result of this, statistics regarding energy usage have in the past seldom extended beyond energy costs as recorded in the company balance sheet.

Consequently, the data requested for this survey was in some cases simply not available.

In other cases, the data were available but in an uncollated form. Since the supply of statistics is essentially a non-productive task, management was not prepared to divert someone onto the task of collating all the necessary data.

The economic recession that the country has recently been experiencing has also played a part in limiting the response. In certain industries, reductions in staff numbers has meant that remaining staff has had their work load increased substantially and there simply was no one to divert to the job.

A further factor is what one might term the "questionnaire syndrome". Besides the data that certain industries are required by law or their association to submit on a regular basis, companies receive questionnaires from time to time requesting information on widely differing aspects of their operations. Often, after a lot of work collecting the data, the company hears no more. This lack of feedback leads to resentment and the companies adopt a policy of supplying information only where absolutely necessary.

It was/......

It was initially anticipated that a 25% response would be obtained from the domestic sector (16). However, when only 10% were received it was decided that a further wave of questionnaires would be dispatched.

As a total of just over 500 questionnaires was required (16) it was decided to incorporate a safety factor and a further 5000 were sent out. A total of 1 047 completed usable questionnaires were received which was equivalent to a response of about 14%.

Although the sample was selected at random, it was interesting to note that a larger percentage of English-speaking families replied. The ratio of English to Afrikaans speaking families was 73,9%/26,1%. No definite reason could be established for this pattern and it is a matter of conjecture whether the antipathy shown by certain sectors of the Afrikaans population towards English-speaking universities was not part of the reason.

Since the questionnaire was distributed in both official languages, it is possible that a small percentage of the Afrikaans speaking public complete the English side. One might not have expected to receive a bilingual questionnaire from and English-speaking institution and only on completion have realized that an Afrikaans version of the questionnaire was attached.

The response from urban dwellers to the questionnaire was higher than that obtained from rural dwellers (88,5%/11,5%).

According to the Department of Statistics (17) the split was 86,7% to 13,3% in 1970. The results of the survey agree closely with these findings.

No major problems were experienced in obtaining data from the transport sector. Due to the monopolistic nature of some of the sub-sectors the problems associated with competitors did not arise.

However, it is not Government policy to publish data relating to the use of oil-based products, so problems of confidentiality once again arose while dealing with South African Airways. This information

was finally/.........

was finally obtained on the understanding that it would not be published.

Concerning the survey as a whole it was felt that advance publicity would improve the response and to this end the press, radio and editors of technical journals were requested to publish details of the study (18). It proved difficult however to gauge the effectiveness of these measures.

3. GENERAL FINDINGS ON A SECTORAL BASIS

3.1 Introduction

This chapter summarizes the findings of the investigations into energy usage by the various sectors of the South African economy. The sectors are considered individually and salient features of the reports (included as appendices) are presented.

For ease of reference, the sectors have been arranged in ascending order according to the Standard Industrial Classification of All Economic Activities(S.I.C.) (13).

3.2 Coal Mining (SIC 21000)

The major South African coal producing areas lie in the Eastern Transvaal and Natal, although other fields such as those in the Northern Transvaal hold great development potential.

In general, South African coal is not of high quality, often having high ash contents and very seldom having good coking properties.

However, reserves are abundant and the industry will play an increasingly important role in supplying South Africa's future energy needs.

The fact that coal is a price-controlled commodity has had a stifling effect on the growth of the industry since investors have preferred to support more profitable undertakings. However, the recent series of price increases granted to coal and the increased awareness of its importance as South Africa's most important energy reserve, has injected new life into the industry.

The most common mining method at present employed by the industry is bord and pillar. This method is expected to predominate even to the end of this century. The more capital-intensive longwall methods will be restricted to certain areas.

As South Africans/..

As South Africans become more environment-conscious, open cast mining methods can be expected to meet increased opposition. Government measures to enforce the reclaimation of open cast lands could become stricter, thus diminishing the cash incentives to use this mining method.

As an energy user, the coal mining industry is relatively small. Comparing the data obtained from this study with information published by Kotzé (19) the industry only accounted for 0,5% of the total useful energy consumption of South Africa during 1973.

Although the industry cannot be considered as energy-intensive, its importance as an energy supplier to the rest of the country merits the investigation undertaken to determine its energy usage pattern and trends.

Currently, electricity is the major energy input to the coal mining industry, accounting for some 50% of the total requirements. Over the past ten years electricity has grown in importance as an energy source (from 41% in 1966) while coal has decreased from 54% of the total input in 1966 to 38% in 1975.

As the use of mechanization increases, electricity can be expected to account for an even larger percentage of the total inputs. Since the efficiency of conversion of electricity by the coal mining industry is high (80%), its increased use will raise the overall conversion efficiency from its present value of 55%. The rate of increase will depend on how rapid the change over to electricity is. Assuming that electricity and coal follow similar trends for the next ten years to those shown over the past ten years, the overall efficiency of energy conversion can be expected to increase by about 3%.

3.3 Gold Mining (SIC 24000)

South African gold mines, which produce about 80% of the free-world's gold and indirectly account for some 35% of the country's exports, constitute the most important mining operation in the Republic.

The industry/.....

The industry uses a significant portion of South Africa's energy needs. According to the latest Escom report (15), gold and uranium mining accounted for 22,7% of their 1975 sales. Comparing the results of the study with Kotzé's figures (19), the gold mines of South Africa accounted for 64% of the useful energy requirements of the mining sector and 7,3% of the total useful requirements of the country during 1973.

Electricity is the major energy input to the industry. This input has shown a steady increase in importance over the last thirty years as more mine-operated power stations were decommissioned and power was purchased directly from Escom. In 1947, electricity accounted for about 17% of the total energy requirements while by 1974 this had increased to over 70%. Over the same period, coal declined in importance from 82% to 26%.

If this trend continues in the future, it will result in marginal improvements in the overall efficiency of energy conversion since at present coal and electricity are converted at similar efficiencies. Some improvement could be expected if coal-fired boilers were to be replaced by electrode units, but when including the energy requirements for the generation of the extra electricity requirements by central power stations, the total energy requirements would be greater.

The industry is at present engaged in a number of research projects which, if implemented, could change the present energy usage pattern of the industry. These projects relate to rock breaking, ore conveying and hoisting as well as milling.

Rock cutters have been the subject of investigation for the past ten years but to date no successful commercial model has been marketed.

Swing-hammer miners and reef-boring have also been investigated with the main aim of developing a continuous mining method. The use of explosives necessitates the periodic evacuation of the mine with resultant loss of production time.

A further concept under investigation is the underground milling of ore.. This reduces the amount of material that must be hoisted to the surface but is unlikely to be introduced before compact centrifugal mills come into use.

The decision/...

The decision by mine managements to improve the underground working environment has resulted in the large scale installation of air conditioning equipment. In the eighteen mines surveyed during the study, it was found that the air conditioning capacity doubled over the period 1970 to 1974.

As far as the future energy requirements are concerned, coal requirements are likely to drop to an insignificant amount by the 1990's, while electricity will tend to replace it. These two energy sources account for over 90% of the total requirements of the industry so changes in the requirements of other fuels will have very small effects on the future overall efficiency of energy conversion.

Until about 1970 the net specific energy requirements of the industry gradually decreased. Since then the trend has reversed. What happens in the future depends to a large extent on what happens to the price of gold. By law, the mines must recover ore of grades equal to the average grade of their reserves. (Reserves imply that they are economically recoverable). Hence as the price of gold increases, ores of lower grade can be economically mined. The average ore grade drops and mines must process a larger mass of rock to obtain a similar amount of gold. Consequently, the specific energy requirements, related to the mass of gold recovered, increases.

The increase in the capacity of air conditioning plant and increased mining at deep-levels (in the Orange Free State) has also had the effect of increasing the specific energy requirements of the industry.

To estimate the future energy requirements of the industry, detailed information regarding the ore grades of all the producing mines is required and an estimate must be made of what is likely to happen to the price of gold.

Since the required information regarding ore reserves was not available at the time the study was undertaken, no estimate of the future energy requirements has been ventured.

3.4/......

3.4 The Processed Food Industry (SIC 31100 - 31340)

The processed food industry is made up of a number of sub-sectors each processing specialized products. It was therefore decided to consider the most energy intensive of these sub-sectors individually to ensure that their energy usage patterns and energy conversion efficiencies. were accurately assessed.

According to the most recent Manufacturing Census (14), the food processing industry utilized about 14% of the total energy requirements of the manufacturing (industrial) sector during 1968. According to Van Doornum (20) the industrial sector utilizes 39,8% of the energy requirements of the country and the food processing sector thus accounts for 6% of the total requirements of South Africa.

The sectors investigated individually include :

a) Bakeries
b) Sugar milling and refining
c) Grain mills
d) Fish products
e) Fruit and vegetable preserving
f) Distillers and wineries
g) Aerated mineral waters
h) Cocoa, chocolate and sugar confectionery
i) Breweries and malt works

a) Bakeries

Over the last twenty years there has been a major shift in the baking industry away from static to travelling ovens. In the forseeable future effectively all bread will be baked in these more modern ovens.

The newer ovens operate at improved efficiencies due to improved design and closer control on temperatures. Consequently, the overall efficiency of energy conversion of the industry can be expected to improve from the present value of 64% but is not expected to exceed 75%.

A factor/.........

A factor hindering the improvement of the conversion efficiency is the fact that the industry is closely controlled by an outside body, the Wheat Control Board. The utilization of ovens is indirectly determined by this board and hence it is not possible to increase outputs from existing ovens and reduce specific energy losses.

A further constraint on the development of the industry is the fact that bread is a price-controlled commodity and profits are strictly controlled, thus discouraging high risk investments.

b) Sugar Milling and Refining

This industry is in the fortunate position of being able to produce most of its own energy requirements from bagasse. So that although the process of sugar milling and refining is energy intensive (approximately 26 MJ/kg of sugar produced), the industry only purchases approximately 10% of its requirements. The toal energy requirements of the sugar industry during the 1974/75 season were approximately 48 000 x 10^6MJ.

Within the industry there have been some significant changes within the past ten years. While about 56% of the cane processed by the sugar mills was transported by rail nine years ago, only 27% is transported in this manner at present. Large specially-designed trucks now account for nearly half of the cane transport.

Mechanized cane cutting is a further development which could have a significant impact on the industry in future. At present only a very small percentage of the cane is cut mechanically but it has been estimated that between 65% and 80% of South Africa's cane could be harvested in this manner.

While the conventional method of extracting the juices from the cane is by crushing, a diffusion process has been pioneered in South Africa. This method, consisting of washing the juices from the cane, does not change the energy requirements significantly, but lower capital and maintenance costs are achieved.

Bagasse accounts for about 90% of the industry's energy requirements and as there is little alternative use for this waste product, it is doubtful that the industry would consider converting to alternative energy sources. Similarly, as long as there is sufficient bagasse to supply their energy needs, it is unlikely that energy conservation measures would be adopted, beyond minimizing energy purchases.

The possibility of the sugar industry selling excess power to Escom has been investigated, but problems relating to the reliablity of supply (among others) have caused the project to be shelved.

It is interesting to note that although the industry is subject to price-control regulations, it has flourished, mainly due to exporting sugar at world market prices.

c) Grain Mill Products

This sector of the economy is also subject to price-control regulations and it is hence difficult to estimate the future energy requirements of the industry.

According to the results of the study undertaken into energy utilization in this industry, grain mills used about 111 x 10^6kWh of electricity (the major input) during 1975. According to the latest Escom Annual Report (15) this is equivalent to 0,6% of the total electricity requirements of the industrial sector.

None of the companies surveyed included the requirements of their transport fleets, but in most cases this would be insignificant since large mills commonly use rail transport or are situated adjacent to bakeries.

Since electricity is the major energy input, the overall conversion efficiency is relatively high at 76%.

Energy conservation measures are not expected to change this value significantly although an increased demand for bulk-delivered flour could reduce handling and packaging costs. This is however, an insignificant amount of the total energy requirements and the overall usage pattern is expected to remain similar to that at present in existence.

d) Fish Meal and Fish Oil

This is another energy-intensive subsector of the processed food industry. When including the energy requirements of the fishing fleets with processing requirements, values of between 16-20 MJ/kg of product are obtained. It is difficult to compare these specific energy requirements with those obtained by other researchers since they are dependant on the method of fishing employed and the distance to be travelled to reach fishing grounds.

The main energy input to the factories was coal required for process heating and steam generation purposes. During 1975, coal accounted for 67% of the total requirements.

No significant changes in energy usage are expected within the industry beyond increased attention to energy conservation. The overall efficiency of energy conversion is therefore not expected to change much from its present value of 63%.

e) Fruit and Vegetable Preserving

Electricity and heavy furnace oil are the two major energy inputs to this industry.

Over 90% of the total energy requirements are used for heating or cooling purposes. As the industry operates on a seasonal basis, large air conditioning and refrigeration plants are required for raw product storage. About 15% of the electricity requirements are utilized in this manner.

A problem which faces an industry that only receives its raw materials in certain seasons is the large capacity required for their finished products, to ensure a year-round supply to the market. Luckily, in the case of fruit and vegetable canning, no energy is required during storage.

A development/........

A development of interest related to energy usage is an experiment by one factory into the use of peach pips as a boiler fuel. Initial results were disappointing, with excessive deposits on boiler surfaces but tests are continuing.

However, it is unlikely that the increased use of waste products as a fuel will change the overall efficiency of conversion significantly from its present value of 67%.

Energy conservation is receiving the attention of most manufacturers in this sector, but improvements in excess of 5% of present values are not expected.

f) Small Energy Users

The other sectors of the processed food (and beverages) industry investigated during the course of the study individually utilize less than 1% of the energy required by the manufacturing industry.

In general, the energy costs to these sectors amount to less than 3% of the total production costs and little attention is paid to energy use or conservation. Statistics were often sketchy and a number of questionnaires were returned incomplete.

Where savings have been achieved as a result of energy conservation measures, they have had a minimal effect on the overall energy demands of the food processing industry, since the energy demands of these less energy-intensive sectors are comparatively small.

3.5 Textiles (SIC 32100 - 32191)

According to the most recent Manufacturing Census (14), the textiles industry accounted for approximately 5% of the energy requirements of the manufacturing sector of the economy or in other words, about 2% of the total energy needs of the country.

The subsector/.....

The subsector of the textiles industry utilizing the most energy is spinning and weaving, accounting for about 45% of the requirements of the textiles industry.

The processes employed by this subsector are energy intensive and it was found that the specific energy requirements were between 40-50 MJ per kilogram of product. Consequently, energy costs are closely watched. Since the 1973 "energy crisis" there has been a marked swing away from heavy furnace oil to coal as a boiler fuel. While heavy furnace oil accounted for about 46% of the total requirements during 1973 (and coal 20%), by 1975 coal accounted for nearly half the total energy requirements and oil little more than 20%

Although new techniques of yarn processing are expected to be adopted, it was not possible to ascertain how these would affect the energy demands of the industry.

The other subsectors of the textiles industry do not expect any new processes or technologies to be adopted within the forseeable future and present energy usage patterns and conversion efficiencies are expected to remain unchanged.

The increased popularity of synthetic fibres (see Section 3.9) are expected to affect the growth rate of the textiles industry, since as these fibre products capture an increased share of the market, the demand for natural fibre products will be reduced.

3.6 Clothing (SIC 32200 - 32206)

Clothing accounts for about 1,6% of the energy requirements of the manufacturing sector (14). At the start of the study, this sector was selected for a pilot survey and it is therefore possible to consider the findings for this relatively small energy-using sector separately.

The industry is highly labour-intensive, having the second highest labour force in the country. Although the cost of labour is expected to increase continually, the small production runs required for the

South African/....

South African market weigh against the introduction of automated equipment. It is only in the area of non-fashion garments (overalls, etc.) where long production runs of similar designs exist, that advances in the field of automation can be expected to be made.

There is some evidence of a change within the industry from heavy furnace oil to coal as a boiler fuel. Historically, those factories situated at the coast have opted for oil-firing equipment due to its ease of handling and favourable price. However, since the oil price rises, this industry (as well as most others) have had to reconsider its continued use.

As energy accounts for only 1% of the industry's manufacturing costs, large scale conservation measures are not expected to be introduced. Any changes in present energy usage patterns are more likely to be the result of the lack of availability of labour, a far more important input to the industry than energy.

3.7 Pulp and Paper (SIC 34110)

The South African pulp and paper industry is well developed, supplying most of the country's paper needs and even exporting some of its products.

During 1974, the industry used some 26 000 terrajoules of energy or approximately 3% of the country's total energy requirements. The industry is heavily reliant on three energy sources; namely electricity, coal and heavy furnace oil. Together these sources accounted for 96% of the energy requirements of the industry during 1974.

The mills can be classified into two types : integrated mills producing both pulp and paper and paper mills manufacturing paper from purchased pulp. The steam requirements, especially in integrated mills, are high and it has been common practice in the past to utilize some of the steam to generate electricity. However, this practice seems to be losing favour since it was found that while 29% of the electricity requirements of integrated mills were purchased during 1971, this value had slowly declined to 21% by 1974. This has had a beneficial effect on the overall efficiency of energy conversion by the industry, since less of the losses associated with the generation are suffered by the paper industry.

During 1974, the overall conversion efficiency was calculated to be 66% and if the trend towards purchased electricity continues, it can be expected to rise,but only marginally. If all the electricity requirements of the industry were purchased, the overall conversion efficiency could be expected to rise by between 1% and 2%.

Kraft pulp, manufactured by a chemical process, has high specific steam requirements. It is the intention of one of the manufacturers to install continuous digesters for this process which they estimate will reduce the specific steam requirements by about 40%.

A further attempt at reducing enery costs is being made by the use of bark as a fuel. It has been estimated that between 3500 - 7000 tonnes of coal will be saved per annum by the use of 28000 tonnes of bark.

Although it is known that a process for making paper without using water has been developed overseas, none of the manufacturers visited mentioned plans to install such a plant. It is therefore unlikely that such a development, if proven successful overseas, would be introduced in South Africa before the late 1980's or 1990's. From an energy viewpoint, this is an exciting development since the main energy input to the paper manufacturing process is in the form of steam for evaporating unwanted water from the drying product.

3.8 Printing and Publishing (SIC 34200)

The printing and publishing industry is a comparitively small energy user accounting for approximately 1% of the energy requirements of the manufacturing sector. However, a number of developments within the industry are expected to have a significant effect on the future energy usage pattern.

The first/......

The first of these is the replacement of conventional letterpress machines, for newpaper printing, with photographic techniques. At present hot-metal type-setting is commonly used followed by the manufacture of metal plates for the actual printing process. It was estimated by one of the printers approached that the replacement of hot metal type-setting with photo-type setting would reduce specific energy demands by about 5% while photo-lithographic processes require about 10% less specific energy than conventional metal plates.

Energy conservation is also receiving the attention of a number of large printers although it is unlikely that savings in excess of 10% will be achieved. However, when considered with the conversion to photographic-based printing methods, specific energy savings of up to 25% could be achieved.

Even so, it should be remembered that the printing and publishing industry uses comparitively little energy and the overall effect of these savings on the energy demands of the manufacturing sector would be minimal.

3.9 Chemicals (SIC 35100 - 35600)

According to Harrison (21) the South African chemical industry utilized 11% of the country's total useful energy requirements during 1974. In doing so, the industry accounted for 5% of the country's electricity consumption, 14% of the gaseous fuels, 8% of the liquid fuels and 3% of the coal during that year. As such, the chemical industry is an important energy user and merits close examination.

Unfortunately, very little energy-related information for the chemical industry is published and one of the biggest problems experienced during the study of this sector was the collection of complete and reliable data for sometimes very complex plants.

Some of the large chemical factories manufacture a wide range of products by various processes, some of which are exothermic. The heat thus generated is often utilized in the manufacture of other products, thus complicating the energy flow patterns even further.

For the large/....

For the large chemical complexes, the main products were isolated where possible, and specific energy requirements for their manufacture estimated. For example, it was estimated that the specific energy requirements for the manufacture of ammonia were about 60 MJ/kg. According to Harrison (2.1) the estimated demand for ammonia during 1974 was 490 000 tonnes. The total energy requirements for the manufacture of ammonia during that year were thus of the order of 29,4 x 10^9MJ (compared with 23,2 x 10^9MJ obtained by Harrison).

Similarly, it was calculated that specific electricity requirements for the manufacture of chlorine were between 3 and 3,5 MwH(D.C.) per tonne. D.C. has been quoted since there are losses associated with the conversion of electricity from A.C. Harrison's estimates South Africa required 260 000 tonnes of chlorine and caustic soda during 1974. Remembering that slightly over one tonne of caustic soda is produced for every tonne of chlorine manufactured, the total energy requirements for this subsector were calculated to be between 1,5 - 1,8 x 10^9MJ excluding losses associated with the generation of electricity. It was also possible to calculate the efficiency of energy conversion for the manufacture of ammonia and this was found to be between 41% and 47% related to the A.C. electrical input.

It is very difficult to estimate the energy conversion efficiency for complex chemical factories (Harrison simply used efficiences as proposed by the Department of Planning and the Environment (12) in his estimation of the useful energy requirements of the chemical sector).

Louw (22) has shown that the thermodynamic efficiency of typical chemical plants is in the range of 10 - 25%. This would seem to be the best available data at present available but there is much scope for work in this field.

Calcium carbide, another energy intensive product, was investigated. It was found that the specific energy requirements are about 50 MJ/kg of product. The total energy input to the industry was 4 x 10^9MJ during 1975 and the overall conversion efficiency was 76%.

At present 73% of the electricity requirements are purchased, the remainder being generated at the factory. In 1970 63% of the electricity requirements were purchased. If this trend towards the purchase of electricity continues, the overall efficiency of energy conversion will rise. It was estimated that if the industry purchased all its electricity requirements, the conversion efficiency would rise to 83%.

A number of other sectors in the chemical industry were also investigated to determine the efficiency of energy conversion. These sectors include :

i) Industrial gases
ii) Fertilizers
iii) Synthetic Resins
iv) Paints, varnishes and lacquers
v) Medicines, and pharmaceuticals
vi) Soap, cleaning preparations, perfumes, cosmetics and other toilet preparations
vii) Polishes, waxes and dressings
viii) Miscellaneous petroleum and coal-based products
ix) Miscellaneous plastic products

In most cases it was found that manufacturers are considering the adoption of energy conservation measures. However, they were unable (or reluctant) to estimate the savings they expected to achieve but it is thought unlikely that these measures would result in savings exceeding 10%.

There is also a trend towards the replacement of oil with coal wherever possible. Obviously in some cases, such as the use of oil as a feed-stock, this is not possible. However, the new coal-based ammonia plant erected by AECI at Modderfontein, as well as Sasol 1 and 11, demonstrates the potential of coal as a feedstock.

In certain cases, manufacturers mentioned plans of introducing new processes and technologies. Once again they were unable in most cases to estimate the effect of these innovations on future energy requirements.

Harrison (21) has estimated that by the year 2000, the chemical industry will account for 20% of the useful energy requirements of the country (as opposed to 11% during 1974). This is not suprising when one considers that the chemical industry, regarded as strategically important, can expect encouragement from the Government with its expansion plans.

3.10/....

3.10 Rubber Tyres and Tubes (SIC 35510)

Rubber tyre and tube manufacture accounted for slightly more than 1% of the energy requirements of the manufacturing industry during 1968 (14).

The four large manufacturers in the sector are Dunlop, General, Goodyear and Firestone. No information regarding energy usage is published by these manufacturers and due to the competitiveness of the industry in South Africa, there was some initial reluctance to supply the data required for the study. However, after personal contacts were established, the required information was provided.

Coal is the most important energy source for the industry, having accounted for 41% of the total energy requirements during 1975. The other important sources of energy were heavy furnace oil (36%) and electricity (20%). Since 1973 there has been a gradual shift away from heavy furnace oil towards coal, and this trend will only continue ifimproved guarantees regarding the availability of coal during the winter months can be obtained. Since most of the factories are situated at the coast, oil has in the past been the preferred fuel.

At present energy is converted by the industry at an efficiency of 67%. Improvements in this value can be expected since all the companies approached have adopted energy conservation measures. One of the manufacturers hopes to reduce specific energy requirements by 10% within the next five years. At present the average value for the industry is 32 MJ per kilogram of cured products.

Future developments within the industry are not known. None of the manufacturers approached expected new technologies or processes to be adopted, but due to the competitiveness, it is unlikely that they would divulge confidential information regarding future products.

As speed limits are unlikely to be lifted in future and since the trend seems to be towards the use of smaller cars, the demands made on tyres will be less than those experienced in the past. These factors will undoubtedly be considered by tyre manufacturers during the development stage of the next generation tyres. However, whether it is valid to say that these tyres will require less energy for their production is debatable.

As a/......

As a conservative estimate of future specific energy requirements and conversion efficiencies achieved by the industry, new developments have been ignored and the stated goal of a 10% reduction within the next ten years accepted as a reasonable estimate.

3.11 Glass (SIC 36200)

Representatives of the glass industry have estimated that energy accounts for between 14% and 20% of their total manufacturing costs. The industry is therefore continually investigating methods to reduce their energy costs. These methods include the increased use of insulating material, increased utilization of waste heat and electrical boosting of furnaces. As a result of these measures, as well as others such as improved house-keeping, the average specific energy requirements of the industry have improved by 1,9% per annum over the past five years. Indeed, the specific energy requirements of the industry compare favourably with those obtained by overseas manufacturers.

During 1973 the industry's energy requirements were 6,4 x 10^9MJ. This is equivalent to 1,7% of the requirements of the industrial sector or 0,7% of the country's total requirements (20)

Of the various inputs coal is the most important single source. In 1975, coal accounted for 33% of the total input to the industry. This is significantly less than the figure for 1970, namely 51%. The decline in the importance of coal has resulted from the change over to purchased coal gas which has grown in importance from 3% of the total requirements during 1970 to 24% in 1975. This conversion has enabled manufacturers to shut down gas producers and has also led to an improvement in the overall efficiency of energy conversion.

The energy conversion efficiency is at present 27%. The reason for this relatively low value is the high proportion of energy converted in inefficient glass furnaces. The radiation losses from these furnaces are high and have been included in the calculation of the energy conversion efficiency.

The use of/.....

The use of so-called "non-returnable" containers by the beverages industry has an interesting side effect on the energy demands of the glass industry. While these lightweight containers require less energy for their manufacture, the fact that they are only used once results in more having to be produced.

The returnable container is often refilled about 6 or 7 times and consequently if these were to be replaced by lightweight non-returnable bottles, about six or seven times as many containers would have to be manufactured. However, since the lightweight containers have approximately half the mass of a conventional bottle, the energy requirements for the production of these containers would increase by about three fold.

Although these lightweight containers are convenient to both beverage manufacturer and consumer, they add significantly to the energy demands of the glass industry. However, since the glass industry is also able to increase its sales via non-returnables, it is undoubtedly delighted at this trend towards wastage.

3.12 Bricks (SIC 36910)

Due to the wide range of kilns and drying methods in use in South Africa it is not possible to calculate accurately the efficiency of energy conversion without a complete census of the industry. As this was beyond the scope of this study, appropriate overseas data was used to arrive at an overall conversion effiency for the industry of 31%.

A further problem in the determination of the energy conversion efficiency relates to the moisture content of the clay. The higher this is, the more energy is required to remove water and hence the operating efficiency of the dryer is reduced.

During 1972, the brick industry utilized about 2% of the energy requirements of the manufacturing sector or 0,7% of the country's total requirements (23). In quoting these figure De Kock admits that they are rough estimates based on private information, thus highlighting once more the lack of available statistics in the energy field in South Africa.

As the brick/........

As the brick industry expands, newer, more efficient kilns will be commissioned and the efficiency of energy conversion will improve. Greater attention will be paid to energy conservation especially in the area of heat losses and kiln firing control.

Alternative building materials are expected to capture an increased share of the market in future but the security of the brick industry would seem assured. An interesting recent development is the use of sliced bricks applied to a concrete slab to give the impression of a conventional brick wall. Not only is the brick content of such a wall lower (and thus the energy content) but the concept allows the prefabrication of walls and thus cuts down building time.

3.13 Cement (SIC 36920)

The cement industry accounted for 6% of the energy used by the manufacturing industry(and 2.4% of the country's needs during 1972 (23)) In 1975 the energy used amounted to 38 x 10^9MJ of which over 93% was derived from coal.

At present three types of kiln are used by the industry, namely wet. semi-dry and dry. Since the late 1950's there has been a trend towards the use of more efficient dry kilns. In fact, South Africa is ahead of some other countries, notably the United States,in the conversion of these kilns. The dry kiln offers the advantage of not having to evaporate water used in both wet and semi-dry versions. Consequently, the specific energy requirements are lower and energy conversion efficiencies higher. As an example, during 1964 when dry kilns accounted for 18% of the installed capacity in South Africa, the average specific energy requirement of the industry was 7,1 MJ per kilogram of clinker and the energy conversion efficiency was about 25%. By 1973 dry kilns accounted for 63% of installed capacity and the specific energy requirements had dropped to 5,9MJ/kg while the conversion efficiency had increased to 30%.

As part of the study, an estimate has been made that by the year 2000 the specific energy requirements of the industry will have further reduced to a value of 3,7 MJ/kg. This will be brought about by the continued commissioning of larger,more efficient dry kilns as older, wet and semi-dry units are taken out of service.

Besides the installation of new equipment, possibilities exist for increasing the capacity of existing plants. It has been estimated that by separately calcining limestone before mixing it with other materials, the specific capacity of a conventional dry kiln with suspension preheaters can be increased by a factor of 2,7 (24). However, it is not always possible to increase the output of existing plants due to considerations relating to milling capacities, foundation loads, etc.

There is a world wide trend in industrialized countries towards the sale of cement in bulk. South Africa seems to be following this trend. There would also seem to be a switch away from road transport to rail, possibly as a result of the increased price of fuel.

Although the greater percentage of cement sold in bulk will have very little effect on the overall energy demands of the industry, the reduced demand for paper bags will result in an indirect saving.

3.14 Iron and Steel (SIC 37100)

The iron and steel industry is the largest energy user in the manufacturing sector. During 1973, this industry accounted for 20% of the energy required by the manufacturing sector and over 11% of the country's total energy requirements.

Coal is by far the most important input, accounting for over 92% of the total requirements. The only other important energy sources are electricity (6%) and heavy furnace oil (1%).

As far as the utilization of energy is concerned, the industry compares favourably with other large steel producing countries, considering the poor quality of coking coals available. The industry, and especially Iscor, has not been afraid to experiment with new ideas and is in fact far advanced in the field of form-coke manufacture.

In other areas, such as hydro-carbon injection into blast furnaces, the industry lags behind. This is shown by the comparatively poor coke rate

achieved/...

achieved. However, the industry is to be commended in its attempts to reduce its consumption of imported fuel oil. Over the period 1973 to 1975, these requirements dropped by a third.

Over the past twenty years there has been a significant change in the furnace types used to manufacture steel. As has occurred in other steel-producing countries, the Basic Oxygen Furnace (BOF) has gained favour to the extent that by 1975 nearly half of the steel produced in South Africa was from BOF's.
The older Open-Hearth and Rotor furnaces are rapidly being replaced by BOF's and to a certain extent by electric-arc furnaces.

Electric-arc furnaces have captured an increasing share of the market in recent years. These versatile furnaces allow the use of up to 100% scrap and are used extensively in the production of high quality and high-alloy steels.

During 1975 the specific energy requirements for the manufacture of steel in South Africa were 47 MJ per kilogram of finished steel. However, a number of energy-related developments are likely to affect this value by the end of the century.

In the field of coke preparation, Iscor is actively engaged in research into the use of form-coke. Although small energy savings may result from the use of form-coke, its main advantage is that coal with very poor coking characteristics can be used. Since metallurgical coal constitutes less than 5% of South Africa's coal reserves, and iron ore reserves total about 8,6 x 10^9 tonnes, the country is likely to run out of coking coal before iron reserves are depleted. It is expected that Iscor will commission form-coke units in production furnaces before the end of this decade, barring unforseen circumstances.

Other developments include the preheating of coal to drive off moisture before introduction to coke ovens. Iscor was one of the first steel producers in the world to install equipment of this type.

Coal briquettes have been proposed to improve the bulk density of the coal and hence the productivity of the coke ovens. Energy savings are likely to be modest.

The injection/......

The injection of hydrocarbons into blast furnaces has already been mentioned as a method of reducing coke requirements. However, with the oil situation as it is today an interesting alternative, likely to receive increased attention in the future, is the injection of coal. The concept has been tried in America where coke replacement levels of up to 25% and the use of non-coking coals with average ash contents of 9% have been reported (25). Although Iscor has done some work in this field, no immediate plans exist for its introduction on a commercial scale.

External desulphurization of blast furnace fuels has been adopted by Iscor to allow more abundant high-sulphur coal to be used for coking purposes. Since one of the requirements of slag is the removal of sulphur, smaller amounts of slag need to be used and the associated heat loss is lessened.

There seems to be scope for greater utilization of BOF off-gas. It was calculated that if these gases together with other gases at present wasted were harnessed for the generation of electricity, a 185 MW station operating at a 0,5 load factor could be commissioned. Problems relating to the sale of this power to Escom exist and the fact that the gas is not all produced at the same geographic location detract from the scheme.

A further concept that could be adopted on a large scale is the direct reduction of iron ore. In this process iron ore is reduced in a kiln, thus by-passing the need for a blast furnace. At least seven such plants are already in operation in South Africa. In comparison with the conventional blast furnace method of producing hot metal, it has been estimated (26) that the sponge iron process requires only 66% as much energy.

Combining the effects of these developments on the future energy requirements of the South African iron and steel industry, it has been estimated that the specific energy requirements will show an improvement of 23% by 2000 on the value obtained in 1975. By that date the energy demands of the iron and steel industry are likely to exceed the total demand for energy in South Africa during 1975.

It may/.......

It may have been noted that no mention has been made of the efficiency of energy conversion by the iron and steel industry. In the report on this sector (included in the Appendices) a value of 89% was derived. However, it must be stressed that this value should be used with caution. Depending on definition, this value can vary widely and its use is not recommended.

3.15 Copper and Aluminium (SIC 37200)

These two non-ferrous metals are both energy-intensive to manufacture. During 1975 the copper industry purchased 679 x 10^6kWh of electricity while Alusaf, the only primary aluminium producer in South Africa, required 1268 x 10^6kWh. In other words, these two industries accounted for 3,4% of Escom's sales during that year (15).

In terms of total energy consumption the copper industry accounted for slightly over 1% of the country's energy needs during 1973 while primary aluminium accounted for about 0,4% (20)

At present, three energy sources account for about 98% of the energy needs of the copper industry. They are coal (67%), purchased electricity (18%) and light diesel fuel (13%) At present approximately 25% of the total electricity requirements are generated by the industry but a trend towards the purchase of more electricity is evident. In 1971 for example, over 40% of the electricity requirements were generated internally.

The isolated location of some of the copper mines has in the past necessitated the generation of electricity on site. However, as the country has developed the demand for electricity in some of these areas has increased enabling Escom to expand its nation-wide grid. With the price of coal at more than R30 per tonne at some of these mines, the incentive to convert to purchased electricity is great.

If all the power stations at present operated by the mines were to be decommissioned, the demand for coal would be about 57% of its present level and the efficiency of conversion of this fuel would rise from its present value of 34% to around 45%. Similarly, the overall efficiency of energy conversion for the industry would rise from 34% to 40%

The specific/......

The specific energy requirements for the production of primary copper are very dependent on the grade of ore mined. At present with grades in the region of 0,7% the South African specific energy requirements are in the region of 84 MJ/kg of copper. These could be reduced to 64 MJ/kg if all the electricity required was purchased.

In predicting the future energy requirements of the copper industry, one once again comes up against the problem of a lack of data relating to the grades of ore reserves. Without this data it is very difficult to estimate the future energy requirements of the industry, even if the future demand for copper could be accurately estimated.

No major developments are expected in the forseeable future within the copper industry and methods of mining ore,ore benefication and metal extraction are not expected to change.

The primary aluminium industry in South Africa is confined to the electrolytic reduction of alumina. Alumina, converted from bauxite overseas, is imported and consequently the specific energy requirements of the industry are lower than those of countries where the conversion of bauxite is also carried out.

The main energy input to the industry is electricity, accounting for about 92% of the total requirements. About 95% of the electricity is utilized in the electrolytic reduction process, the balance being used for heating, lighting and machinery drives.

Due to the highly energy-intensive nature of the reduction process (15 kWh per kg of aluminium) alternative processes are at present being investigated overseas. One such development, patented by Alcoa, is said to achieve energy savings of up to 30% while another, the AARC-Toth process results in electricity reductions of 90% of present requirements. However, these processes are still in the development stages overseas and it is unlikely that such a plant would be installed in South Africa until it had been proven in commerical service elsewhere.

At present, Alusaf is under the indirect control of the government (through the Industrial Development Corporation) and it would therefore probably require further government decisions to determine the future direction that the industry will take.

3.16/.......

3.16 Fabricated Metal Products and Machinery (SIC 38100 - 38399)

This sector of the economy comprises a number of smaller subsectors of which the following were investigated individually :

1) Metal fabrications
2) Cables, wire products and gates
3) Engineering workshops
4) Other metal products
5) Agricultural machinery
6) Specialized machinery
7) Electric machinery

Considered as a whole, the above subsectors accounted for 8,5% of the money spent on energy by the manufacturing sector during 1968 (14).

Although each of the above subsectors has its own characteristics regarding the energy sources used, the overall efficiency of energy conversion for each lies in the band between 64% and 74%.

No new processes or technologies that are likely to affect the specific energy requirements of the various subsectors are expected to be introduced in the near future, although a number of the companies contacted expect small savings from energy conservation programmes. These savings are not expected to exceed 10% of present requirements and will therefore have little effect on the overall demand for energy by the manufacturing sector of the economy.

Diversification into new products could affect future energy demands but very little information was available and it was therefore not possible to estimate to what extent this would change the present patterns of energy usage. Large scale diversification into products not allied to present operations could result in factories being reclassified into different Standard Industrial Classification groups and the change would therefore not be felt by these particular subgroups.

In general, little change is expected either in energy inputs or conversion efficiences in any of the subsectors considered.

3.17 Motor vehicles (SIC 38400).

The motor vehicle manufacturing and assembly industry accounted for 1,4% of the money spent on energy by the manufacturing sector during 1968 (14).

The industry uses a wide range of energy inputs, the most important being electricity (30% of the total requirements) followed by coal (22%) liquid petroleum gas (17%) and petrol (12%). The overall efficiency of energy conversion by the industry was calculated to be 63%.

The local content programme, instigated by the government to encourage the growth of the local motor industry, has had the effect of increasing the proportion of energy expended in this country to manufacture motor vehicles. However, the incentive scheme is based on the mass of the components manufactured in this country. Hence manufacturers are encouraged to manufacture heavy components and import others, irrespective of the energy-intensiveness of the various items. It is therefore difficult to draw comparisons between specific energy requirements for the industry in this country and overseas manufacturers.

As the government would like to increase local content of South African manufactured motor cars to over 90%, the specific energy requirements of the industry related to the number of units manufactured will increase. However, a greater increase in the energy demands of subcontractors is likely. The relatively small South African market makes it economically impossible for individual manufacturers to produce certain components for their exclusive use. Therefore subcontractors supply specialized components to the whole industry. As more of these components are produced locally, the energy demands of this subsector will increase.

Although the energy demands of the industry as a whole are expected to increase, the overall energy conversion efficiency will not necessarily change, since this is dependent on the processes used rather than the amount of energy required.

Energy conservation measures have been introduced by most of the South African manufacturers although these are not expected to result in savings in excess of 5%.

At present/......

At present the industry is concentrating on research towards the production of smaller, more efficient cars rather than on alternative technologies such as battery cars. However, increasing petrol costs are likely to stimulate development of this and other alternative vehicles.

The more general use of smaller vehicles not only results in a reduction of the specific energy demands of the industry but will also result in significant fuel savings for the country. An American study (27) has estimated that savings of 32% for inter-city driving and 46% for urban conditions could be achieved by the use of compact rather than large cars.

Finally, the recently published Driessen Report is likely to change present patterns of transport usage in South Africa and this is likely to have an effect on the motor industry, although it is difficult at present to estimate its extent.

3.18 Small Energy Users in the Manufacturing Sector

Besides the large energy users in the manufacturing industry, a number of subsectors exist which use relatively small amounts of energy. The time and resources available for this study precluded personal visits to each of these subsectors, so a general questionnaire was distributed to evaluate the energy needs of these industries.

Sufficient data was received from the following subsectors to allow analysis :

1) Tobacco products (SIC 31400)
2) Leather tanneries (SIC 32310)
3) Leather goods excluding footwear (SIC 32330 - 32339)
4) Footwear (SIC 32400)
5) Wood products excluding furniture (SIC 33110 - 33119)
6) Furniture (SIC 33200)
7) Paper products (SIC 34120 - 34191)
8) Automotive parts (SIC 38403)
9) Bicycles (SIC 38540)
10) Brushes and Brooms (SIC 39091)

Considered collectively, these industries accounted for about 5% of the money spent by the manufacturing sector on energy during 1968 (14). Individually, none of these subsectors is a significant energy user, but for the sake of completeness, their results have been included.

In general, the overall efficiency of energy conversion in these subsectors is in the range of 55% to 75%. Electricity and coal are the two most common inputs to these industries, often accounting for over 90% of the total requirements.

There is a general trend in the subsectors considered towards the replacement of oil-based fuels with either coal or coal gas. This trend has only become evident since 1973 and is likely to continue and possibly accelerate as the price of oil rises.

No new processes or technologies are likely to be introduced by any of the industries considered although changes in present energy usage patterns will result from energy conservation measures. These measures in the form of improved "housekeeping" are not likely to reduce present specific energy requirements by much more than 5%.

Further changes could result from product diversification but it is difficult to gauge the extent of these changes at present.

3.19 Hotels and Hospitals

These two sectors of the economy have been considered collectively since in a sense they provide similar services to the public.

It was found that the specific energy requirements of hospitals are approximately double those of hotels. The reasons for this include the large wards that require heating in hospitals in comparison with the cluster of small rooms that can be individually heated in hotels. A half-occupied hotel results in only half the rooms being heated, whereas all wards still require heating in a half-occupied hospital.

Energy conservation measures that can be introduced are to an extent limited by the need to ensure the comfort of residents. This is particularly applicable to hotels where guests are likely to leave if services are not up to standard.

However, hotels are looking at ways to cut their energy costs (rather than energy use) by restricting the maximum demand for electricity where possible. Beyond this, staff is being educated to switch off unnecessary lighting and heating. One representative of the hotel industry estimated that measures they intend introducing are expected to reduce energy costs by up to 25%. Hospitals are also actively engaged in energy conservation measures but it is unlikely that savings of the order of those expected by the hotel industry will be achieved. As mentioned, the large wards that require services do not facilitate the easy introduction of saving measures.

The present energy conversion efficiency in hotels is 62% while in hospitals the average figure is 68%. Since no new technologies or processes related to energy requirements are likely to be introduced, these values should be representative for some time into the future.

3.20 Railways

The South African Railways is a major energy user, having utilized 123×10^9 MJ during the 1974/75 financial year. This is equivalent to approximately 12% of the country's total energy requirements.

At present coal is the major energy input accounting for nearly three quarters of the total energy requirements. Light diesel accounts for a further 15% and electricity 10%

The S.A.R. has already started a programme to phase out all steam locomotives. This will have a major effect on the future energy demands of the industry. At present the efficiency of energy conversion in the S.A.R. is 39% and this can be expected to increase to about 45% by the time the last steam locomotive has been decommissioned in about 1990.

When one/.....

When one considers that in 1960 the overall energy conversion efficiency was 12%, it is obvious that large improvements have already occurred.

The phasing out of inefficient steam locomotives has resulted in the fact that the total input energy to the S.A.R. has been steadily declining. This decline is expected to continue until in 1990, when the total energy demands are expected to be 58 x 10^9 MJ, 47% of the 1974/75 requirements.

While at present electric traction performs some 50% of all rail movements, it is estimated that by the year 2000 this figure will have risen to 80%. By that stage it is possible that the price of diesel fuel would be so high that diesel-electric locomotive operation would prove uneconomic. This in turn would encourage increased electrification. One disadvantage of electrification is the enormous costs associated with the installation of the trackside equipment required. Notwithstanding this, the vast coal resources of the country weigh heavily in the favour of increased electrification.

3.21 Buses and Road Transport

During 1973 the energy utilized by buses in South Africa amounted to 4 x 10^9 MJ or approximately 0,4% of the country's requirements. Similarly, road transport accounted for 180 x 10^9 MJ or 18,6% of the country's needs.

The present efficiency of energy conversion by buses and trucks has been calculated to be 25%. This value is not expected to change significantly in future unless the diesel engines used are replaced by other power units. This is not likely to happen unless oil restrictions or similar measures are introduced.

Johannesburg is the only city still operating electric trolley-buses and these are expected to be phased out in the near future. The high maintenance and erection costs of overhead power lines together with the difficulties associated with changing routes outweigh advantages of low noise and pollution levels.

Road transport/...

Road transport offers many advantages over rail including speed and flexibility of routes. These factors have resulted in the healthy growth of this sector to the extent that at present road transport performs roughly one third of all the land transport in South Africa. Goods distribution over routes not serviced by rail accounts for about 60% of the road transport, the balance operating in direct competition with rail services.

As far as the future is concerned, the increased use of buses for commuters is likely to be encouraged by both local and central governments. The congestion caused by the use of private vehicles in cities and increased pollution levels are expected to result in legislation limiting access to central areas. An improved bus service as far as punctuality and comfort is concerned would also assist to persuade people to use public rather than private transport.

The only cloud hanging over the future of road transport is the uncertainty of future oil supplies. As mentioned earlier, alternative fuels could be used if it were found that shortages of diesel fuel were hampering operations.

3.22 <u>Pipelines</u>

South African Railways operates the only commercial pipelines in South Africa for fluid transportation over long distances. At present two main lines exist between Durban and the Transvaal although plans have been made to enlarge the system considerably.

A pipeline is a very efficient mode of transporting fluid. It was calculated that the specific energy requirements are of the order of 0,025 kilowatt hours of electricity per tonne kilometre.

The system operates at an efficiency (of energy conversion) of 70% since nearly all the energy is utilized for electric-driven pumps.

The expansion of the pipeline system to other parts of the country is not likely since the Reef is the only major inland energy-using area and a steady demand for products is necessary to ensure the economic viability of this capital-intensive system.

No/........

No significant changes are expected in the future as far as the overall energy conversion efficiency is concerned.

3.23 Harbours

During 1975, the energy requirements of South African harbours totalled 2×10^9 MJ. This is equal to approximately 0,2% of the country's energy needs.

It proved difficult to obtain a breakdown of energy usage and an estimate of 50% was made for the overall efficiency of energy conversion.

The introduction of containerization will reduce the specific energy requirements for the moving of cargo by about half of its present value. Although a start has already been made on the switchover to containerization, it will be many years before the older conventional shipping is taken out of service.

3.24 Air Transport

South African Airways has had an impressive growth record, having shown a ten-fold increase in the amount of traffic handled in the last fifteen years. This increase has been achieved with substantially the same number of aircraft in the fleet, indicating the increase in size and flying speeds of the newer aircraft.

During the 1975/76 financial year, South Africa utilized 436 000 tonnes of jet fuel with an equivalent energy content of $18{,}8 \times 10^9$ MJ or roughly 2% of the country's needs. It has been projected that by the year 2000 jet fuel requirements will be 760 000 tonnes per annum. This is a 75% increase on the 1975 value but when one considers that the number of passenger kilometres flown is expected to increase to 300% of the present level, an indication can be obtained of the increase in aircraft size and improvements in fuel utilization that are likely to occur. At present the efficiency of conversion of energy in jet engines is 40% and this can be expected to increase to 50% by the turn of the century.

Besides the improved design of jet engines other areas exist where fuel savings could be achieved. These include changing altitude as fuel is burned off, reducing cruising speeds or carrying less reserve fuel. Some of these measures could endanger the safe operation of the fleet and would not be introduced. However, SAA is aware of the need for conserving fuel and is likely to implement as many conservation measures as possible.

Supersonic aircraft are not likely to be used on domestic flights and in fact are likely to be confined to routes over the sea as a result of the sonic boom. The sub-sonic jet-powered airliner will probably remain as the most common commercial aircraft in use until oil shortages, expected towards the end of the century, necessitate the introduction of alternatively powered aircraft.

3.25 Street Lighting

Of the various light sources used for streetlighting purposes, incandescent and mercury vapour lamps account for over 85% of the street lighting energy requirements.

There is a general trend in the large cities towards the replacement of incandescent with mercury vapour lamps and it is estimated that by 1985, this light source will account for over 90% of street lighting energy requirements.

During 1975, 467 x 10^6kWh of electricity was utilized for street lighting at an average conversion efficiency of 5%. With the conversion to mercury vapour lighting this efficiency is expected to increase slightly but will not rise much above 7%.

3.26 The Domestic Sector

Due to the large number of relatively small energy users in this sector, it would have been impossible within the time and resources available to personally interview a representative sample.

It was/........

It was therefore decided to distribute a postal questionnaire using names and addresses obtained from the voter's roll. Further questionnaires were distributed in black and coloured townships, but the response to these was too poor to allow analysis of these sectors. Consequently, the results apply only to the White population of the country.

It was found that electricity was by far the most commonly used energy source by the domestic sector, i.e. widespread in terms of the number of households using it rather than the quantity used.

It also became apparent that the amount of electricity used is roughly proportional to income, especially in urban areas. In rural areas the affluent tend to use other energy sources to supplement their electricity requirements. The proportionality of income and electricity usage does not apply in all cases since a point is reached where just about every conceivable appliance has been purchased.

A marked difference was noted between electricity usage in urban and rural areas. Whereas in urban areas it accounts for about 67% of the total energy requirements (excluding transport) in the rural areas it only accounts for about 7%. Diesel oil is the major input in rural areas accounting for about 44% of the requirements (excluding transport).

It was found that about 80% of the electricity requirements are converted to heat and the overall efficiency of energy conversion of this energy source is about 64%.

The domestic sector is expected to rely more heavily on electricity as time goes by and thus the use of other fuels is expected to decline.

The transport energy requirements of this sector are relatively large amounting to more than the energy inputs of all the other sources combined. Petrol is the most commonly used transport fuel, being utilized by between 80% and 90% of the respondents.

As a result of the relatively high proportion of the total energy requirements converted at low efficiencies in petrol and diesel engines, the overall energy conversion efficiency of the domestic sector is low at 30% for urban areas and 21% for rural areas. The conversion

efficiency/.....

efficiency in rural areas is lower than that obtained in urban areas since besides the transport requirements, rural dwellers also use diesel for driving static machinery.

As mentioned earlier, electricity is expected to account for an increasing proportion of the total sector energy requirements. This trend is expected to be more evident in rural areas where, as Escom expands its national grid, cheap electricity will become available to an increasing number of farmers. In urban areas, Black and Coloured townships will also receive electricity supplies thus boosting requirements.

In the transport field the total energy requirements are expected to be affected by the continual rise in the price of petrol and diesel. Especially in urban areas, increased use will be made of public transport and the average man is likely to be purchasing smaller vehicles in future. These two factors will cause a drop in the rate of growth of the demand for these fuels.

Further in the future, alternative technology vehicles, such as battery cars, will be in more common use. Battery cars will of course increase the demand for electricity even more at the expense of oil-based fuels.

Solar water heating is a further possibility worth considering in the future. It is already an economic proposition in most areas of the country and since it is possible to reduce electricity requirements between one third and a half, these units could make a significant contribution towards energy conservation, if installed in enough households.

4. THE OVERALL SOUTH AFRICAN PICTURE

Up until now, the various sectors of the South African economy have been considered individually. It would be useful though to consider energy usage in South Africa in the broader sense and highlight trends common to a number of sectors. As may well be imagined, this is not as simple a task as it first appears, since the sectors being considered are engaged in widely differing activities with different degrees of dependence on a wide range of energy inputs.

A fact that did emerge as a result of this study is the widespread lack of energy-related data. Even relatively large energy users were in some cases unable to supply usable data. Those companies that did maintain energy statistics, were in most cases unable to supply information for the period before 1970. Since energy was not considered a priority then this is not surprising. However, it does mean that when these companies plan future energy policies, they will be unable to make use of anything but sketchy historical data.

It was also found that energy-related statistics published by government bodies are lacking. The presently available input-output tables are useless for energy analysis purposes. The fact that no energy statistics are published on an annual basis also hinder the energy analyst. The often quoted reason for this is that security does not allow it. Security should therefore not allow the publication of South African Airways timetables, since with these and readily available information from Boeing, it is possible to estimate quite accurately the total jet fuel requirements of South African Airways.

At the moment South Africa is heavily dependent on coal for its energy requirements. From the findings of this study, it is apparent that this dependence is likely to increase in future. In a large number of the manufacturing sub-sectors, plans have either been made or already carried out to substitute oil-based products, notably heavy furnace oil, with coal. The change-over started in 1973 and has been continuing ever since. One point of concern in this regard is whether the South African Railways will be able to cope with the transportation of this extra coal to coastal areas, especially during the winter months. Already there is an acute shortage of coal for limited periods during the winter

in certain/.......

in certain coastal towns (Cape Town and Port Elizabeth for example). Unless increased stockpiling is carried out in these areas or the Railways improves its services dramatically, the problem is expected to persist.

Energy conservation measures have already been adopted in most energy-intensive sub-sectors of the economy and their introduction is expected to spread as energy costs increase. In most cases these measures entail improved housekeeping methods, such as fixing leaks, fitting insulating materials and instructing staff on the need for conservation. Power-factor correction is already widely used & other concepts such as maximum demand control have been practised by some sectors (such as gold mining) for some time. It must be remembered that in this country, people do not seem to have the well-developed conservationist tendencies in evidence in America today. Energy conservation in South Africa is still in the stage of energy cost conservation. This entails reducing energy bills rather than energy requirements, and can be achieved by tariff manipulation and conversions to other fuels. The widespread conversion from heavy furnace oil to coal is an example of this.

As a result of this approach, energy conservation measures are not likely to effect energy savings in excess of 5 - 10% of present values. Significant energy savings are only likely to be achieved with the installation of additional equipment or alternative processes, both capital-intensive operations in a climate presently unfavourable for ventures of this type.

With regard to the introduction of new technologies and processes, the cement and steel industries can be regarded as in the forefront.

In the cement industry, the adoption of dry kilns (as opposed to wet and semi-dry units) has already had a beneficial effect on the specific energy requirements for the manufacture of cement. Dry units will continue to be installed until by the end of the century, effectively all South African cement will be manufactured by this process. By that stage, the specific energy requirements are expected to have dropped to roughly 60% of their present value.

In the steel/........

In the steel industry, new technology such as "formed-coke", will enable abundant reserves of coal with poor coking qualities to be used. The use of the direct reduction of iron ore will also reduce coking coal requirements while also resulting in reduced energy demands in comparison with conventional processes. This and other processes, such as external desulphurization, and the greater use of waste gases, is expected to result in a 23% reduction in the specific energy requirements of the industry by the turn of the century.

A complete listing of the energy conversion efficiencies has been compiled in Appendix A. In certain sectors of the economy using large amounts of energy, the efficiency of conversion to light has not been calculated. In these cases only negligible amounts of energy were used for lighting and respondents did not indicate exact values. It should also be noted that conversion efficiencies for the iron and steel industry have not been included. It was mentioned in section 3.14 of this report that this conversion efficiency could be misinterpreted and should be used with care. Excluding the iron and steel industry, conversion efficiencies are listed for industries whose total energy bill accounted for 65% of the money spent on energy by the manufacturing sector during 1968 (14).

The weighted average overall energy conversion efficiency for these sectors was calculated to be 57%. If one assumes that the other 35% of the manufacturing sector utilizes energy in a similar manner, this value of 57% can be used as the overall average figure for the manufacturing sector. However a large proportion (20%) of the industries for which no conversion efficiency was calculated consists of the iron and steel industry. If the efficiency of this industry is taken as the 89% mentioned in section 3.14, the weighted average conversion efficiency for the manufacturing sector rises from 57% to 65%.

Incorporating possible errors associated with the derivation of this important value, the overall energy conversion efficiency for the manufacturing sector can be said to be 60% ± 10%. This also takes into account errors associated with the fact that the cost rather than the

amount of energy/.......

amount of energy used was considered in the caluclation of the overall value.

Considering the mining sector, it must be remembered that only the coal and gold sectors have been considered (Copper mining was included under the manufacture of primary copper). Since together, coal and gold mining accounted for 82% of the electricity sold by Escom to the mining sector (excluding copper) during 1975 (15), these two sectors can be considered representative of the sector. The weighted average overall energy conversion efficiency for this sector was calculated to be 60% with the possible error of ± 10%.

Weighting the various sub-sectors of the transport sector according to the amounts of energy they use results in an overall conversion efficiency for this sector of 31%. This does not include the transport energy requirement of the domestic sector which is included in the domestic sector.

If one considers the efficiency of energy conversion in urban and rural areas and weights these values according to the population of each area, an average weighted value of 29% is obtained for the overall efficiency of energy conversion for the domestic sector.

The values obtained for the various sectors of the South African economy are summarized below.

TABLE 1 : OVERALL EFFICIENCY OF ENERGY CONVERSION ON A SECTORAL BASIS

SECTOR	EFFICIENCY OF ENERGY CONVERSION
Mining	60% ± 10%
Industry	60% ± 10%
Transport	31% ± 10%
Domestic	29% ± 10%

The determination of the overall efficiency of energy conversion depends on the energy used by the individual sectors. A breakdown is thus required of this usage and a summary is given of results obtained by van Doornum (20) and the Department of Planning (12). Note that the Department of

Planning' figures were converted from useful energy to total energy inputs by using the conversion efficiencies of the various energy sources adopted by the Department of Planning and the Environment.

TABLE 2 : ENERGY INPUTS ON A SECTORAL BASIS

SECTOR	VAN DOORNUM (REF 20)	DEPT OF PLANNING (REF 12)	AVERAGE VALUES
Mining	8,9	16,4	12,6
Industry	39,8	35,9	37,9
Transport	35,2	32,8	34,0
Domestic	16,1	14,9	15,5

Applying the average conversion efficiencies yields the following :

TABLE 3 : OVERALL EFFICIENCY OF ENERGY CONVERSION ON A COUNTRY-WIDE BASIS

SECTOR	CONVERSION EFFICIENCY (%)	SECTORAL ENERGY USAGE (%)	EFFICIENCY OF ENERGY CONVERSION		
			Lower Limit	Av. Val.	Upper Limit
Mining	60 ± 10	12,6 ± 4	4,30	7,56	11,62
Industry	60 ± 10	37,9 ± 2	17,95	22,74	27,93
Transport	31 ± 10	34,0 ± 2	6,72	10,54	14,76
Domestic	29 ± 10	15,5 ± 1	2,76	4,50	6,44
Overall	-	100,0	31,73	45,34	60,75

The method of calculation has been to assume the lowest, average and highest values within the stated tolerances. Using this method the overall efficiency of energy conversion for the country has been calculated to be 45% ± 15%. This conversion efficiency does not include the energy conversion industries such as oil refineries and power stations. A further modification would be required if these were to be incorporated. However this is outside the scope of this study and a value has not been derived.

The overall efficiency of energy conversion for the country can be expected to rise gradually as more efficient plant is installed and as alternative technologies that utilize energy more efficiently are brought into operation.

5. CONCLUSIONS/........

5. CONCLUSIONS

The study to determine patterns of energy usage and conversion efficiencies provided an excellent opportunity of finding out how little certain sectors of the economy know about their energy requirements. Undoubtedly, as energy costs increase, there will be an increased awareness regarding energy matters, but when that does occur certain sectors are going to find a lack of historical data to assist them with the planning of a corporate energy policy.

The response to our requests for information was in general encouraging with many individuals and companies going out of their way to provide data as complete as possible. The problem lay in the fact that in some cases the information was simply not available.

The suggestion that more complete energy statistics be published by some authorative body is worth repeating. Without this data a number of estimations must be made leading to possible errors. Besides being of interest to the energy analyst, this data would be of benefit to the individual sectors of the economy to enable trends in fuel usage to be established.

Having completed the study after two years of close contact with the problems of energy analysis, attention should be drawn to some of the shortcomings of using the approach of useful energy.

Firstly, if the efficiencies of energy conversion, as calculated in this report,are adopted in future,it will not be possible to compare results with those obtained by the Department of Planning using different conversion efficiencies. The only accurately known figure is the energy inputs to various industries.

Secondly, the conversion efficiencies of some industries are difficult to determine. The steel industry is an example where the indiscrimate use of the conversion efficiency could lead to erroneous results.

Thirdly/.....

Thirdly, the efficiency of energy conversion changes with time and although an attempt was made to estimate the degree of change, continuous updating is required to ensure that accuracy is maintained.

Fourthly, confusion could arise between the efficiency of energy conversion and the efficiency of energy utilization. In this report, emphasis has been laid on the efficiency of energy conversion but it should be remembered that a further efficiency, that of utilization is associated with the end use of energy. For example, in an electric room heater, electricity is converted to heat at an efficiency of 100%. However losses through windows, walls and doors result in only a percentage of the heat doing useful work in heating the room.

Considering the above shortcomings one must use the concept of useful energy with considerable care. A possible alternative approach is the use of specific energy requirements. These relate output to energy requirements and are usually easier to determine than useful energy. Specific energy requirements also indicate trends and enable future energy requirements to be established. However, in cases where more than one product is manufactured in a factory it is some times difficult to split the energy requirements for the individual products. Difficulties also arise when applying this technique to non-productive sectors such as the domestic sector.

It can be seen that either method has shortcomings and indeed an ideal method of energy analysis still needs to be developed.

Finally, it is suggested that a study similar to this one is repeated in about five years time. This will enable checks to be carried out on predictions made in this report and will result in the updating of information.

6. ACKNOWLEDGEMENTS/........

6. ACKNOWLEDGEMENTS

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7. REFERENCES

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Appendix 1/.......

APPENDIX 1 - EFFICIENCIES OF ENERGY CONVERSION

INDUSTRY	EFFICIENCY OF ENERGY CONVERSION					
	To heat	To mech energy	To light	To chem. energy	To other	Overall
Coal Mining	36	80	-	-	-	55
Gold Mining	58	61	-	-	-	60
Fruit Canning	69	53	7	50	-	67
Fish meal & oil	67	50	6	-	-	64
Grain Mills	55	81	7	-	-	76
Bakeries	65	61	10	-	-	64
Cocoa, choc.	69	76	7	50	0	67
Distilleries	99	39	8	-	-	41
Breweries	69	41	7	-	-	66
Aerated waters	70	31	8	-	-	48
Tobacco	71	82	18	-	-	70
Spinning/weaving	69	73	9	50	0	69
Manuf. textiles	68	61	9	-	-	61
Knitting mills	69	72	10	-	-	67
Cordage, rope & twine	72	79	10	-	-	73
Clothing	76	70	17	-	-	72
Leather tanneries	71	73	10	-	-	70
Leather goods, excl. footwear	65	51	10	50	-	58
Footwear	98	75	10	-	-	74
Wood products	70	76	7	-	0	70
Furniture	100	74	8	-	-	59
Paper & Pulp	70	52	-	-	-	66
Paper products	71	70	8	50	-	70
Printing/publish.	69	58	9	50	-	57
Chlorine	-	-	-	45	-	45
Calc. carbide	76	82	10	-	-	76
Ind. Gases	83	68	8	-	-	72
Other basic ind. chemicals	68	79	8	50	-	68
Fertilizers	63	79	6	-	0	39
Synthetic resins	69	79	7	-	70	74
Paints/varnish	60	79	7	-	-	61

Medicines/.......

Appendix 1 (cont.)

INDUSTRY	EFFICIENCY OF ENERGY CONVERSION					
	To heat	To mech energy	To light	To chem energy	To other	Overall
Medicines	71	48	9	-	-	53
Soap etc.	68	44	7	-	0	55
Polish etc.	70	78	8	50	-	70
Petrol/coal based products	70	42	10	50	0	60
Plastic products	83	80	10	-	-	80
Rubber tyres	70	72	5	-	55	68
Glass	22	56	9	-	50	24
Bricks	30	63	-	-	-	31
Cement	30	85	-	-	-	34
Copper	34	32	-	-	-	34
Aluminium	68	62	7	32	-	35
Metal Fabrications	69	62	10	50	-	65
Cable/wire	78	79	9	50	0	74
Eng. workshops	73	47	8	50	0	66
Metal products	67	74	9	50	-	69
Agricultural m/c	76	65	8	50	-	73
Specialized m/c	73	72	10	-	-	68
Elec. machinery	79	66	9	50	-	67
Motor vehicle manufacture	70	56	10	50	0	63
Automative parts	72	63	5	50	-	64
Bicycles	63	81	5	-	-	63
Brushes/brooms	60	25	5	-	0	40
Hotels	68	82	5	-	-	62
Railways	-	38	-	-	-	38
Road Transport	-	25	-	-	-	25
Pipelines	-	71	-	-	-	71
Harbours	-	50	-	-	-	50
Airways	-	40	-	-	-	40
Streetlighting	-	-	6	-	-	6
Domestic	51	16	11	-	-	29

Appendix 2/.......

APPENDIX 2

THE ENERGY REQUIREMENTS OF THE SOUTH AFRICAN COAL MINING INDUSTRY

(Formerly issued as Report ESI/11)

SUMMARY

This report details the utilization of energy in the South African coal mining industry. The main findings are :

1) Electricity accounted for 41% of the total energy input in 1966, but rose to 50% by 1975

2) During the same period, coal has dropped from 54% to 38% of the input requirements

3) The specific energy requirements have shown a gradual decrease over the past ten years

4) The specific electrical energy requirements for bord and pillar mining methods are at present 10,4 kWh/tonne of coal sold, while open cast mining only requires half that amount

5) Electricity is converted by the mines at an efficiency of 80%, coal at 36%, liquid petroleum gas at 36%, petrol at 14%, light diesel at 21%, power paraffin at 2% and illuminating paraffin at 0% (as a result of its use as a cleaning agent)

6) The overall conversion efficiency for the industry is 55%

7) The industry can expect rapid growth in the future

8) Bord-and pillar mining is expected to remain the most important mining method used by the industry for the forseeable future

9) The specific energy requirements of the industry are not expected to change significantly in the near future, although small improvements can be expected

10) The introduction of mechanization will have an effect on the long term energy requirements but not to any significant extent, as the savings in other areas will tend to balance any increased requirements resulting from mechanization.

INDEX

1. INTRODUCTION

The aim of this report is to detail the energy requirements of the South African coal mining industry.

The recently published "Report of the Commission of Inquiry into the Coal Resources of the Republic of South Africa" (1) is the result of an extensive study of the coal mining industry and the reader is referred to this report for further details regarding the industry.

This report is not intended to overlap with the Petrick Commission's work and as such the study has been confined to the past, present and future energy requirements of the industry, as well as the determination of the method of energy utilization within the industry.

After an initial approach to the three largest coal mining groups was made, a questionnaire was formulated and distributed to forty mines. (See Appendix A for a copy of the questionnaire).

The response from the industry was very good and 35 completed questionnaires were received. This report summarizes the findings of that survey.

2. ENERGY INPUTS

The annual reports of the Chamber of Mines have been used to extract information relating to the energy inputs of Chamber coal mines from 1966 onwards. However, as some coal mines are not members of the Chamber, it is necessary to establish what percentage of the total energy requirements is reflected by the Chamber of Mines data. This has been estimated to be proportional to the amount of coal produced by Chamber coal mines, expressed as a percentage of South Africa's total production. This data is contained in Appendix B, where it will be seen that the data contained in the annual reports of the Chamber of Mines represents the requirements of between 72% and 89% of the whole industry. Note that the coal sales of the industry have been compared with the total production. The coal used by the mines for its own purposes are not included under the sales and there may be a further discrepency due to stockpiling of coal by mines. Coal utilized by Sasol and Iscor is not reflected in the sales figures. However, Appendix B does indicate the degree of representation of the industry by the Chamber of Mines and as such allows one to estimate the overall energy requirements of the industry.

The reason for the increase in representation of the industry by the Chamber during 1975 is the inclusion of members of the Natal Coal Owners Society for the first time.

In Section (ii) of Appendix B the 1975 coal sales figures are broken down into coal type and it will be seen that bituminous coal accounts for over 90% of the coal production of South Africa.

In Section (iii) of Appendix B, the degree of representation of the survey has been calculated. The survey respondents accounted for about 77% of South Africa's 1975 coal sales and it is felt that this is sufficient to provide representative results for the industry.

The energy inputs to the Chamber coal mines over the period 1966 to 1975 are included as Appendix C. In Part (i) of this Appendix the energy inputs are listed in their original units, while in Part (ii) they have been converted to common energy units utilizing the listed calorific values and conversion factors. In Section (iii) the individual energy inputs have been expressed as percentages of the total input requirements to enable their relative importance to be gauged.

It will be seen from Section (iii) that although liquid fuels have been increasing in importance over the past ten years, they still only account for some 10% of the industry's requirements. Electricity has also become more important over the past ten years, increasing from 41% of the total input to about 50% in 1975. During the same period, the importance of coal can be seen to have decreased from 54% to 38% of the total input requirements.

In Section (iv) of Appendix C, the gross energy requirements of the Chamber coal mines have been calculated. The gross requirements include the losses associated with the generation of purchased electricity.

Using the above data, the specific net and specific gross energy requirements have been calculated for the industry. Both show a gradual decrease over the past ten years (approximately 2% p.a.) and a sudden increase of 46% in the net specific energy requirements and 30% in the gross specific energy requirements. The 1975 increase has resulted from the inclusion for the first time of data relating to the Natal Coal Owners Society.

This sudden increase has not been explained and it is possible that a different method of reporting by the Natal mines has resulted in the sudden increase in specific energy requirements.

The 1975 specific requirements are a more accurate representation of the true picture since they are derived from a greater sample, but the inclusion of data related to earlier years does show a trend in usage patterns as well as demonstrating how the results can be affected by the selection of data.

Although data for the Natal mines were not obtained for earlier years, it is likely that the same downward trend in specific energy requirements has occurred.

The downward trend has resulted from economies of scale as well as from improved mining equipment. This trend is likely to continue for some time in the future as larger mines open up but is not expected to accelerate.

An acceleration would only occur if there was a large scale change to such low-energy-intensive mining methods as opencast and as will be pointed out in a later chapter, the industry does not forsee such a change.

It is interesting to note that the specific energy requirements for coal mining are roughly ten times lower than the requirements of the gold mining industry (7). As such, the coal industry is not an important energy user, but since the industry plays such a big part as an energy supplier to other sectors of the economy, it is of interest to determine its own needs.

3. ENERGY UTILIZATION

There are three basic methods used to extract coal in South Africa. They are ;

1) Bord and pillar mining,
2) Longwall mining and
3) Open-cast mining

A description of these mining methods will not be given here and the reader is referred to references (1) and (8) for further information.

It had been hoped to calculate the specific energy requirements of each mining method. However, it was found that every mine included in the survey uses the bord and pillar method of mining, while some use a combination of bord and pillar and open-cast methods. Only one of the responding mines utilizes open cast techniques extensively while one other uses longwall mining to account for 70% of its production. The data obtained from the mine utilizing longwalling was so different from other mines that it is thought not to be representative.

In Appendix D the utilization of energy in the coal mines is detailed.

3.1 Electricity

The electricity requirements have been divided into eight categories and the reader is referred to Appendix A for more details of the breakdown.

Data for open cast and bord and pillar methods are presented in Appendix D Part (1). It will be seen that the overall electricity requirements for bord and pillar mining are twice as large as those for open cast methods. This is to be expected since savings in the areas of hoisting and ventilation are substantial in open cast workings.

The electricity is used largely for driving electric motors. The only electric heating occurs in mine housing and hostels and this is an insignificant portion of the total.

The efficiency of energy utilization of electricity by the coal mines will therefore be in the region of 80%.

3.2 Coal

Coal is utilized in three main areas by the coal mining industry; namely in steam locomotives, hostels, and for domestic purposes. A breakdown of the requirements is given in Appendix D Part 2.

Of the three, the hostels utilize the most coal, accounting for over half of the industry's requirements.

The coal is used in the hostels for cooking, steam generation and space heating and as a breakdown was not requested, the efficiency of utilization could not be calculated directly. However, its usage pattern within the hostels can be expected to be similar to that of the gold mining hostels and a conversion efficiency of 58% has been adopted (7).

The portion used for domestic purposes can be expected to be utilized at an efficiency similar to that obtained in the domestic sector of the country i.e. roughly 10%.

Steam locomotives are generally extremenly inefficient and the actual value depends on the ratio of standing time to operating time. An efficiency of conversion of 3% has been adopted for these locomotives (9).

Applying the above conversion efficiencies, the overall conversion efficiency for coal was calculated to be 36%.

3.3 Other Fuels

The other fuels comprise a small percentage of the total energy requirements, but for completeness, their method of utilization and conversion efficiencies will be described and calculated.

Approximately half of the liquid petroleum gas requirements are utilized for transport purposes at a conversion efficiency of 14%. The other half is used for direct process heating in workshopsand underground, mainly for soldering purposes. Applying a conversion efficiency of 60% for this process yields an overall conversion efficiency for liquid petroleum gas of 36% (See Appendix D Part 3).

Petrol/ .....

Petrol is used exclusively for transportation purposes and is converted at an efficiency of 14%.

Light diesel fuel is also used exclusively for transport by the industry, both on surface and underground. The conversion efficiency of 21% has therefore been adopted. This is in line with the value adopted in earlier reports of this series.

Of the total power parafffin requirements, approximately 17% is utilized for motive power. The balance is used as a cleaning agent and as such its energy content is not utilized. In Section 4 of Appendix D the overall conversion efficiency of power paraffin is calculated to be 2%.

Similarly, illuminating paraffin is used almost exclusively for cleaning purposes and the conversion efficiency has therefore been assumed to be 0%.

Most of the compressed air requirements are utilized in rockdrills, having a very low conversion efficiency of 9%. (7)

In Section 5 of Appendix D, a summary is given of the conversion efficiencies of the individual energy sources and the overall conversion efficiency of the industry is calculated to be 55%. In comparison, energy is converted by the gold mining industry at an effficiency of 60%. However, the gold industry is more dependent on electricity (approximately 70% of total input requirements) and can thus be expected to have a slightly higher conversion efficiency.

Although the coal requirements, expressed as a percentage of the total energy requirements, have been decreasing in recent years, this has partly been due to the increasing electricity requirements. The availability of coal will ensure that it is widely used by the mines.

4. FUTURE ENERGY REQUIREMENTS

The growth of the coal mining industry can be expected to be rapid in the future. The fast increasing price of oil coupled with recent rises in the coal price should encourage investment in the coal industry. However, to exploit the potential of the situation to its fullest, some improvements will have to be made to the present transport system. Already, the non-availability of coal during the winter months is proving a great inconvenience to users remote from the coal fields.

The Petrick Commission has dealt with the pros and cons of a coal exporting policy and no further comments in this regard need be made here.

As far as the different mining methods are concerned, there is likely to be a drive (on the part of conservationists especially) towards longwall mining techniques. These enable a higher percentage of the in-situ coal to be extracted and thus extend the life of the country's coal reserves. Open-cast techniques are also attractive from the point of view of increasing the extraction ratios, but environmentalists will be strongly opposed to extensive open-cast workings, especially near urban areas. A second attractive feature about open-cast mining is the relative low specific energy requirements, but against this is the very high initial cost of drag-lines and associated equipment. However, the development of conventional mines also requires vast amounts of capital and this is therefore not a valid argument against open-cast mining techniques.

The availability of coal fields suitable for open-cast methods is likely to be the factor determining the rate of growth of this mining method. These of course change as the coal price changes. A higher coal price means that it is possible to mine deeper, smaller deposits than was previously economic. This applies to the other mining techniques as well, so that below a certain depth it will still be economic to mine by conventional underground techniques.

It should never be forgotten that the coal mines exist to make money. Consequently it is unlikely that exhortations regarding patriotism and the need for conservation will be heeded unless the industry is compensated. If not, capital will not be attracted to the industry and expansion will slow down. It is therefore highly unlikely that any large change to either longwalling or open-cast methods will occur until it is economic to do so. For this reason, great changes within the industry are not expected in the near future. This is born out by representatives of the industry who have stated to the author that they do not expect significant changes in the make-up of the industry (as far as mining methods are concerned) before the year 2000. The specific requirements of the industry can therefore be expected to remain at levels similar to those occurring at present and the growth of the demand for energy by the industry should be proportional to the rate of growth of the industry itself.

Mechanization, although expected to increase, will only affect certain areas of the mining operation and the overall effect of its introduction is likely to be small as regards future energy requirements.

Further small improvements in the specific energy requirements can be expected due to larger mines being opened, as well as further improvements in equipment and techniques, but in general no large scale changes are expected.

5. ACKNOWLEDGEMENTS

I would like to thank the following Companies for supplying data, without which it would not have been possible to write this report.

1) Amalgamated Collieries of S.A. Ltd. - Cornelia Colliery
2) Anglo American Corporation of S.A. Ltd.
3) Anglo Power Collieries (Pty) Ltd. - Arnot Division
4) Anglo Power Collieries (Pty) Ltd. - Kriel Division
5) Balgray Collieries (Pty) Ltd.
6) Blinkpan Collieries Ltd. - Blinkpan Colliery
7) Blinkpan Collieries Ltd. - Haasfontein Colliery
8) The Clydesdale (Tvl) Collieries Ltd. - Coalbrook Collieries
9) Delmas Colliery (Pty) Ltd.
10) Douglas Colliery Ltd. - Albion Section
11) Douglas Colliery Ltd. - Douglas Section
12) Douglas Colliery Ltd. - Union Section
13) Douglas Colliery Ltd. - Van Dyks Drift Section
14) Douglas Colliery Ltd. - Wolvekrans Section
15) General Mining and Finance Corp. of S.A. Ltd.
16) Hlobane Colliery (Pty) Ltd.
17) Indumeni Coal Mines Ltd.
18) Kilbarchan Colliery
19) Natal Ammonium Collieries (1946) Ltd.
20) Natal Anthracite Colliery Ltd.
21) New Clydesdale Colliery
22) New Largo Colliery Ltd.
23) Northfield Colliery
24) Optimum Collieries (Pty) Ltd.
25) Rand Mines Ltd.

26)/.......

26) Springbok Colliery Ltd. - Main

27) Springbok Colliery Ltd. - Hope

28) Transvaal Navigation Collieries & Estate Co. Ltd.

29) Umgala Colliery

30) Usutu Collieries Ltd.

31) Utrecht Colliery

32) Vierfontein Colliery Ltd.

33) Vryheid Coronation Ltd. - Coronation

34) Vryheid Coronation Ltd. - Vrede

35) Zimbutu Colliery

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CONFIDENTIAL

APPENDIX A

1976 NATIONAL ENERGY SURVEY

COAL MINING QUESTIONNAIRE

Please complete before :

1st OCTOBER, 1976

and return to :

The Director,
Energy Research Institute
University of Cape Town,
Private Bag,
RONDEBOSCH
7700.

1976 NATIONAL ENERGY SURVEY

1) GENERAL INFORMATION

a) Coal Mine Name ....

b) Address ....

....

c) Year in which mine was commissioned ....

d) Mining operation (please tick as applicable). If your mine carries out more than one of the below operations, please estimate the percentage of your 1975 production attributable to each type of mining.

	%
1) Bord and pillar ...	
2) Long wall mining ...	
3) Open cast ...	
	100%

e) Official to whom further enquiries regarding this questionnaire should be sent :

NAME ....

POSITION ....

ADDRESS : Head Office/Mine (delete as necessary)

PHONE NUMBER : Dialing Code .... No. ....

2) 1975 PRODUCTION FIGURES

a) Anthracite (tonnes) ....

b) Bituminous Coal (tonnes) ....

c) Other .... (tonnes) ....

(Please specify)

3) 1975 ENERGY REQUIREMENTS

a) Electricity purchased (MWh)	....
b) Electricity generated (MWh)	....
c) Coal (tonnes)	....
d) Liquid Petroleum Gas (kilolitres)	....
e) Petroleum (kilolitres)	....
f) Light Diesel (kilolitres)	....
g) Power Paraffin (kilolitres)	....
h) Illuminating Paraffin (kilolitres)	....
i) Light Furnace Oil (kilolitres)	....
j) Heavy Furnace Oil (kilolitres)	....
k) Other .... ( )	....
l) Other .... ( )	....

4) ENERGY USAGE

Of your total 1975 electricity requirements, (i.e. generated and purchased electricity), please estimate the percentage used in the following operations :

a) Coal Face Operations ....%
Including coal cutters, loaders, shuttle cars, compressors, armoured face conveyors, shearers, hydraulic pumps, stage loaders, face lighting, tail gate winches, drilling and draglines.

b) Underground Haulage and Hoisting of Coal ....%
Including section conveyors, endless ropes and underground arterial conveying to primary crushers.
Also including overland conveying to primary crushers.

c) Crushing ....%
Including run of mine and product crushing

d) Coal Preparation ....%
Washing plants but excluding interplant conveying

e) Surface Conveying ....%
Interplant conveyors from Primary Crushing to product outloading or take-over point by others such as Escom

f) Ventilation ....%
Including section fans and main fans

g) Pumping ....%
Including all pumping of water from underground, section and main u/g pumps but excluding surface effluent pumping or ash pumping (power station mines only)

h) Other ....%
Including high- and low-density housing, water and sewerage and waste disposal

TOTAL : 100 %

i) Of the other fuel inputs mentioned in Section 3, please detail their uses briefly and where these fuels are used for more than one application, please estimate the percentage used for the various applications :

1) Coal ....
....
....

2) Liquid Petroleum Gas ....
....
....

3) Petroleum ....
....
....

4) Light Diesel ....
....
....

5) Power Paraffin ....
....
....

6) Illuminating Paraffin ....
....
....

7) Light Furnace Oil ....
....
....

8) Heavy Furnace Oil ....
....
....

9) Other Fuel ....
....
....

10) Other Fuel ....
....
....

1976 NATIONAL ENERGY SURVEY : COAL MINING

GROUP QUESTIONNAIRE :

1975 PRODUCTION

1 a) Bituminous coal .... 10^6 tonnes
b) Anthracitic coal .... 10^6 tonnes
c) Other .... 10^6 tonnes
(Please specify)

2. What percentage of the above totals was won by the following methods :

	Bituminous (%)	Anthracitic (%)
1) Bord and pillar 2) Longwall 3) Open cast		
	100%	100%

3. Please estimate your group's total production for the following years :

	1980	1990	2000
a) Bituminous coals (10^6 tonnes)			
b) Anthracitic coal (10^6 tonnes)			
c) Other (10^6 tonnes)			

What is/ ....

What is the basis for the above forecast (Please tick as applicable)

	1980	1990	2000
a) Complete sales, budget or economic projections			
b) Informal forecasts			
c) Educated guesses			

4. Please estimate the percentage of the total production for the following years using the following mining methods :

	1980	1990	2000
1) Bord and pillar			
2) Long wall			
3) Open cast			
	100%	100%	100%

What is the basis for the above forecast? (Please tick where applicable)

	1980	1990	2000
a) Complete sales, budget or economic projections			
b) Informal forecasts			
c) Educated guesses			

5. Please estimate the electricity requirements for your group for the following year :

	1980	1990	2000
Electricity requirements (MWh)			

What is the basis for the above forecast? (Please tick where applicable)

	1980	1990	2000
a) Complete sales, budget or economic projections			
b) Informal forecasts			
c) Educated guesses			

APPENDIX B : COAL PRODUCTION 1966 - 1975

i) South African Production

YEAR	Coal Sales of Chamber Mines (tonnes)	Total S.A. Coal Production (tonnes)	Coal Sales of Chamber Mines (% of total)
1966	34 615 703	47 975 000	72,2
1967	35 621 703	49 366 000	72,2
1968	37 593 441	51 650 000	72,8
1969	38 034 835	52 295 000	72,7
1970	39 822 364	54 612 000	72,9
1971	43 277 788	58 666 000	73,8
1972	43 941 451	58 440 000	75,2
1973	47 878 199	62 352 000	76,8
1974	50 810 900	66 100 000	76,9
1975	63 169 663	71 000 000	89,0
Refs.	(3)	(2), (4), (5)	-

ii) 1975 Sales of Coal in South Africa broken down into Coal Type

Source : Reference (6)

Coal Classification	1975 Coal Sales (tonnes)	(%)
Bituminous	62 672 861	92
Anthracite	1 607 815	2
Metallurgical	3 886 493	6
TOTAL	68 167 169	100

iii) 1975 Output of Coal Mines Included in the Energy Survey

Coal Classification	1975 Output (tonnes)	(%)
Bituminous	47 882 691	74
Anthracite	1 351 680	84
Metallurgical	3 336 890	86
TOTAL	52 571 261	77

APPENDIX C : DIRECT ENERGY IN PUTS TO CHAMBER COAL MINES 1966 - 1975

i) Original Units

a) Solid Fuels, Electricity and Compressed Air

YEAR	Coal (tonnes)	Coke (tonnes)	Electricity (10^6 kWh)	Compressed Air (m^3 Free Air)
1966	53 348	114	306,968	3 313
1967	56 195	0	373,0	2 747
1968	58 295	0	354,558	16 226
1969	55 131	0	389,797	4 219
1970	48 550	0	404,982	1 000
1971	36 334	0	424,691	196 000
1972	35 733	0	451,299	208 000
1973	45 618	0	475,809	172 200
1974	32 632	0	474,041	228 289
1975	78 883	0	772,912	191 779

b) Liquid Fuels

YEAR	Petrol (kilolitres)	Paraffin (kilolitres)	Diesel Fuel (kilolitres)
1966	1416,7	233,0	1614,7
1967	1464,8	240,3	2493,7
1968	1556,9	255,7	1746,2
1969	1713,7	241,7	1860,4
1970	1635,3	267,2	2661,2
1971	1796,3	304,7	4595,7
1972	1727,5	299,6	4295,6
1973	1807,8	315,7	5848,1
1974	1520,3	266,3	8535,3
1975	2782,8	808,9	12586,9

iii) Common Energy Units (10^6MJ)

a) Solid Fuels, Electricity and Compressed Air

Calorific Values and Conversion Factors

Coal = 27MJ/kg Coke = 30MJ/kg

Compressed Air = 634,7MJ/m^3 (Ref. 7)

YEAR	Coal (10^6MJ)	Coke (10^6MJ)	Electricity (10^6MJ)	Compressed Air (10^6MJ)	Sub-total (10^6MJ)
1966	1 440	3	1 105	2	2 550
1967	1 517	0	1 343	2	2 862
1968	1 574	0	1 276	10	2 860
1969	1 489	0	1 403	3	2 895
1970	1 311	0	1 485	1	2 770
1971	981	0	1 529	124	2 634
1972	965	0	1 625	132	2 722
1973	1 232	0	1 713	109	3 054
1974	881	0	1 707	145	2 733
1975	2 130	0	2 783	121	5 034

b) Liquid Fuels

Calorific Values : Petrol = 34,5 MJ/litre

Paraffin = 37 MJ/litre

Diesel Fuel = 38 MJ/litre

YEAR	Petrol 10^6MJ)	Paraffin (10^6MJ)	Diesel (10^6MJ)	TOTALS	
				Liquid (10^6MJ)	Overall (10^6MJ)
1966	49	9	61	119	2 669
1967	51	9	95	155	3 017
1968	54	9	66	129	2 989
1969	59	9	71	139	3 034
1970	56	10	101	167	2 937
1971	62	11	175	248	2 882
1972	60	11	163	234	2 956
1973	62	12	222	296	3 350
1974	52	10	324	386	3 119
1975	96	30	478	604	5 638

iii) Energy Inputs on a Percentage Basis

a) Solid Fuels, Electricity and Compressed Air

YEAR	Coal (%)	Coke (%)	Electricity (%)	Compressed Air (%)	Sub-Total (%)
1966	54,0	0,1	41,4	0,1	95,6
1967	50,3	0	44,5	0,1	94,9
1968	52,7	0	42,7	0,3	95,7
1969	49,1	0	46,2	0,1	95,4
1970	44,6	0	49,6	< 0,1	94,2
1971	34,0	0	53,1	4,3	91,4
1972	32,6	0	55,0	4,5	92,1
1973	36,8	0	51,1	3,3	91,2
1974	28,2	0	54,7	4,6	87,5
1975	37,8	0	49,4	2,1	89,3

b) Liquid Fuels

YEAR	Petrol (%)	Paraffin (%)	Diesel (%)	Liquid Fuel Total (%)
1966	1,8	0,3	2,3	4,4
1967	1,7	0,3	3,1	5,1
1968	1,8	0,3	2,2	4,3
1969	1,9	0,3	2,4	4,6
1970	1,9	0,3	3,6	5,8
1971	2,2	0,3	6,1	8,6
1972	2,0	0,4	5,5	7,9
1973	1,9	0,4	6,5	8,8
1974	1,7	0,3	10,5	12,5
1975	1,7	0,5	8,5	10,7

iv) Gross Energy Requirements of the Coal Mining Industry

YEAR	Electricity (10^6MJ)	Generation Efficiency (%) *	Gross Elec. Requirements (10^6MJ)	Other Energy Requirements (10^6MJ)	Total Energy Requirements (10^6MJ)
1966	1105	23,45	4712	1564	6276
1967	1343	23,36	5749	1674	7423
1968	1276	24,02	5312	1713	7025
1969	1403	24,97	5619	1631	7250
1970	1458	25,28	5767	1497	7246
1971	1529	25,10	6092	1353	7445
1972	1625	26,25	6190	1331	7521
1973	1713	26,74	6406	1637	8043
1974	1707	27,33	6246	1412	7658
1975	2783	29,11	9564	2855	12419

* Source : Escom Annual Reports

v) Specific Energy Requirements related to Coal Sales by Chamber Mines

YEAR	Coal Sales (10^3 tonnes)	Net Energy Usage (10^6MJ)	Specific Net Energy Usage (MJ/tonne)	Gross Energy Usage (10^6MJ)	Specific Gross Energy Usage (MJ/tonne)
1966	34 616	2 669	77	6 276	181
1967	35 622	3 017	85	7 423	208
1968	37 593	2 989	80	7 025	187
1969	38 035	3 034	80	7 250	191
1970	39 822	2 937	74	7 246	182
1971	43 278	2 882	67	7 445	172
1972	43 941	2 956	67	7 521	171
1973	47 878	3 350	70	8 043	168
1974	50 811	3 119	61	7 658	151
1975	63 170	5 638	89	12 419	197

APPENDIX D : ENERGY UTILIZATION

1) Electricity

Coal Face Operations

Bord and Pillar	2,4 kWh/tonne
Open cast mining	2,1 kWh/tonne

Underground Haulage and Hoisting and Overland Conveying to Primary Crushers

Bord and Pillar	2,2 kWh/tonne
Open cast mining	0,2 kWh/tonne

Crushing	0,6 kWh/tonne
Coal Preparation	1,2 kWh/tonne
Surface Conveying	0,9 kWh/tonne

Ventilation

Bord and Pillar	1,3 kWh/tonne

Pumping

Bord and Pillar	0,8 kWh/tonne
Open cast mining	0,1 kWh/tonne

Other

Bord and Pillar	1,0 kWh/tonne
Open cast mining	0,1 kWh/tonne

Total (washed coal)

Bord and Pillar	=	10,4 kWh/tonne
Open cast mining	=	5,2 kWh/tonne

2/COAL ....

2. COAL

i) End Usage

	Percentage of total Requirements
Steam Locomotives	22%
Hostels	57%
Domestic Usage	21%

ii) Conversion Efficiency

	Input (%)	Conversion Efficiency (%)	Useful (%)
Steam Locomotives	22	3	1
Hostels	57	58	33
Domestic Usage	21	10	2
TOTAL	100	36	36

3. LIQUID PETROLEUM GAS

	Percentage of Total Input	Conversion Efficiency (%)	Useful Energy expressed as a percentage of input
Transport	52%	14%	7 %
Workshops	48%	60%	29 %
TOTAL	100%	36%	36 %

4. POWER PARAFFIN

	Percentage of total input	Conversion Efficiency (%)	Useful energy expressed as a percentage of input
Motive Power	17%	14	2%
Cleaning Agent	83%	0	0%
TOTAL	100%	2	2%

5. SUMMARY AND CALCULATION OF THE OVERALL CONVERSION EFFICIENCY OF ENERGY IN THE COAL MINING INDUSTRY

Energy Source	Input expressed as a percentage of the total requirements.	Conversion Efficiency (%)	Useful energy expressed as a percentage of input
Electricity	49,4	80	39,5
Coal	37,8	36	13,6
Petrol	1,7	14	0,2
Power Paraffin	0,3	2	< 0,1
Illuminating Paraffin	0,2	0	0
Diesel Fuel	8,5	21	1,8
Compressed Air	2,1	9	0,2
Liquid Petroleum Gas	< 0,1	36	< 0,1
TOTAL	100,0%	55,3 %	55,3 %

Appendix 3/......

APPENDIX 3

ENERGY USAGE IN SOUTH AFRICAN GOLD MINES

(Formerly Report ESI/5)

SUMMARY

The report summarizes energy usage within the gold mining industry.

The main findings of the report are:

1) Coal and electricity together account for about 98% of the energy requirements of the industry.

2) The amount of coal purchased is decreasing and expected to approach zero by the mid-1990's.

3) Electricity overtook coal in 1965 as the single most important source of energy and its share of the total is continuing to increase.

4) The net demand for energy has shown a decrease in the past fifteen years but is expected to increase again in the future.

5) The gross demand for energy (this includes losses associated with the generation of purchased electricity) has shown a general increase in the past.

6) The net specific energy demand has shown a gradual decline in the past, but it expected to increase in the future.

7) Electricity is converted by the mining industry at an overall conversion efficiency of 61%.

8) The specific demand for compressed air has shown an increase over the past five years and it is recommended that the industry investigate the cause of this.

9) Coal is converted at an efficiency of 58%.

10) The overall efficiency of energy conversion in the mining industry is 60%.

11) If the losses associated with the generation of purchased electricity are included, the above efficiency drops to 20%.

12)/................

12) The installed capacity of refrigeration equipment has shown a sharp increase over the past five years. This trend is expected to continue.

13) Mechanized mining techniques will be utilized on a larger scale in the future.

14) The total net demand for energy by the gold mining industry was 65×10^9 MJ in 1974.

15) The report cannot and does not take into account such factors as the discovery of other gold deposits, the change in the gold price and the effect of an increased demand for uranium.

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THE SOUTH AFRICAN GOLD MINING INDUSTRY

1. Introduction

South Africa produces about 80% of the free-world's gold (1) and as such has become a world leader in the techniques of deep-level mining.

The increased price of gold on the world's markets has given another lease of life to some mines where poor-grade ore would have otherwise forced closure.

The gold mines employed over 430 000 people in 1973 (1) and consumed over 26% of the electricity produced by Escom in that year(2).

The importance of gold to the South African economy is highlighted by the fact that in 1972, it constituted 36,5% of the exports (1).

To obtain a clearer picture of energy usage in the mines, it is useful to have a look at the history of the gold mining industry in general and at certain energy-intensive areas in particular, to appreciate trends and possible future innovations.

2. The Search for Gold in South Africa

From about 1800 on there were many rumours, some substantiated, of the discovery of gold in various parts of Southern Africa, including Louis Trichardt (1836), Warm Bokkeveld (1840), Smithfield, Burghersdorp and Worcester (1854), Marabastad (1858), the Tati district on the Limpopo River (1867), Murchison range (1868) and Lydenberg (1869) (3).

Following the discovery of a gold reef near Marabastad and alluvial gold near Lydenberg, the first gold mining company in the Transvaal was formed (The Lydenberg Gold Prospecting Company).

In 1872 gold was discovered at MacMac, Waterfal and in 1873 at Pilgrim's Rest.

Although all these discoveries had been made, it seems that up until 1872 they had been of little value since up to that time less than £3000 worth of gold had passed through the banks of Natal and the Cape Colony.

Looking back, it seems strange that gold was not discovered on the Witwatersrand at an earlier stage.

In 1801, Sir John Barrow reported "high mountains supposed to contain gold mines" in the Witwatersrand (or Magaliesberg) region (4).

In 1836 it was reported that natives north of the Vaal were mining gold.

It has been suggested (3) that in 1852 gold was discovered near Krugersdorp, but for political reasons, was not exploited.

In 1853 small quantities of gold were found in the Jukskei river, north of present-day Johannesburg.

Finally at the end of March or beginning of April 1886 (the exact date is uncertain) the Main Reef was found on the farm Langlaagte, by either George Harrison or George Walker.

The Witwatersrand gold fields developed very rapidly and spread towards Krugersdorp in the west and Nigel in the east, in which area they were confined for the next forty years.

Then in 1930, exploration west of Randfontein began and in 1939 the first mine in the Far West Rand started production at Ventersposst.

Gold was discovered in 1938 in the Orange Free State near Odendaalsrus and after further survey work the first mine went into production in 1951.

The Klerksdorp area was developed in 1952 and Evander in 1958.

3. The History of Energy Utilization in the South African Gold Mining Industry

In 1886 wood was the main fuel used in the Witwatersrand area, but in 1887 some coal was imported from the Middelberg area (at £3 per ton!) (3). In the same year coal was discovered at Boksburg, Brakpan and Springs, thus forcing the price down.

3.1 Drilling

Initially, holes had to be drilled by hand for blasting charges. Heavy reciprocating machinery (of over 100 kg mass) was introduced in 1892 and it wasn't until 1900 that the natives began to operate the drills. Because of the clumsiness of the heavy drills, the vast majority of drilling was still being done by hand in 1908.

The Chamber of Mines had invited designs for a light rock drill in 1903 and in 1908, such a drill was bought into service.

In 1910 another competition was held and as a result, in 1912, a light hammer drill with a mass of less than 8 kg and using about 0,5 cubic metres of free air per minute was introduced (3). 1912 also saw the introduction of the Ingersoll-Leyner hammer drill, using hollow drill steel.

This drill soon established itself and whereas in 1914 about 48% of stoping was done by machine, this figure had risen to about 78% in 1924 and 93% in 1928. (5).

The jackhammer has maintained its predominance up till now, and even if experiments with rock cutters prove successful it will be a number of years before jackhammers will be replaced.

The demand for compressed air grew as the number of pneumatic drills increased. Steam driven reciprocating compressors were used initially but turbo-compressors became more prominent. Rosherville Power Station had

an/......

an installed compressor capacity of some 80 MW .

By 1925 there was some 150 MW of air compressing machinery on the reef. (5)

3.2 Explosives

In the early days of mining on the Reef, blasting gelatine was the most popular explosive. This is formed when guncotton reacts with up to fifty times its own weight of nitroglycerine to form a gelatinous compound.

By 1896, South Africa's first explosives factory went into operation at Modderfontein, near Johannesburg. Its production increased from 192 000 kg of blasting gelatine in 1896 to 6 238 000 in 1899 (3).

In 1902 the explosives factory at Somerset West was started and in 1908 a further factory was established at Umbogintwini in Natal.

By 1905, blasting gelatine had dropped to about 70,5% of the total output of explosives, and by 1939 to 0,5%. By this stage the less powerful explosives with a 50% nitroglycerine content had become more popular. These were to a large extent replaced by ammon-gelignites and they in turn were replaced by ammon-dynamites.

A more recent development is the use of ammonium nitrate and fuel oil This has the obvious advantage that both constituents are completely safe until prepared for blasting.

3.3 Ore Removal

Ore was initially removed from the rock face to the main haulages by means of small railway cars pushed by hand. This method was still in general use as late as 1946.

Diesel locomotives were first tried out in 1928 and mules were common, there having been some 400 living underground in 1938 (3).

Rope or locomotive haulages are used to transfer the ore to the main hoists depending on such factors as the payability of reef, whether values have been proven and so on.

Hoisting/......

3.4 Hoisting

In 1902 there were nine electrically driven hoists of about 70 hp in the whole South African mining industry. At that stage there were over 300 steam driven hoists (5).

By the end of 1943 there were 130 steam hoists, 476 electric hoists and 17 air hoists on the Witwatersrand (3).

While the shafts were still shallow, it was possible to use unbalanced hoisting with a single skip and the rope winding round a drum.

As the shafts became deeper however other hoisting methods were adopted. These included

1) the use of two ropes, one attached to the skip and the other to a balance-weight;

2) the use of two skips and two ropes, one ascending as the other descends;

3) the practice of filling the empty descending ore skip with water as well as a number of other methods.

The capacity of the hoisting skips has gradually been increasing so that now capacities of 9-13,5 tons are common (6).

3.5 Ore Sorting and Crushing

The ore is generally tipped into bins attached to the headgear and from there transported to the crushing plant by track haulage or conveyer belt, where it is delivered to bins, stockpiles or silos. From this storage depot the ore travels into the crushing plant, where it is separated usually into fines and coarse. The coarse section is washed and hand sorting of waste (or reef-picking depending on the ratio of reef to waste) is carried out. The waste consists of quartzite or shale and can constitute between 4% and 40% of the ore brought to the surface (6).

Hand sorting has been carried out since gold mining began on the Witwatersrand. More recently with the increased cost and uncertainty of labour, automated sorting equipment has been given consideration.

Mechanical, radiometric, optical and electronic methods of sorting have been tested with various degrees of success.

If the gold reef is very narrow, it has been found that treating all large pieces of rock as waste is a reliable sorting method and mechanical separation methods can be used.

If the uranium content of the gold-producing ore is sufficiently high and well distributed, scintillation counters can be used to identify reef which can then be separated using pneumatics.

Optical methods, using photo-electric cells to scan each piece of rock have been attempted with moderate success (8).

The electronic methods of sorting consist of detecting some characteristic of reef, either the presence of iron pyrites, its response to an ultrasonic beam, or its behaviour under X-rays. Up till now little success has been achieved using these methods.

Although manual sorting seems to be open to abuse, efficiencies of 98-99% are achieved.

If rock cutting replaces blasting, the need for sorting will disappear.

If autogeneous milling is carried out (rock is used to grind rock), the pebbles for this purpose are separated after sorting. The remaining ore is then crushed down to a size acceptable to the mills. The crushing is usually carried out in either jaw, gyratory or disc crushers.

3.6 Milling Equipment

The milling plant of the early mining days consisted of stamp mills, where hammers were lifted and dropped onto a bed of ore, thereby crushing it. These mills were commonly driven through a long line shaft with clutches. Later, each mill was installed with its own electric motor (usually about 40 kw) (7).

Before 1904 all milling was done in stamp mills. In that year, tube mills were introduced to the Witwatersrand. These consisted of rotating cylinders loaded with ore and (sometimes) steel balls, and it was common practice to do the primary milling using stamp-mills and follow this up with secondary tube-mills.

Classifiers were used to separate any material that was of sufficient fineness after primary and secondary milling. The gold in the Witwatersrand ore is usually encased in sulphide particles so the classifiers are required to ensure that the sulphide particles that pass to cyanidation are small enough not to affect the efficiency of the extraction process.

Hydro-cyclones have been used as classifiers on an extensive scale since their introduction in 1951. They are now used to dewater crusher station washings, as primary, secondary and tertiary mill classifiers as well as classifiers for concentrator tailings.

Rod-mills were introduced in 1949 and it has generally been accepted that this is a more effective method of primary milling of the Witwatersrand rock.

The newer gold plants, erected from 1960 have used either rod or ball mills for primary milling and pebble mills (autogeneous mills) for secondary milling.

Run-of-mine milling was introduced in South Africa in 1958 in Evander. Here crushing and milling is all carried out in one cylindrical mill. The reef here is wide enough to ensure that only a minimal amount of waste rock is broken.

Dry milling experiments were carried out round about 1955 but no significant improvement in efficiency was detected (6). In contrast to the cement industry, where dry milling is used extensively, the milled product is required in a wet state, to facilitate cyanidation. The dust problem associated with dry milling is another factor favouring the continued use of wet milling.

3.7 Recovery of Ore by Gravity Concentration

After milling, a certain amount of free gold exists in the pulp and it has been common practice to remove this, prior to cyanidation of the remainder.

The earliest method used was to allow the pulp to flow over amalgamated copper plates. The gold which became attached to these plates could

then/......

then be removed for further treatment. However due to cases of mercurial poisoning and thefts, this method was to a large extent replaced by corduroy tables. Corduroy strips overlapping in a manner similar to roof-tiles were positioned so that the mill products flowed over them. The riffles of the corduroy, being at right angles to the direction of flow, tended to trap the heavier fraction of the mixture, including the free gold.

In 1926, the Johnson concentrator came into use. This consisted of a slowly rotating cylinder tilted at about 5^o from the horizontal. The inner surface of the cylinder was lined with corduroy. The mill product was fed into the cylinder at the higher end and flowed by gravity along the length of the cylinder depositing the heavy fraction of the mixture in the corduroy. The heavy concentrate was washed off into a trough by water sprays directed at the apex of the cylinder.

In 1949, riffled rubber belting was introduced in a concentrator. The belt was set at an angle of about 12^o and the mill products directed over it. The belt moved slowly in the opposite direction to the material and after passing over a head-pulley, was washed by water-sprays.

In the same year another design using riffled rubber belts was introduced. However this had no moving parts and the riffles were arranged in the direction of the flow. The concentrate deposited in the riffles would slowly work its way along until it reached an extraction slot.

It wasn't until 1958 that the Johnson concentrator, with riffled rubber material, instead of corduroy, came into use.

Once the free gold and other heavy sediments were separated from the other mill products, mercury could be added to amalgamate the gold. This allowed most of the other impurities to be removed and the amalgam could be heated to volatize the mercury. The product thus obtained consisted of about 87-90% gold, 8-9,5% silver and the balance mainly copper (7).

Heavy-medium separation has been a fairly recent introduction in gravity concentrators , having only been considered once the market for uranium became significant.

In/......

In this process, the ore is separated prior to milling into fractions with high and low uranium oxide concentrations. This is done in hydrocyclones using a medium of ferro-silicone and magnetite particles suspended in water to obtain the correct specific gravity. This process can be successfully carried out due to the uniform distribution of uranimite within the gold bearing reef.

Some ores, due to the presence of other minerals, are not suitable for direct cyanidation, so flotation methods are first used to concentrate the gold-bearing ore. This method was first introduced in 1935 by the Transvaal Gold Mining Estates. The process consists of causing some of the mineral particles to adhere to air bubbles and the remainder to water. The gold-bearing sulphide particles adhere to air introduced either by mechanical agitators of as streams of compressed air. This froth can then be collected and roasted to produce a product which takes readily to cyanidation.

When in 1952 the demandfor uranium increased, the use of flotation was given a new lease on life. The uranium was extracted from the residue slime with sulphuric acid, the sulphur for the acid being obtained from iron pyrites floated from the residue slime.

3.8 Cyanidation

Up until 1894 it was common to separate sand and slime, the slime being discarded and the sand treated with cyanide. By then it had been realized that a considerable amount of gold was locked up in the slimes tailing dams and methods were evolved to extract this. The slimes were allowed to settle, the water was decanted and the partially dewatered slimes treated with cyanide. It was not until vacuum filtration of the gold-bearing cyanide solution was introduced that great quantities of slimes could be treated.

In the early twenties, the all-sliming treatment came into use.

Rotary filters were the next step, the first complete rotary drum plant being installed in South Africa in 1931.

Although the trend in the future seems to be towards operating plants continuously, there are still a few batch process plants in operation.

The/......

The method adopted to extract gold using cyanide is as follows:

The slimes are first thickened, either by rotary thickeners in the continuous process or by decanting water in the batch process. The thickened pulp is transferred to tanks, where cyanide at a concentration of 0,025% is added. The mixture is agitated by streams of compressed air and the following chemical reaction takes place:

$$4Au + 8\ NaCN + O_2 + 2H_2O \ = \ 4Na\ Au\ (CN)_2 + 4\ NaOH$$

One ton of cyanide will treat approximately 6 600 tons of pulp and agitation times vary from 15 to 45 hours (6) depending on such factors as fineness of free gold particles, degree of pyritic encasement etc.

Air consumption is of the order of one cubic metre per minute per $50m^3$ of pulp i.e. 35 tons of solid treated (6).

Once all the gold has been taken into solution, the liquid phase of the mixture is filtered out and the barren pulp can be disposed of on slimes dams.

.9 Gold Precipitation from Cyanide Solutions

The gold-bearing cyanide solution is first clarified in sand-bed filters and then de-aerated, since precipitation is a reducing reaction calling for a lack of oxygen.

Zinc,either in the form of dust or shavings,can be used as the reducing agent, while other processes utilize either charcoal or an electrolytic cell.

Zinc has been the most favoured reagent on the Witwatersrand, with dust (Merrill-Crowe process (1911)) having replaced shavings (McArthur process (1890)).

Lead nitrate is added to the solution, the lead depositing on the zinc to form a lead-zinc couple.

A certain amount of free cyanide must be present during the precipitation process to prevent the deposition of sulphides and oxides on the zinc surfaces.

The/......

The following chemical reaction occurs during precipitation;

$$Zn + 2Na\ Au\ (CN)_2 = Na_2Zn\ (CN)_4 + 2Au$$

Any free zinc in the precipitate is removed by acid cleaning and most other impurities can be removed by roasting before submitting to smelting.

Ion exchange has been considered as an alternative to the zinc process but since the South African ores are mostly low in refractory constituents, which adversely affect the zinc process, there has been no need for it.

Finally, the gold is smelted in electric arc furnaces before being transported to Rand Refinery for refinement.

4. Possible Innovations in Gold Mining

4.1) Rock breaking

In 1970, there were some 17 000 rock-drills in operation in South African gold mines operating at an overall efficiency of about 9%. The compressors driving these rock-drills consumed more energy than that contained in the explosives used on the gold mines in the same year (9).

From the above figures it is obvious that pneumatic rock drilling is inefficient and a lot of work has been done to find some replacement for this mining tool.

Hydraulic rock-drills have been proposed. These operate at an overall efficiency of about 30% (10) but have a number of disadvantages, one of the major being the lack of cooling present in the exhaust of a conventional pneumatic rock-drill. Besides the lack of cooling there is also the problem that almost all the energy input to a hydraulic device will be converted to heat. This of course applies to any drill which does not use a fluid as a refrigerant.

The details as regards energy consumption are dealt with in greater detail in a later section.

Other/......

Other disadvantages of the hydraulic rock drill are that the power pack needs to be in the immediate vicinity of the drill; the high degree of cleanliness required and the need for skilled maintenance. However, the hydraulic rock drill should not be ruled out as an alternative to pneumatic drills. A recent report (19) states that the Chamber of Mines is very optimistic about the future of hydraulics especially for use in mines which can be reopened due to the increased price of gold and where the compressed air supply lines have already been removed.

The rock drills are used mainly for drilling holes so that explosive charges can be set to blast the rock. If non-explosive methods of rockbreaking could be developed, the need for rock-drills would diminish. The intermittent nature of mining would also be overcome as there would be no need to evacuate working areas while blasting is in progress.

When using explosives to break rock, it is not normally possible to break a stoping width of much less than 1 metre (10). The thickness of the reefs in the newer goldfields are given below (11) :

TABLE 1

Goldfield	Reef	Average Thickness
Evander	Kimberley	64 cm
Far West Rand	Ventersdorp Contact	76 cm
	Carbon Leader	25 cm
Klerksdorp	Vaal	50 cm
Orange Free State	Basal	38 cm

A detailed study of the Vaal reef has shown that more than 80% of its gold content is found in the lower four inches of its thickness (11).

Since the mining costs are roughly proportional to the volume of rock removed, it would be an obvious advantage if more selective mining methods could be adopted, since as has been shown above, a large proportion of the rock mined is waste.

A number/.............

A number of methods for breaking rock without using explosives have been proposed and some are discussed below.

The use of heat in the form of microwaves, laser beams or high temperature gas have so far proved inefficient and besides, the additional heat load is undesirable for South African conditions.

Rock cutting, diamond drilling, roller bits, water jets, percussive drilling and bull wedges have a similar efficiency but roller bits are not considered suitable for the hard quartzite rock found in the vicinity of the gold reefs.

The specific energy consumption of the above processes for typical particle sizes produced is given below (11) :

TABLE 2

	Specific Energy Consumption (kwh/ton)	Approx. particle size cm.
1) High temperature jet piercing	1000	0,5
2) Laser beam (marble)	200	0,5
3) Microwave heating	40	0,5
4) Percussive drilling	50	0,1
5) Diamond drilling	80	0,05
6) Explosive steam shattering	300	0,01
7) Water jet	30	0,1
8) Roller bit (shale) (limestone)	5	0,5
9) Rock - cutting	20	0,1
10) Explosives	0,2	10
11) Bull wedge	0,1	10
12) Milling	25	0,01

The above table gives the process in ascending order of efficiency.

Milling is the most efficient method of rockbreaking but is more suited to the comminution process.

Since any process to replace explosives should have a similar efficiency, rock cutting, bull wedges and water jets seem attractive alternatives. (The heat associated with explosive steam shattering weighs against this process).

The Chamber of Mines began work in the sixties aimed at developing a rock-cutter which would advance the face by 7,5 metres/month from one shift per day and mine 3,3 m^3 of rock before replacement of the tool became necessary (12). These figures corresponded to the breakeven point with explosives. Prototype rock-cutters were installed at Doornfontein and Stilfontein Gold Mines and in 1972 the largest areas mined out in one month on a one shift basis was 120 m^2 per machine at Doornfontein and 106 m^2 at Stilfontein. On the basis of these results, eighteen more rock-cutters have been ordered (13). However, by the end of 1973 no definite cost figures were available for comparison with explosive techniques of rock-breaking.

It is now about ten years since work was started on the development of rock-cutters and it would seem that there are still many difficulties to be overcome before installation of rock-cutters could be undertaken on a large scale.

A further consideration in the installation of rock-cutters is the extra heat load which would occur due to the lack of cooling by exhausted compressed air. A variation of the bull wedge has been tested on the mines. This consisted of a wedge which was initially forced into a drilled hole by means of a static thrust of some 90 tonnes. Further tests at Doornfontein and West Driefontein showed that it was not always necessary to first drill a hole.

A pneumatic pile-driver was tested at Virginia and was fairly succesful. Mechanical wedges have however been unsuccesful.

Water jet cutting has also been tried out with moderate success, but the conclusions drawn from the tests were that the power requirements would be "an order of magnitude" higher than those of conventional methods (14). (This does not tie up with the figures given in Table 2 - but the rock used to obtain this figure is not known). In addition to this, the technological difficulties involved with the suggested pressure of 1 000 MPa (14) are formidable to say the least. It does seem a pity though that this method of rock breaking could not be utilized, especially at the bottom of a mine where a static head of some 2000 - 3000 metres of water could be obtained relatively easily.

The use of a high-pressure jet of air for rock-cutting has been investigated but the cost of piping high-pressure air was prohibitive and the concept was modified so as to consist of a cylinder containing combustible gas under high pressure. The gas was ignited electrically to cause a rapid expansion and break the rock. Although tests are still continuing with this system, it suffers from the drawback that holes have to be drilled for the gas cylinder.

A few other developments which deserve a mention include the swing-hammer miner and reef-boring.

The swing-hammer miner consists of a number of pivoted hammers which are rotated to hammer the rock face to bits. A 50 kw prototype was put into operation at the end of 1974.

Reef boring has the advantage that the reef is extracted in such a finely divided form that further milling is kept to a minimum. Research is at present being undertaken into drill-bit design.

Hybrid rock-cutting, whereby an oxy-acetylene flame moves ahead of a rock-cutting tool has been tried. The rapid heating of the rock induces thermal stresses, thereby lowering the strength of the rock.

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This system has the disadvantage of the heat given off by the flame and has not been pursued.

4.2) Ore Conveying.

Present methods of face-cleaning are inefficient and labour intensive.

For some time now tests have been conducted using an armour-faced conveyer, capable of withstanding the effects of an explosive blast at a distance of about a metre.

An advantage of a system of this type is that with suitable scatter screens, most of the broken rock can be directed directly into the conveyer by the blast. The capacity of the unit under test was of the order of 200 tons/hr.

Since the conveyer is in close proximity to the face, drill rigs may be mounted on it to facilitate easier drilling.

Loading ploughs have been incorporated so that any ore not falling directly onto the conveyer after the blast may be piled on with ease.

To enable rock-cutting machines to achieve their full potential, the whole system should be mechanized and to this end small conveyers have been used to extract the reef from the rock-cutting panels. The use of these conveyers also allows immediate sorting of reef and waste, so that less rock needs to be hoisted.

Three types of conveyers have been considered, vibrator, scraper and shaker. Excessive mechanical problems were encountered with the vibrator conveyers while the scraper conveyer with its associated hydraulics proved too expensive and heavy. The shaker conveyer has

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therefore been adopted and consists of a tray suspended, hammock-like by chains in its frame and coupled flexibly to the next section. Twenty such conveyers have so far been constructed and are in service with rock-cutters at Doornfontein and Stilfontein.

4.3) <u>Hydraulic hoisting and rock transport</u>

The hydraulic hoisting of ore has been under consideration for a number of years and is in fact already in limited operation (18). This involves the milling of reef underground and pumping the resultant slurry to the surface for further treatment. Since the further development of this concept will depend to a large extent on developments in the field of milling, these will now be discussed.

4.4) <u>Milling</u>

It has generally been accepted that the energy aborbed in crushing and grinding is directly proportional to the new surface area produced in the material being comminuted (11),(15). Experiments have been carried out (11) to ascertain the efficiency of milling and figures in the region of 20% were obtained. From measurements taken on the mills during tests it seemed that about 80% of the energy available for comminution was converted directly to heat.

Although rotary mills are used extensively throughout the gold mining industry, they are very bulky and not suited to underground milling.

Vibratory milling was investigated at Durban Roodepoort Deep Gold Mine in the sixties and although operating costs in terms of power consumption and tons of grinding media were comparable with rotary mills, the capacity of mills of this type were too small for the volume of reef that had to be handled (16).

The efficiency of milling increases as the speed of rotation increases. This occurs because the forces acting on the rock are increased, allowing a larger proportion to do useful work.

However, if the speed of a rotary mill is increased, the centrifugal force prevents the efficient extraction of the pulp. Union Corporation has recently been experimenting with the peripheral discharge of the mill products. Initial tests showed that too much pulp was extracted in this way, with consequent high liner wear and pebble consumption. This drawback was overcome by the installation of a screen to retain a portion of the pulp and later tests yielded outputs 40% greater than that obtained from rotary mills of a similar size with conventional pulp extraction fixtures.

Centrifugal milling has been under investigation by the Chamber of Mines since 1968. The work was initially undertaken in an attempt to produce a mill of smaller size which would be suitable for underground installation.

Prototype tests have indicated a specific power consumption of about 27 kWh/tonne, which compares well with rotary mills.

The main advantages of the centrifugal mill are the low capital cost (15% of the cost of a conventional mill of equal capacity (17)) and the fact that due to its compact size it could be installed underground. This in turn could lead to the hydraulic hoisting of slurry.

Besides underground milling, there are considerable advantages in carrying out some metallurgical treatment (such as flotation) on ore underground, in order to concentrate the metal values and generate a waste suitable for hydraulic back fill. Studies are at present being undertaken to look at means of concentrating the metals into a mass of 20 to 40% of the feed and containing 95% of the gold. This entails leaving 5% of the gold underground, but this is not excessive when it is considered that in some of the deeper mines up to 20% of the reef is left in place to ensure structural stability. (17)

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The centrifugal mill is still very much in the testing stage and it would be some years before it could be brought to a state of development which would enable it to be installed on any large scale.

4.5) Thiourea Leaching of gold

A system to extract gold from ore which by-passes the cyanide process, filtration, clarification, deaeration, zinc precipitation and smelting would naturally arouse interest.

One proposed system is the leaching of mill pulp in acidic thiourea solutions. Studies have shown that the performance of the cyanide process may at least be equalled by leaching in acidic thiourea for one quarter of the time required for a cyanide leach (14). It is hoped to recover the gold from the thiourea solutions by a process based on the use of strong cation exchangers.

4.6) Discussion

On reading through the previous section, one might have gained the impression that the gold mining industry is on the verge of adopting a number of new processes and methods.

However, when one considers how much money is invested in plant already in operation, it requires more than a slightly improved efficiency to convince mine managements that it was time to modernize their plants. This applies especially to such items as milling plant and processes other than that based on cyanide for the extraction of gold.

Only in certain circumstances, such as opening up a new mine, would it be worthwhile considering the installation of new processes and only then when the efficiency and reliability of that process had been thoroughly proven elsewhere .

Some of the processes may never be adopted, due to economic inviability, but they should be mentioned in a report of this kind to give an indication of the trends in thinking within the gold mining industry.

5. Energy Inputs to the SA Gold Mining Industry

5.1 Source of data

The energy purchases by member mines of the Chamber of Mines of South Africa are listed in the Chamber's annual reports. To determine whether this data is representative of the industry, the gold production of member mines has been compared with South Africa's annual production for the period 1947 to 1974 in Appendix A. It will be seen that at no time during this period did the production of member mines account for less than 95% of the total annual production of South Africa. Consequently, data relating to energy usage by member mines can be said to be truly representative of the industry.

5.2 A note on purchased compressed air and electricity

Purchased compressed air must be considered as one of the energy inputs to the industry. In recent times this practice has all but ceased and at present effectively all the energy required to compress air is supplied by the mines, either in the form of steam or, more commonly, electricity.

The energy contained within the purchased compressed air must be included along with the other energy inputs to obtain a true picture of energy usage by the industry.

The losses associated with the generation of purchased compressed air are not included however, since these losses occur outside the industry. Naturally, as a greater proportion of the compressed air requirements are provided by the individual gold mines, the losses associated with its generation are transferred to the mining industry.

Details of the method used to calculate the energy content of the purchased compressed air are included as Appendix B.

While the practice of generating compressed air instead of purchasing it has had a detrimental effect on the efficiency with which the industry uses energy, the trend towards purchasing electricity and closing down small inefficient mine power stations has had the

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opposite effect.

As time has passed, Escom has provided an increasing percentage of the electricity requirements of the gold mining industry, to the extent that of the eighteen mines included in the survey detailed in a later section of the report, not one generated its own electricity. It is believed that only one or two gold mines at present generate their electricity requirements.

The effect of this trend has been that losses associated with the generation of steam and electricity have been transferred from the gold mining industry to Escom.

The degree to which the mines have converted to electricity is shown in Appendix C which lists the energy inputs to member mines of the Chamber of Mines.

5.3 Calorific Values

The physical units used in Appendix C have been converted to units of energy by the use of various calorific values.

The calorific value of coal and coke was estimated by considering the output of all producing collieries in South Africa as well as representative calorific values for each of these mines as determined by the Fuel Research Institute.

Liquid fuel calorific values were extracted from various handbooks. A summary of the calorific values used for the calculation of the energy content of the fuels detailed in Appendix C is included as Appendix D.

5.4 General Trends

Appendix C shows some definite trends in energy usage. Section 1 of this Appendix lists the energy units in physical units while section 2 lists the same inputs but in common units of megajoules. It will be seen from section 2 of the Appendix that the amount of energy purchased in 1947 is almost identical to the 1974 purchases. Over the same period the amount of ore treated increased by 50%.

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As was explained earlier, the reason for this apparent anomoly is that where previously the mines used to purchase energy to generate steam for compressor and hoist drives as well as/or electricity generation, the electricity is now purchased from Escom and hoists and compressors have been replaced by electric motor driven units. Consequently the fuel requirements for boilers have dropped off substantially as have the losses associated with the generation of steam.

In section 3 of Appendix C, the energy inputs have been reworked on a percentage basis and it was found that electricity and coal constitute about 98% of the total energy requirements of the industry. (The liquid fuels as a percentage of the total requirements are so small that they have not been calculated individually

It is interesting to note the decline of coal at the expense of electricity over the period 1947 to 1974. While in 1947 coal purchases accounted for 82,1% of the energy purchases and electricity 16,5%, in 1974 the picture has altered dramatically. By this time 71,7% of the energy requirements were supplied by electricity while only 26,1% was obtained from coal. Figure 1 shows how constant the rate of change has been over this period.

The above comments serve to underline the effect of the decommissioning of power stations by the gold mining industry and the switch from steam powered hoists and compressors to electrically-driven units.

5.5 <u>Gross energy demand</u>

To ensure that the wrong impression is not created with regard to energy requirements one should consider the gross energy demands of the gold mining industry. These have been estimated by considering the energy expended by Escom in the generation of the electricity purchased by the gold mining industry. The efficiency of generation has been calculated from Escom annual reports and includes distribution losses but losses associated with the compression of purchased compressed air, being small, have been ignored. These results are shown in Appendix E.

Until 1962/......

Until 1962, a gradual increase in the gross energy requirements of the gold mining industry is evident. After that date a significant drop in the demand occurred until 1966 when the demand started increasing once again and this trend has continued.

Figure 2 has been drawn to show the difference in the net energy demand and the gross energy demand. It will be seen that over the period 1962 to 1966 the net energy requirements also declined. This decline is probably due to the decommissioning of electricity and steam generating plant and corresponds to a region of rapid decline in the amount of coal purchased, also indicated in figure 2.

The growth in electricity demand over the period 1947 to 1974 has been remarkably constant and to a certain extent seems to have been insensitive to the amount of coal burned. One would have expected that after the mine power stations were decommissioned, the demand for electricity would have increased at a greater rate. This however assumes that the production of gold (or more accurately the tonnage of rock processed) also increases at a constant rate. This has not been the case and the production of gold, after reaching a peak in 1970, has declined annually.

5.6 Specific energy usage

To obtain a clearer picture of the efficiency of energy usage (gross and net), the energy usage has been related to the tonnage of rock milled over the period 1947 to 1974 in Appendix F. These results are summarized in Figure 3.

While the net specific energy demand shows a gradual decline the gross specific energy demand is more erratic. From this graph, it is apparent that the industry as a separate unit utilized the energy it purchased more efficiently each year from 1947 up until the mid-sixties. After that point, the net energy requirement per kilogram of rock milled has shown a slight increase. The slight increase is due to the fact that now that effectively all the old mine power stations are out of commission no further savings can be achieved. The very deep Free State mines came into operation at about this time as well, necessitating greater hoisting energy requirements. Increased refrigeration requirements are another factor. The gross specific energy requirements show no significant trends, beyond the fact that before the early sixties these requirements were increasing while the net requirements were decreasing. Since that time the gross and net requirements have both tended to increase. Once again this is due primarily to the replacement of less efficient mine power-stations with more efficient Escom ones.

6. The Utilization of Individual Energy Sources

6.1 Source of data

To determine the utilization of individual energy sources in the gold mining industry, a questionnaire was formulated (see Appendix G) and distributed to all the major mining companies. Returns were obtained from 18 mines, whose combined output accounted for 50,9% of South Africa's 1974 gold production. The mines included in the survey represent a good cross-section of the industry, data having been obtained for old and new mines in the Transvaal and Free State as well as mines with large and small outputs.

The problems which arose from the questionnaire centred around the breakdown of usage of individual energy sources. Whilst the mines do have a certain amount of information regarding this breakdown, the detail asked for in the questionnaire proved to be a little ambitious. The power used for underground lighting for instance was in most cases not known. This is hardly surprising as it constitutes a small fraction of the overall usage and little attention has been paid to it in the past by the mines.

Consequently it was necessary to summarize electricity usage in a slightly different manner from that initially envisaged.

6.2 Electricity

A summary of the breakdown of electricity usage is given in Appendix H. It will be seen that an overall figure is given for the energy requirements of the reduction works. This figure includes usage by crushers, mills, thickeners, flotation, the cyanide plant and the smelting plant. The data related to these individual items of the reduction works were not available.

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From Appendix H it can be seen that compressors account for the largest single portion of electricity (22,3%) followed by fans and refrigeration (21,7%) and the reduction works 16,2%.

6.2.1. Electricity Conversion Efficiencies

An estimate has been made of the consumption of useful electrical energy by considering the efficiency of conversion of electricity in the various items of plant.

It must be emphasised that in some cases the efficiencies stated are estimates only, as they include a variety of plant, which would require individual testing to arrive at an accurate figure.

In general, the compressors used by the mines are of the turbo-type,driven by very large electric motors. Information received from the industry indicates that the overall efficiency of these units is of the order of 71%. Similarly, hoists are 80% efficient and the large fans used for ventilation purposes 75% efficient. Refrigeration plants are given as 50% efficient while the efficiency of pumps varies widely, dependent on the type and application. Sludge pumps for instance can have efficiencies below 25% while large multi-stage centrifugal pumps can have efficiencies above 70%.

The efficiencies mentioned up to this point have in most cases been measured or are available from handbooks. The accuracy can be assumed to be ± 10%.

However for the remaining items of plant the derivation of a conversion efficiency is much more difficult.

The reduction plant for example is in reality a complete factory in itself and as such consists of a group of widely different items of plant operating at different efficiencies. However a large proportion of the energy used in a reduction plant goes into milling the ore. As mentioned in an earlier section of the report, tests have shown that these mills are approximately 20% efficient and this efficiency has been taken as representative of the reduction works. The breakdown of electricity usage in mining housing and compounds was not obtained. Results obtained from a separate survey of the domestic sector carried out by this Unit indicate that the conversion efficiency of electricity is of the order of 65%.

The remaining electricity used in the uranium plant and for "other" uses is assumed to be converted at an efficiency of 50%. This is a purely arbitrary figure but as this sub-sector only accounts for 10% of the total input, the effect on the overall result will be small.

As mentioned earlier, the estimation of the efficiency of conversion of electricity in such areas as the reduction plant and housing is difficult to assess without extensive testing and the accuracy of the figures cannot be expected to be better than ± 25%.

Using the above efficiencies, the conversion efficiency of electricity in the industry as a whole was calculated to be 61%.

While information related to milling plant was requested as a separate item on the questionnaire, only eleven of the eighteen mines supplied data in sufficient detail to calculate the specific energy usage for ore milling. These eleven mines used a total of $498,7 \times 10^6$ kWh in their milling plant during 1974 to treat $23,3 \times 10^6$ tonnes of rock. In other words the specific energy usage was 21,4 kWh/tonne or 77,1 MJ/tonne of ore. This is slightly better than the figure of 25 kWh/tonne mentioned in Table 2. Over the same period of time, the eighteen mines included in the survey used $782,9 \times 10^6$ kWh to hoist $50,5 \times 10^6$ tonnes of rock or 14,4 kWh/tonne.

6.3 Compressed Air

Compressed air is used chiefly for rock breaking but some (about 14% of the total) is used for other purposes, mainly agitation during the cyanide process.

Eleven of the mines provided data of sufficient detail for analysis purposes. A significant feature to show up is that over the period 1970 to 1974, the usage of compressed air per tonne of rock broken has increased by nearly 40%. This is shown in Appendix I. However, before any conclusions are drawn from this data, the method of calculating the compressed air requirements for rock-breaking should be clarified. The total volume of air compressed is known for each mine. However its distribution is difficult to estimate. The requirement of air for the cyanide process is known fairly accurately and it would seem that the requirements for rock breaking were taken as the difference between the total volume compressed and the amount used in the cyanide process. This method of arriving at the air requirements for rock-breaking results in distribution losses and leakages being lumped together with the air used for rock breaking.

The mining industry was approached to explain the increase in specific compressed air requirements. It would seem that the increase cannot be explained by either the conversion to different explosive types or any extra development work which may have taken place during that period.

Surprising as it may seem, it is likely that the major portion of the increase is due to poor housekeeping. Massive leakages have been detected by certain mines already and at least one mining group is at present taking a close look at its demand for compressed air. It is strongly recommended that similar investigations be undertaken by the other groups if this has not already been done.

6.4 Coal

The gold mining industry has in the past tended to use relatively large amounts of coal. The generation of electricity accounted for a large proportion of this, as well as the use of steam-driven hoists and compressors. However, these practices have largely died out and of the sixteen mines which returned usable data, only one stated that it still used some steam for hoisting and as air-compressor motive power.

Steam is also used in the uranium leaching operation, but the balance is used to supply change houses, compounds and mine-run hospitals with a source of steam for hot water, cooking, laundry work and space heating.

The breakdown of coal usage in the gold mines is given in Appendix J. It will be seen that about 68% of the coal is used to fire small industrial boilers for the purposes mentioned above. Of the balance about 17%, or over 38 500 tonnes, was used in stoves for space heating within the compounds, 9,6% was used to supply heat for cooking and 4,5% was burned in open grates and braziers.

Only 0,2% was used in the gold smelting operation. If one assumes that half of the steam generated by the small industrial boilers was required for activities directly related to the production of gold, (and this is quite reasonable considering the requirements of compounds, hospitals and laundries), this leads to the conclusion that about 66% of the coal requirements of the industry (in other words nearly 400 000 tonnes in 1974) is non-productive, in the sense that it does not contribute directly to the production of gold or uranium.

This does not however imply that steps should immediately be taken to change the situation. It will be shown, by the derivation of the conversion efficiency for coal, that the present situation is more efficient for the country as a whole than a general conversion to electricity would be.

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6.4.1. Coal conversion efficiencies

The efficiency of small industrial boilers is of the order of 70%, and efficiencies for coal stoves for cooking and space heating have been extracted from the literature (20). The efficiency of conversion in open grates and braziers has been assumed as 10% while that for gold smelting at 50%. These two sectors account for less than 5% of the total requirements and their accuracy is of minor importance. The other efficiencies should be assumed to have an accuracy of approx±10%.

Using the above data, the efficiency of conversion of coal within the industry has been calculated in Appendix J to be 58%.

If all the coal-burning appliances on the mines were replaced by electrically-operated plant, the efficiency of energy use within the industry as a whole would improve, since the conversion of electricity to heat is more efficient in comparison with coal-fired boilers, after losses in flue gases have been considered.

However, if Escom were to generate this extra electricity, which would in turn be converted to heat by the mines, the conversion of coal-to-electricity-to-heat would have an efficiency in the region of 28%.

Consequently, while it is in the interests of the gold mining industry to convert from coal to electricity, from an energy conservation point of view it is not in the best interests of the country.

6.5 Coke

In 1974, coke accounted for about 0,1% of the energy requirements of the industry. Over 80% of the coke was used in the blacksmith and boilermaker workshops, while the balance was used in open grates and boilers.

6.6 Liquid Fuels

Liquid fuels constitute a very small proportion of the energy required by the mines. For the sake of completeness, the purposes that the fuels are used for are detailed, but no conversion efficiencies have been calculated since the effect on the efficiency of conversion of energy for the industry as a whole is insignificant.

6.6.1. Diesel Fuel

Over 95% of diesel fuel is utilised for transport, both on surface and underground. The use of diesel-powered locomotives accounts for most of the use of this fuel sort. The balance is utilised as a reagent in the extraction of gold.

6.6.2. Paraffin

Most of the paraffin is not used as an energy source at all, but rather as a cleaning agent for rock-drills etc. A certain portion is used in the uranium plant and one mine uses it as a fuel for a jet-turbine-powered emergency alternator.

6.6.3. Petrol

As would be expected, nearly all this fuel is used in mine vehicles, but some (less than 5%) is used by the property maintenance department for petrol-engine powered lawn mowers etc.

7. Overall Efficiency of Energy Conversion within the Gold Mining Industry

Electricity and coal together accounted for nearly 98% of the net energy requirements of the gold mining industry in 1974. Consequently it is valid to assume that the efficiency of conversion of these two energy sources is representative of the industry.

Using data for the industry as a whole and conversion efficiencies derived above, the efficiency of energy conversion within the industry has been calculated in Appendix K to be 60%. This figure does not include the losses associated with the generation of electricity by

Escom. If these losses are considered, the efficiency drops to 20%. This demonstrates the importance of adequately defining what is meant by the term "energy requirements".
Having considered the present efficiency of energy conversion, it would be useful to be able to estimate how this will change with time. For this purpose, a section on the future energy demand trends was included in the questionnaire distributed to the gold mines. The comments included in this section are discussed in the following chapter.

8. Future Energy Demand Trends

The plans for converting from one energy source to another and for energy conservation differ from mine to mine. Each individual energy source will be considered separately to determine any trends.

8.1 Coal

Of the seventeen mines which supplied data, seven stated that they were not considering any measures which might change the overall demand for coal. Of the other ten, two mines are considering replacing their boilers with electrode boilers, electrifying the surface rail transport, and replacing existing coal-fired space heating and hot water units by electrically powered units. One of these mines estimates that this will result in a 10 MW increase in demand.

Only one of the seventeen mines surveyed expects an increase in the demand for coal as a result of plans to replace diesel locomotives used on surface with steam locomotives.

In general the demand for coal can be expected to continue the decline which started in the 1940's. However, the rate of decline is not expected to be as rapid as was experienced up to the mid 1960's. If the data for the years 1966 to 1974 are taken as representative of what will happen in the future a curve of consumption versus time can be drawn. This has been done in figure 4 and it will be seen that the demand for coal drops to zero in the mid 1990's. Although the extrapolation has been made over a long period, relative to the period for which data was considered, the conclusion that the demand for coal will be zero or at least negligible in the mid 1990's is a reasonable one.

8.2 Coke

Coke at the moment accounts for an insignificant portion of the total energy requirements of the industry. No changes are expected in this area.

8.3 Diesel Fuel

The use of diesel as a fuel for underground locomotives is at present being reconsidered by the majority of the mines included in the survey.

Battery powered vehicles seem to be the alternative receiving most attention and their use can be expected in the near future.

As mentioned in the coal section, one of the mines is considering the replacement of its diesel-powered surface locomotives with steam locos.

From the above comments it is apparent that there is a general trend within the industry away from diesel fuel. However, since this fuel accounts for only one or two per cent of the energy requirements of the industry as a whole, the effects of the saving are minimal.

8.4 Paraffin

In some cases paraffin used for cleaning purposes is being replaced by degreasing fluids.

8.5 Petroleum

No changes can be expected in the demand for petrol, beyond the increase associated with the growth of car fleets etc.

8.6 Electricity

From the above sections, it is obvious that where possible the gold mining industry is converting its equipment to use electricity purchased from Escom.

The decline in the demand for coal and the comments related to diesel usage bear this out.

However, besides the conversion to electricity wherever possible, additional requirements for electricity are likely to arise from two sources.

The first of these is refrigeration.

8.6.1. Refrigeration

The gold mining industry has in the past few years undertaken a project to improve conditions for underground workers. The reasons for this decision are beyond the scope of this report, but one of the results of it is the increased amount of refrigeration being installed to improve the environment underground. This is well indicated in figure 5. The installed capacity of the refrigeration on the mines included in the survey doubled between 1970 and 1974. That is equivalent to an annual growth rate of 15 per cent. Even with this very rapid growth rate, by 1974, underground refrigeration only accounted for about 5% of the electricity requirements of the mines surveyed.

This increase is expected to continue for some time to come but unfortunately insufficient data was available to predict the peak requirements and by what date they would be reached.

8.6.2. Rockbreaking

The second area where developments may affect the demand for electricity is rockbreaking, and two developments in this field which deserve special mention are rock cutting machines and hydraulic rock-drills.

These concepts were both mentioned in an earlier section of the report.

While certain authors have been very enthusiastic about the introduction of new rock-breaking machinery, the mines themselves are a little more cautious.

Hydraulic rock drills have not yet passed the testing stage and while some of the mines expect the small scale introduction of these drills within the next two years, it is unlikely that they will be introduced in any great number before the early 1980's. (19)

The same comments apply to rockcutting which can be regarded as still being in the development stage.

Underground centrifugal milling could be introduced within the next ten years, but most mines were not prepared to state when they thought this practice would be employed. While hydraulic hoisting has been practiced to a limited extent in the past, (18) its large-scale introduction is tied very closely to the development of underground centrifugal milling and until this is introduced no further installations of this type can be expected.

8.7 The Forecast of Future Energy Requirements

An accurate forecast of the future energy requirements of the gold industry can only be made when the following data is available.

1) Total gold production
2) Expected specific energy requirements for gold production.

While it is possible to assume that the gold production will follow some Gaussian curve, it is very difficult to estimate future specific energy requirements for gold production.(21) If one simply considers the amount of ore treated, it is possible to make reasonable assumptions regarding the energy requirement, but it must be remembered the grade of the ore determines the gold production to a much larger extent than the ore processed. The South African gold mines have a fixed milling capacity and obviously they work as close to this fixed capacity as possible. Short of commissioning extra milling equipment the only way to increase production is to vary the ore grade. However the mines are not in a position to select the grades of ore that they can mine. They are compelled, by law, to mine ore at grades equal to the average grade of their reserves. These reserves are determined on an annual basis and depending on the grade of these reserves

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and the pay limit (the grade at which it becomes uneconomic to mine, which is determined by the price obtained for gold), the grades of ore to be mined are determined. In other words, as the price of gold rises, the pay-limit decreases the reserves increase and the average ore grade mined decreases. Since the average ore grade decreases and the milling capacity remains constant (until new mines can open up), the amount of gold produced decreases. This effect can be seen to have happened in the past few years.

The situation is such that it is impossible to predict future energy demands unless the tonnage of rock to be processed is known, but this tonnage cannot be determined unless a survey is carried out of the gold reserves in all South African gold mines and the grade of these reserves. Once the amounts of the various grades are known, it is possible to assume various future gold prices to arrive at the associated pay-limit. If the overall gold production (obtained from the Guassian curve) is coupled with the average grade mined it is possible to calculate the amount of ore that will have to be mined.

Knowledge of the tonnage which has to be mined enables the overall energy requirements to be estimated using specific energy requirements.

The collection of data relating to the grades of ore reserves in all South African gold mines would delay publication of this report and would in itself constitute a major study. No estimates of the future energy requirements of the gold industry have therefore been included in this report.

9. Discussion

A factor which has not been considered in the report is the future price of gold and the effect of such events as the IMF's decision to sell gold on the open market. One thing is certain though and that is if the price of gold were to drop significantly, it would affect the South African industry greatly. The wage increases for black workers that have been granted over the past years as well as the decision to improve the underground working conditions have added to the costs of operating gold mines and these factors together with the problem of inflation have resulted in many of the mines operating at relatively small profits.

Consequently any decision to either raise or lower the price of gold will have a direct effect on the energy demand for the industry as a whole.

Problems associated with the introduction of new processes and technologies have been discussed earlier and no further comments in this regard will be made here.

Another factor which cannot be ignored when considering future developments in the gold mining industry is increased mechanization. This has been brought about because of problems experienced with labour and in the hope of increasing productivity. The speed of the introduction of mechanised equipment will no doubt be related to the future price of gold and to the cost of labour. Any decrease in the former or increase in the latter would undoubtedly speed up the introduction of mechanization.

The demand for uranium could have an effect on future energy demands of the industry. The extraction of uranium is a relatively simple extension of existing gold extraction technology and since in some cases uranium rich ores are present in the gold-bearing ores, these are at present extracted by a number of mines.

As far as this report is concerned, the energy required for the extraction of uranium has not been considered. The problem arises here of aportioning the energy requirements of the industry to gold and uranium. As can be seen from Appendix H, less than 2% of the electricity used by the industry was used in the uranium plant, while an unknown quantity of steam was also required.

It was decided/.....

It was decided that uranium would be treated as a by-product of the industry at this stage but at some time in the future, as ore grades drop below payable values, mines could consider reprocessing slimes dams to extract uranium. This would of course depend on the ruling price of uranium at the time the decision would have to be taken. Thus it should be clear that this report details the energy requirements of the gold mining industry which happens to produce a quantity of uranium. The figures should not be quoted as representaive of the energy required to produce uranium.

10. ACKNOWLEDGEMENTS

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Mining Houses

1) The Anglo-American Corp. of S.A. Ltd.
2) The General Mining and Finance Corp Ltd.
3) Goldfields of S.A. Ltd.

Gold Mines

1) Barberton Mines Fairview
2) Buffelsfontein Gold Mining Co. Ltd.
3) Doornfontein Gold Mining Co. Ltd.
4) East Driefontein Gold Mining Co. Ltd.
5) Kloof Gold Mining Co. Ltd.
6) Libanon Gold Mining Co. Ltd.
7) President Brand Gold Mining Co. Ltd.
8) South African Land and Exploration Co. Ltd.
9) South Roodepoort Main Reef Areas
10) Stilfontein Gold Mining Co. Ltd.
11) Vaal Reefs Exploration & Mining Co. Ltd.
12) Venterspost Gold Mining Co. Ltd.
13) Vlakfontein Gold Mining Co. Ltd.
14) Welkom Gold Mining Co. Ltd.
15) West Driefontein Gold Mining Co. Ltd.
16) West Rand Consolidated Mines Ltd.
17) Western Deep Levels Ltd.
18) Western Reefs Ltd.

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FIG. 1 RELATIVE IMPORTANCE OF VARIOUS FUEL AND ENERGY INPUTS TO THE GOLD MINING INDUSTRY

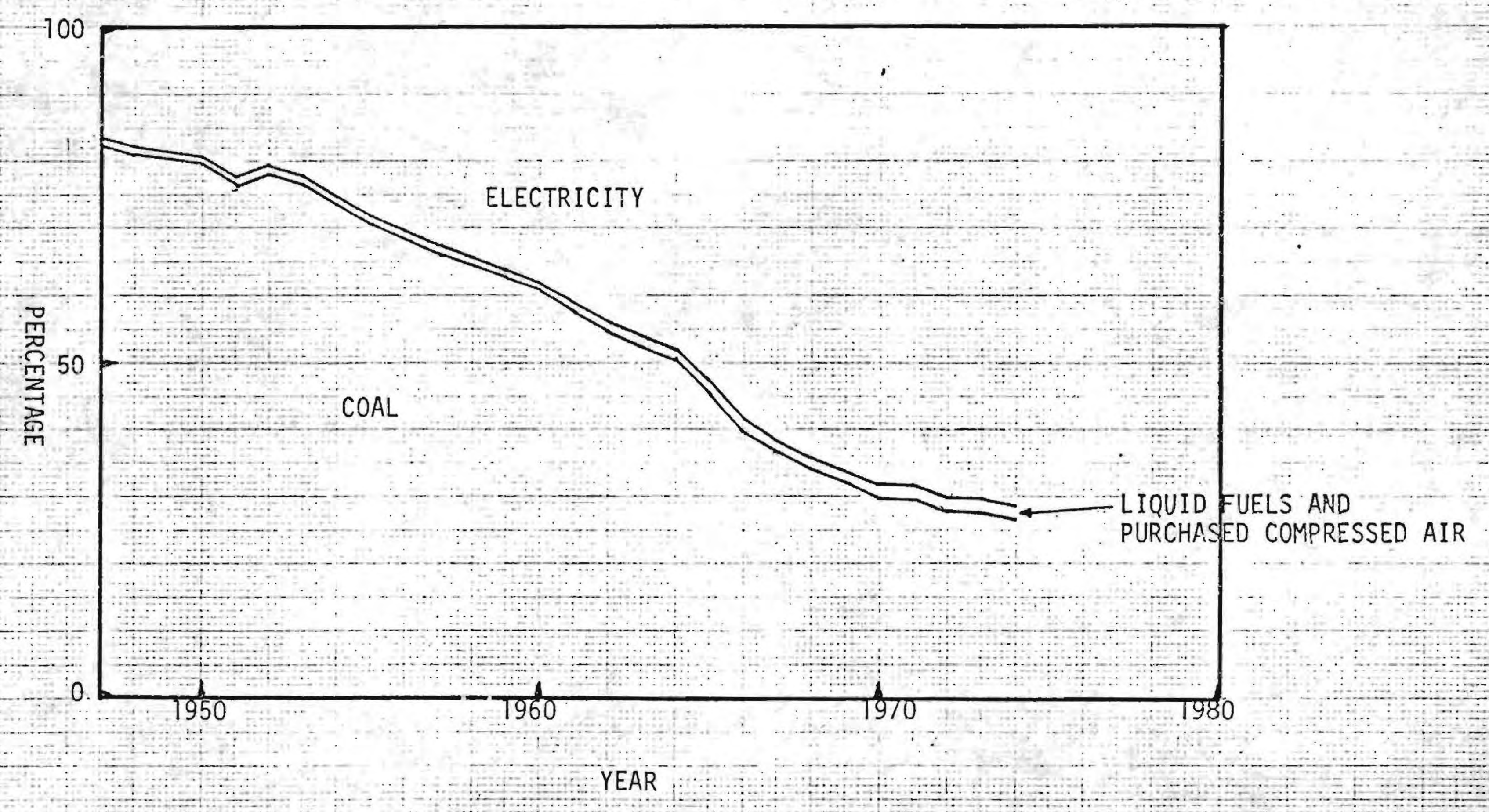


FIG. 2 - COMPARISON OF GROSS AND NET ENERGY REQUIREMENTS

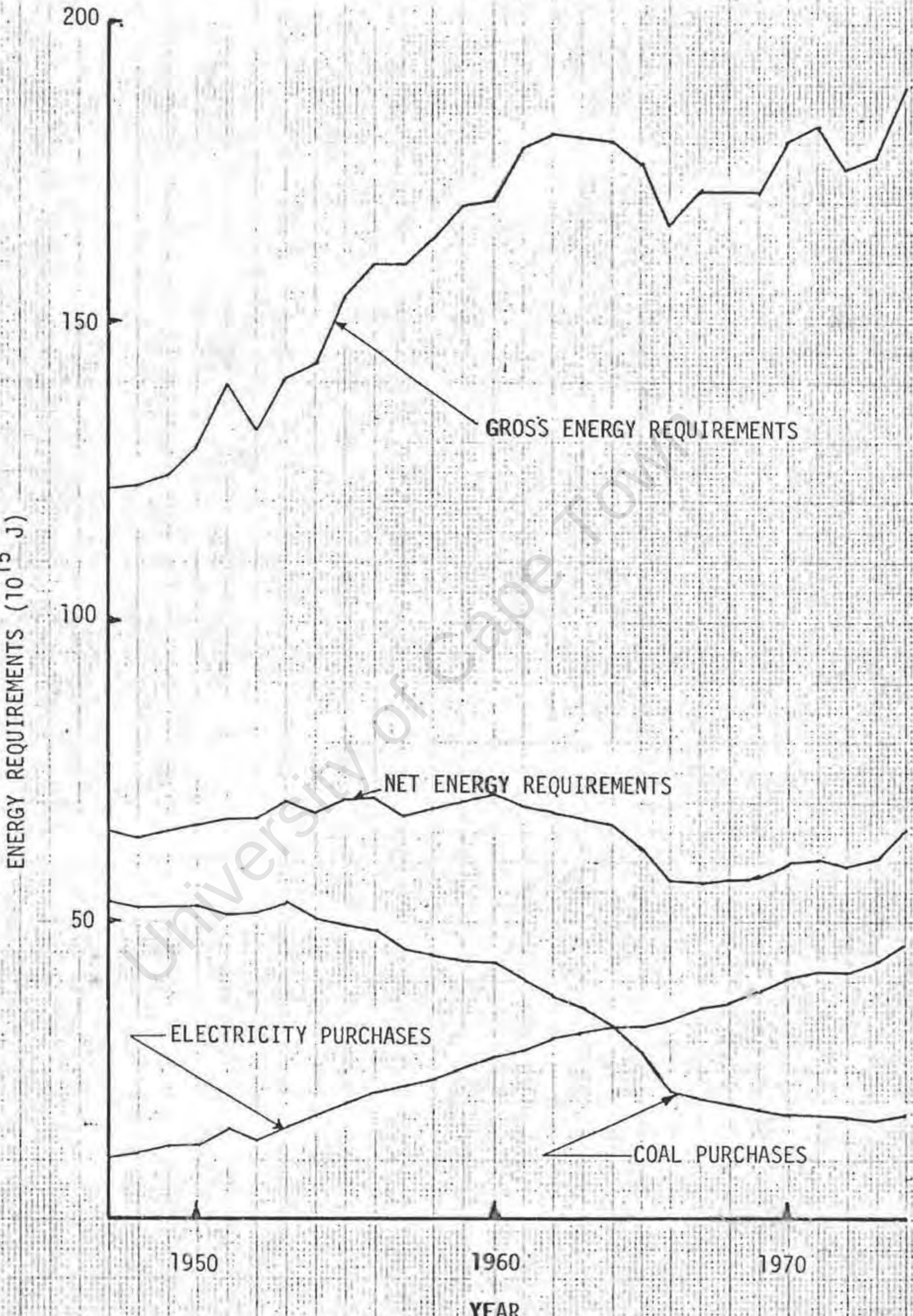


FIG. 3 SPECIFIC ENERGY REQUIREMENTS - ENERGY USAGE PER KILOGRAM OF ROCK MILLED

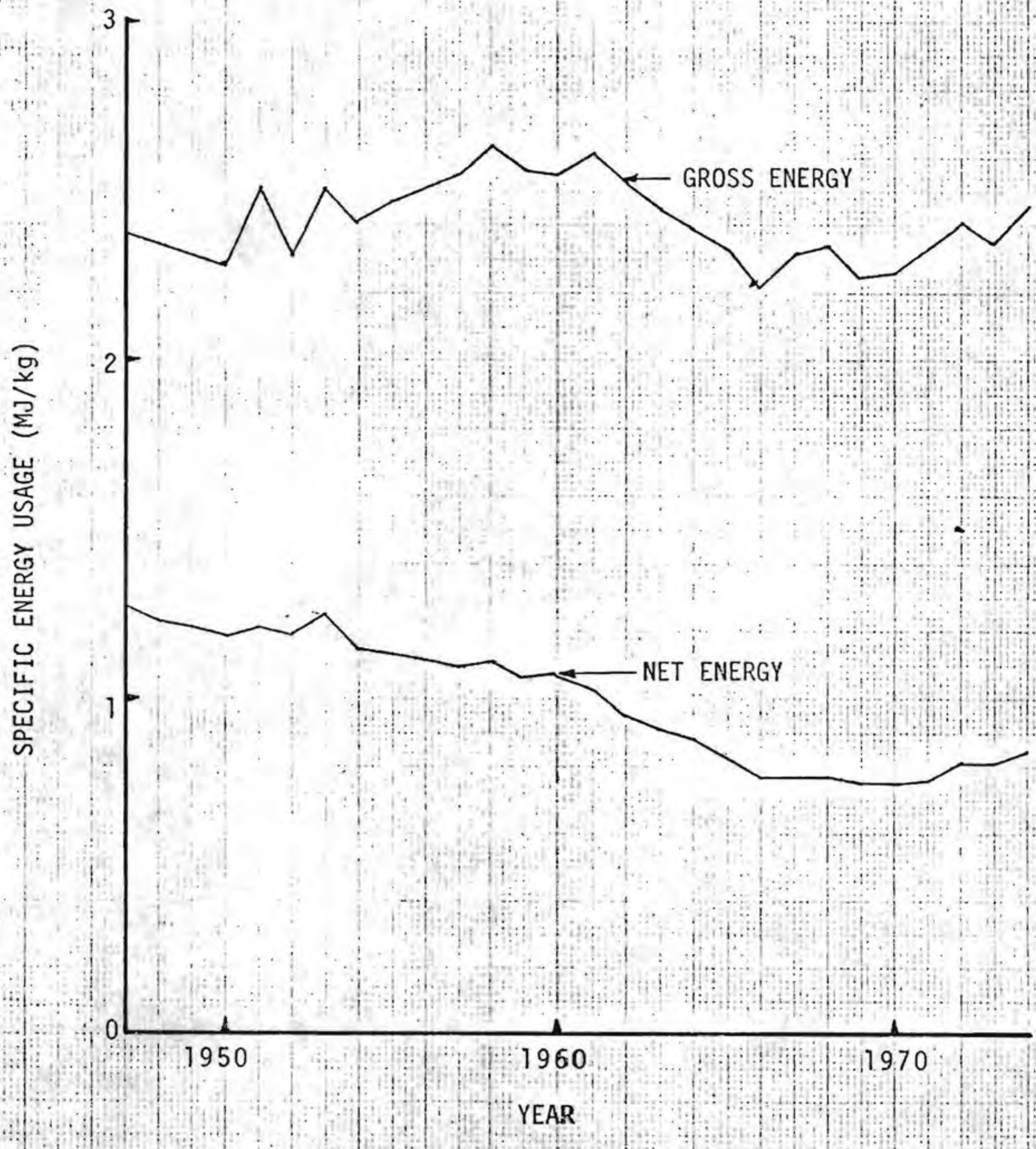


FIG. 4 - EXTRAPOLATION OF COAL REQUIREMENTS

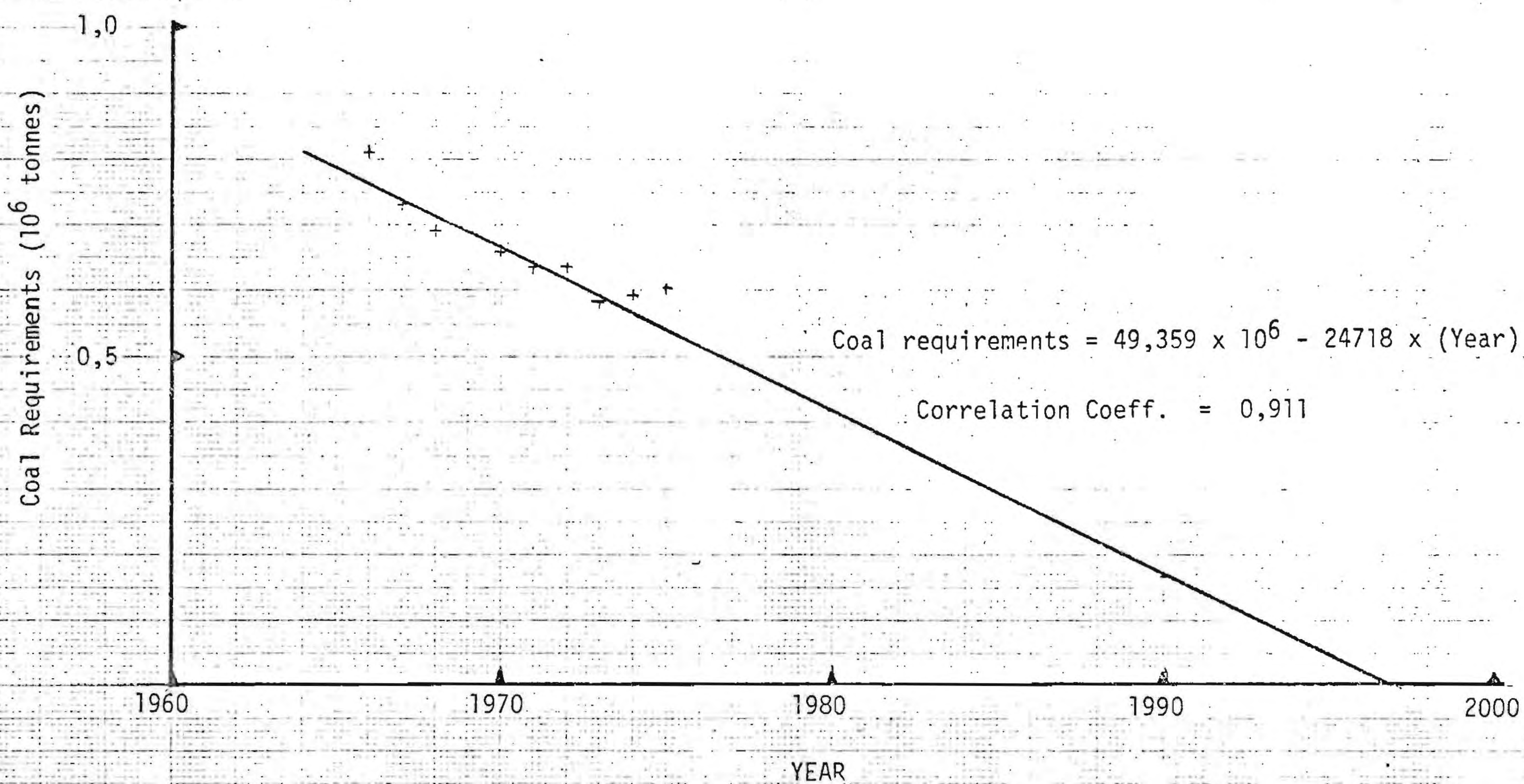
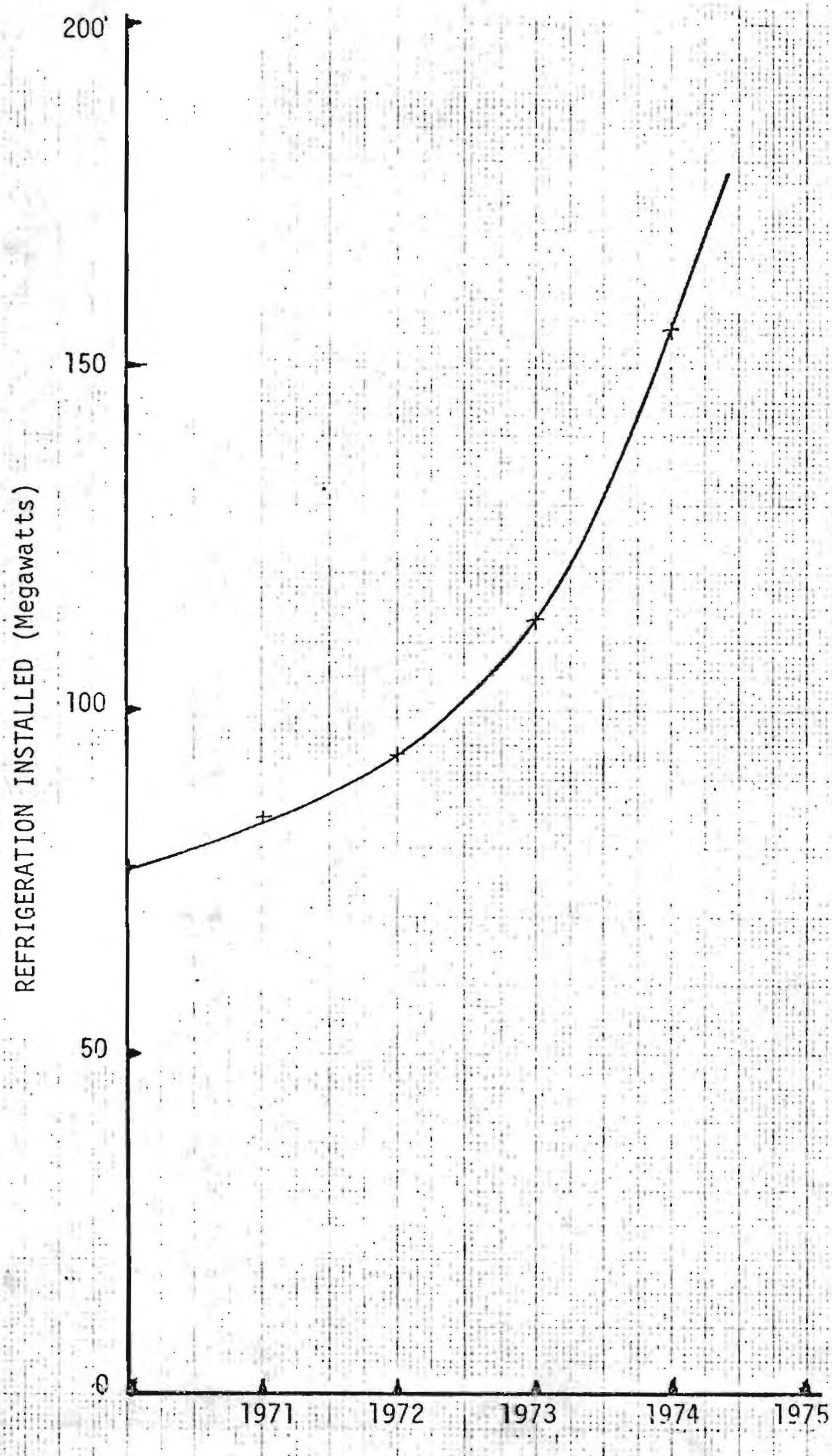


FIG 5. REFRIGERATION INSTALLED



APPENDIX A

GOLD PRODUCTION FIGURES 1947 - 1974
(Source: Chamber of Mines Annual Reports)

YEAR	GOLD PRODUCED BY CHAMBER MINES (kg)	TOTAL S.A. GOLD PRODUCTION (kg)	GOLD PRODUCED BY CHAMBER MINES (% OF TOTAL)
1947	332 826	348 368	95,54
1948	344 938	360 329	95,73
1949	348 789	364 068	95,80
1950	347 902	361 849	96,15
1951	342 731	358 202	95,68
1952	351 147	367 602	95,61
1953	355 850	371 395	95,81
1954	394 464	411 720	95,81
1955	438 362	454 154	96,52
1956	478 175	494 442	96,71
1957	514 477	529 715	97,12
1958	533 549	549 177	97,15
1959	610 566	624 107	97,83
1960	652 113	665 086	98,05
1961	699 972	713 562	98,10
1962	775 032	792 890	97,75
1963	837 028	853 229	98,10
1964	889 678	905 470	98,26
1965	936 284	950 332	98,52
1966	946 385	960 466	98,53
1967	932 192	949 679	98,16
1968	956 720	967 146	98,92
1969	960 941	972 956	98,75
1970	988 933	1 000 417	98,85
1971	964 851	976 297	98,83
1972	899 203	909 631	98,85
1973	844 215	855 179	98,72
1974	743 995	758 559	98,08

APPENDIX B/......

APPENDIX B - ENERGY CONTENT OF THE COMPRESSED AIR PURCHASED BY THE GOLD MINING INDUSTRY

Assuming two stage compression with the same pressure ratio in each stage and intercooling to intake temperature, the work done is given by the formula

$$W = P_1 V_1 \frac{2n}{n-1}\left[\left(\frac{P_2}{P_1}\right)^{\frac{n-1}{2n}} - 1\right]$$

where W is the work done in kNm/kg

V is the specific volume in kg/m³

n is the adiabatic coefficient of compression = 1,2

1 & 2 are subscripts referring to before and after compression respectively

If the above equation is multiplied by the mass flow rate, M_1 the resultant power requirement W in kW can be established.

$$W = P_1V_1M_1 \frac{2n}{n-1}\left[\left(\frac{P_2}{P_1}\right)^{\frac{n-1}{2n}} - 1\right]$$

But $V_1 \times M_1$ = volume flow rate C_1 at inlet conditions

$$\therefore \quad W = P_1C_1 \frac{2n}{n-1}\left[\left(\frac{P_2}{P_1}\right)^{\frac{n-1}{2n}} - 1\right]$$

For P_1 = 83 kPa (2000 m above sea level)

P_2 = 586 kPa

$$W = 83 \times C_1 \times \frac{2 \times 1,2}{0,2}\left[\left(\frac{586}{83}\right)^{\frac{0,2}{2,4}} - 1\right]$$

$$= 996\ C_1 \times \left[(7,06)^{0,083} - 1\right]$$

$$= 996C_1 \times 0,177$$

$$= 176,3\ C_1 kW$$

If C/.......

If C is replaced by the volume of free air compressed in any given time, the equation will yield the energy expended during that time.

e.g. In 1974 the gold mines purchased 86 698 887 m^3 of free air

Energy = 176,3 x 86 698 887 kJ

= 15 285 013 000 kJ

= $15,3 \times 10^6$ MJ

APPENDIX C

DIRECT ENERGY INPUTS 1947 - 1974

C - 1 PHYSICAL UNITS

a) SOLID FUEL, ELECTRICITY AND COMPRESSED AIR

YEAR	COAL (tonnes)	COKE (tonnes)	ELECTRICITY (10^6 kWh)	COMPRESSED AIR (10^6 m^3 free air)
1947	1 919 225	2 523	3002,3	3386,6
1948	1 879 812	2 468	3191,2	3325,6
1949	1 884 608	2 941	3378,3	3323,8
1950	1 898 298	2 897	3586,7	3354,4
1951	1 836 812	3 544	4291,8	3137,1
1952	1 898 802	3 486	3887,0	3066,7
1953	1 913 869	3 162	4395,2	2657,7
1954	1 796 802	3 175	4814,3	2624,1
1955	1 781 241	3 255	5503,7	2519,7
1956	1 741 709	3 260	5956,2	2116,3
1957	1 613 904	3 105	6227,7	1701,4
1958	1 594 519	3 156	6601,0	1648,9
1959	1 568 348	3 170	7089,5	1466,7
1960	1 542 993	3 257	7604,0	1293,5
1961	1 444 696	2 943	7927,5	1266,6
1962	1 334 403	3 007	8382,9	1161,0
1963	1 273 945	2 848	8623,8	1141,8
1964	1 203 881	2 778	8912,6	827,0
1965	1 014 701	2 354	9066,2	767,6
1966	816 026	2 094	9289,1	477,8
1967	737 080	2 280	9786,8	259,9
1968	692 498	2 354	10163,4	213,8
1969	661 745	2 326	10569,9	202,1
1970	638 803	2 253	11371,7	193,1
1971	635 898	1 944	11486,3	31,0
1972	585 382	1 771	11576,1	38,3
1973	598 465	2 339	11948,4	42,0
1974	609 243	2 326	12951,2	86,7

b)/........

b) LIQUID FUELS

YEAR	PETROL (Megalitres)	PARAFFIN (Megalitres)	DIESEL FUEL (Megalitres)
1947	1,795	1,018	2,589
1948	1,943	0,715	2,412
1949	2,801	0,383	2,890
1950	2,025	0,419	3,146
1951	3,630	0,442	3,579
1952	3,825	0,563	5,030
1953	3,969	0,545	7,119
1954	4,026	0,619	7,236
1955	4,035	0,853	9,360
1956	4,275	0,897	9,199
1957	4,102	0,976	10,055
1958	4,065	1,707	10,906
1959	4,371	1,609	12,181
1960	4,634	1,714	13,320
1961	4,613	2,281	14,651
1962	4,682	1,776	15,547
1963	4,530	1,668	16,428
1964	4,455	1,867	17,214
1965	4,502	1,643	17,465
1966	4,409	1,589	17,676
1967	4,712	1,615	18,034
1968	4,745	2,193	19,910
1969	5,060	2,953	20,366
1970	5,298	3,478	21,275
1971	5,336	3,434	23,268
1972	7,213	3,585	22,482
1973	6,173	4,047	25,915
1974	5,548	4,178	26,212

C-2 ENERGY UNITS (10^6 MJ)

(See Appendix B for energy content of compressed air and Appendix D for calorific values used)

a) SOLID FUEL, ELECTRICITY AND COMPRESSED AIR

YEAR	COAL (10^6 MJ)	COKE (10^6 MJ)	ELECTRICITY (10^6 MJ)	COMPRESSED AIR (10^6 MJ)	SUB-TOTAL (10^6 MJ)
1947	53 550	77	10 810	597	65 034
1948	52 450	76	11 490	586	64 602
1949	52 580	90	12 160	586	65 416
1950	52 960	89	12 910	591	66 550
1951	51 250	108	15 450	553	67 361
1952	52 980	107	13 990	540	67 617
1953	53 400	97	15 820	468	69 785
1954	50 130	97	17 330	463	68 020
1955	49 700	100	19 810	444	70 054
1956	48 590	100	21 440	373	70 503
1957	45 030	95	22 420	300	67 845
1958	44 490	97	23 760	291	68 638
1959	43 760	97	25 520	259	69 636
1960	43 049	100	27 374	228	70 751
1961	40 310	90	28 540	223	69 163
1962	37 230	92	30 180	205	67 707
1963	35 540	87	31 050	201	66 878
1964	33 590	85	32 090	146	65 911
1965	28 310	72	32 640	135	61 157
1966	22 770	64	33 440	84	56 358
1967	20 560	70	35 320	46	55 906
1968	19 320	72	36 590	38	56 020
1969	18 460	71	38 050	36	56 617
1970	17 820	69	40 940	34	58 863
1971	17 740	60	41 350	6	59 156
1972	16 330	54	41 670	7	58 061
1973	16 700	72	43 010	7	59 789
1974	17 000	71	46 620	15	63 706

b) LIQUID FUELS

YEAR	PETROL (10^6 MJ)	PARAFFIN (10^6 MJ)	DIESEL FUEL (10^6 MJ)	TOTALS	
				Liquid (10^6 MJ)	Overall (10^6 MJ)
1947	62	38	98	198	65 232
1948	67	26	92	185	64 787
1949	97	14	110	221	65 637
1950	70	16	120	206	66 756
1951	125	16	136	277	67 638
1952	132	21	191	344	67 961
1953	137	20	271	428	70 213
1954	139	23	275	437	68 457
1955	139	32	356	527	70 581
1956	147	33	350	530	71 033
1957	142	36	382	560	68 405
1958	140	63	414	617	69 255
1959	151	60	463	674	70 310
1960	160	63	506	675	71 426
1961	159	84	557	800	69 963
1962	162	66	591	819	68 526
1963	156	62	624	842	67 720
1964	154	69	654	877	66 788
1965	155	61	664	880	62 037
1966	152	59	672	883	57 241
1967	163	60	685	908	56 814
1968	164	81	757	1 002	57 022
1969	175	109	774	1 058	57 675
1970	183	129	808	1 120	59 983
1971	184	127	884	1 195	60 351
1972	249	133	854	1 236	59 297
1973	213	150	985	1 348	61 137
1974	191	155	996	1 342	65 048

C - 3 ENERGY INPUTS ON A PERCENTAGE BASIS

a) SOLID FUELS, ELECTRICITY AND COMPRESSED AIR

(Liquid fuels make up the balance)

YEAR	COAL (%)	COKE (%)	ELECTRICITY (%)	COMPRESSED AIR (%)	SUB-TOTAL (%)
1947	82,1	0,1	16,5	0,9	99,6
1948	81,0	0,1	17,7	0,9	99,7
1949	80,1	0,1	18,5	0,9	99,6
1950	79,3	0,1	19,3	0,9	99,6
1951	75,8	0,2	22,8	0,8	99,6
1952	78,0	0,2	20,6	0,8	99,6
1953	76,1	0,1	22,5	0,7	99,4
1954	73,2	0,1	25,3	0,7	99,3
1955	70,4	0,1	28,1	0,6	99,2
1956	68,4	0,1	30,2	0,5	99,2
1957	65,8	0,1	32,8	0,4	99,1
1958	64,2	0,1	34,3	0,4	99,0
1959	62,2	0,1	36,3	0,4	99,0
1960	60,3	0,1	38,3	0,3	99,0
1961	57,6	0,1	40,8	0,3	98,8
1962	54,3	0,1	44,0	0,3	98,7
1963	52,5	0,1	45,9	0,3	98,8
1964	50,3	0,1	48,0	0,2	98,6
1965	45,6	0,1	52,6	0,2	98,5
1966	39,8	0,1	58,4	0,1	98,4
1967	36,2	0,1	62,0	0,1	98,4
1968	33,9	0,1	64,2	0,1	98,3
1969	32,0	0,1	66,0	0,1	98,2
1970	29,7	0,1	68,3	0,1	98,2
1971	29,4	0,1	68,5	0,0	98,0
1972	27,5	0,1	70,3	0,0	97,9
1973	27,3	0,1	70,4	0,0	97,8
1974	26,1	0,1	71,7	0,0	97,9

APPENDIX D

CALORIFIC VALUES

COAL	-	27,9 MJ/kg
COKE	-	30,6 MJ/kg
PETROL	-	34,5 MJ/litre
PARAFFIN	-	37 MJ/litre
DIESEL	-	38 MJ/litre

APPENDIX E

GROSS ENERGY REQUIREMENTS OF THE GOLD MINING INDUSTRY

YEAR	ELECTRICITY (10^6 MJ)	GENERATION EFFICIENCY (%)	GROSS ELECTRICITY REQUIREMENTS (10^6 MJ)	OTHER ENERGY REQUIREMENTS (10^6 MJ)	TOTAL ENERGY REQUIREMENTS (10^6 MJ)
1947	10 810	16,0**	67 563	54 422	121 985
1948	11 490	16,5**	69 636	53 297	122 933
1949	12 160	17,06*	71 287	53 477	124 755
1950	12 910	17,17*	75 189	53 846	129 035
1951	15 450	17,62*	87 684	52 188	139 872
1952	13 990	17,90*	78 156	53 971	132 127
1953	15 820	18,35*	86 213	54 393	140 606
1954	17 330	18,81*	92 132	51 127	143 259
1955	19 810	19,12*	103 609	50 771	154 380
1956	21 440	19,43*	110 345	49 593	159 938
1957	22 420	19,72*	113 692	45 985	159 677
1958	23 760	19,98*	118 919	45 495	164 414
1959	25 520	20,46*	124 731	44 790	169 521
1960	27 374	21,57*	126 908	44 052	170 960
1961	28 540	20,72*	137 741	41 423	179 164
1962	30 180	21,01*	143 646	38 346	181 992
1963	31 050	21,51*	144 351	36 670	181 021
1964	32 090	22,06*	145 467	34 698	180 165
1965	32 640	22,25*	146 697	29 397	176 094
1966	33 440	23,45*	142 601	23 801	166 402
1967	35 230	23,36*	150 813	21 584	172 397
1968	36 590	24,02*	152 331	20 432	172 763
1969	38 050	24,97*	152 383	19 625	172 008
1970	40 940	25,28*	161 946	19 043	180 989
1971	41 350	25,10*	164 741	19 001	183 742
1972	41 670	26,25*	158 743	17 627	176 370
1973	43 010	26,74*	160 845	18 127	178 972
1974	46 620	27,33*	170 582	18 428	189 010

* Source : Escom Annual Reports ** Estimated

APPENDIX F

SPECIFIC ENERGY USAGE - ENERGY REQUIRED RELATED TO THE TONNAGE OF ROCK MILLED

YEAR	ROCK MILLED (10^3 tonnes)	NET ENERGY USAGE (10^6 MJ)	SPECIFIC NET ENERGY USAGE (MJ/kg)	GROSS ENERGY USAGE (10^6 MJ)	SPECIFIC GROSS ENERGY USAGE (MJ/kg)
1947	51 115	65 232	1,276	121 985	2,386
1948	.52 466	64 787	1,235	122 933	2,343
1949	53 906	65 637	1,218	124 755	2,314
1950	56 459	66 756	1,182	129 035	2,285
1951	55 890	67 638	1,210	139 872	2,503
1952	56 922	67 961	1,194	132 127	2,321
1953	55 639	70 213	1,256	140 606	2,514
1954	59 284	68 457	1,155	143 259	2,416
1955	62 366	70 581	1,132	154 380	2,475
1956	63 730	71 033	1,115	159 938	2,510
1957	62 550	68 405	1,094	159 677	2,553
1958	62 295	69 255	1,112	164 414	2,639
1959	66 190	70 310	1,062	169 521	2,561
1960	66 988	71 426	1,066	170 960	2,552
1961	68 549	69 963	1,020	179 164	2,614
1962	71 995	68 526	0,952	181 992	2,528
1963	74 087	67 720	0,914	181 021	2,443
1964	75 351	66 788	0,886	180 165	2,391
1965	75 396	62 037	0,823	176 094	2,336
1966	74 964	57 241	0,764	166 402	2,220
1967	74 038	56 814	0,767	172 397	2,328
1968	73 757	57 022	0,773	172 763	2,342
1969	76 280	57 675	0,756	172 008	2,255
1970	79 965	59 983	0,750	180 989	2,263
1971	78 659	60 351	0,767	183 742	2,336
1972	73 245	59 297	0,810	176 370	2,408
1973	76 018	61 137	0,804	178 972	2,354
1974	76 770	65 048	0,847	189 010	2,462

SURVEY OF ENERGY CONSUMPTION IN THE GOLD MINING INDUSTRY

(1) TOTAL ENERGY CONSUMPTION (ALL GOLD MINES IN THE COMPANY)

	1970	1971	1972	1973	1974
1) ELECTRICITY kWh x 10^{-6}					
2) COAL (tonnes)					
3) COKE (tonnes)					
4) FUEL OIL (kilolitres)					
5) PARAFFIN (kilolitres)					
6) PETROL (kilolitres)					
7) DIESEL (kilolitres)					

2) OTHER IMPORTANT GROUP FIGURES

	1970	1971	1972	1973	1974
1) ROCK BROKEN (Megatonnes)					
2) ROCK HOISTED (Megatonnes)					
3) ROCK MILLED (Megatonnes)					
ELECTRICITY SUPPLY					
PURCHASED FROM ESCOM (%)					
SELF GENERATED:					
(i) STEAM TURBINE (%)					
(ii) DIESEL GENERATOR (%)					
(iii) OTHER (%)					
ELECTRICITY EXPORTED (kwh x 10^{-6})					
GOLD PRODUCED (tonnes)					
URANIUM PRODUCED (tonnes)					
REFRIGERATION INSTALLED (tons)					

3) ELECTRICITY DEMAND 1974

ITEM	ELECTRICITY kwh x 10^{-6}	PLANT EFFICIENCY (if known)	DESCRIPTION OF PLANT
1) MAIN COMPRESSORS			
2) OTHER COMPRESSORS			
3) SURFACE HOISTS			
4) UNDERGROUND HOISTS			
5) MAIN FANS (Surface)			
6) MAIN FANS (Underground)			
7) ORE CONVEYER BELTS			
8) MILLING PLANT			
9) THICKENERS			
10) FLOTATION			
11) CYANIDE PLANT			
12) SMELTING PLANT			
13) URANIUM PLANT			
14) UNDERGROUND REFRIG.			
15) MAIN PUMPS (Total)			
16) DEWATERING			
17) SLUDGE PUMPS			
18) SURFACE (Other)			
19) UNDERGROUND LIGHTING			
20) COMPOUND			
21) HOUSING			

(4) COMPRESSED AIR

	1970	1971	1972	1973	1974
SUPPLY:					
TOTAL CONSUMPTION ($m^3 \times 10^{-6}$ free air)					
PERCENTAGE PURCHASED (%)					
MAIN COMPRESSORS ($m^3 \times 10^{-6}$ free air) (for u/g usage)					
DEMAND:					
ROCK BREAKING (%)					
FLOTATION (%)					
CYANIDE PROCESS (%)					
OTHER (Please Specify)					
1) ------------------					
2) ------------------					

(5) COAL AND COKE

1) What percentage of coal and coke is burned in:

	COAL	COKE
1) Small Industrial boilers		
2) Stoves for cooking		
3) Stoves for space heating		
4) Open grates and braziers		
5) Other (please specify)		
(i) ------------------------		
(ii)------------------------		

2) What is the steam generated from the coal fired boilers used for? --

----

----

(6) FUEL OIL

1) What percentage of the fuel oil is:

(i) burned in small industrial boilers;	
(ii) used for other purposes (please specify) a) -- b) --	

2) What is the steam generated from the oil-fired boilers used for?

----

(7) PARAFFIN

1) What percentage of the paraffin is:

(i) used for transport purposes (ii) used for other purposes (please specify a) ---------------------------------- b) ----------------------------------	

(8) PETROL

1) What percentage of petrol is used:

(i) for transport purposes other than directly related to gold production (e.g. company cars etc.) (ii) for other purposes (please specify) a) ---------------------------------- b) ----------------------------------	

FUTURE ENERGY DEMAND TRENDS

With regard to the following fuels, have there been any significant changes in demand over the past five years and are any measures being considered to convert to other fuels sort?

(i) Coal --

----

(2) Coke --

----

(3) Fuel Oil --

----

(4) Paraffin --

----

(5) Petrol --

----

(9) LIST OF MINES INCLUDED IN THE SURVEY

1) --
2) --
3) --
4) --
5) --
6) --
7) --
8) --
9) --
10) --
11) --
12) --
13) --
14) --
15) --
16) --
17) --
18) --
19) --
20) --

10) When do you think the following processes will reach a stage where they are likely to be installed in (a) existing gold mines and (b) new gold mines on a large scale.

1) Rockbreaking

(a) Rock cutters (a) ____________(b) __________

(b) Hydraulic rock-drills (a) ____________ (b) __________

(c) ________________________ (a) ____________(b) __________

2) Milling

(a) Centrifugal milling on surface (a)____________ (b)___________

(b) U/g milling (a)____________ (b)___________

(c) _________________________ (a)____________ (b)___________

3) Hoisting

(a) Hydraulic hoisting (a)____________ (b)____________

(b) ____________________________ (a)____________ (b)____________

11) Please describe any other changes which you feel are likely to change the trends in energy consumption in future e.g. increased mechanization, etc.

APPENDIX H

ELECTRICITY USAGE IN EIGHTEEN GOLD MINES

ITEM OF PLANT	ELECTRICITY 10^6 kWh	PORTION OF TOT. (%)	CONVERSION* EFFICIENCY	USEFUL ENERGY 10^6kWh	PORTION OF TOT. (%)
MAIN COMPRESSORS	1382,1	21,0	71	981,3	24,4
OTHER COMPRESSORS	88,5	1,3	71	62,8	1,6
SURFACE HOISTS	523,4	8,0	80	418,7	10,4
UNDERGROUND HOISTS	259,5	3,9	80	207,6	5,2
MAIN FANS (SURFACE)	838,0	12,7	75	628,5	15,6
MAIN FANS (U/G)	273,2	4,2	75	204,9	5,1
REDUCTION WORKS	938,5	14,2	20	187,7	4,7
URANIUM PLANT	131,1	2,0	50	65,6	1,6
U/G REFRIGERATION	316,5	4,8	50	158,3	3,9
MAIN & SLUDGE PUMPS	692,1	10,5	60	415,3	10,4
HOUSING, COMPOUNDS	179,7	2,7	65	116,8	2,9
DEWATERING	442,2	6,7	70	309,5	7,7
OTHER	523,9	8,0	50	262,0	6,5
TOTAL	6 588,7	100	61	4 019,0	100
SUMMARY					
COMPRESSORS	1 470,6	22,3	71	1 044,1	26,0
HOISTS	782,9	11,9	80	626,3	15,6
FANS/REFRIG	1 427,7	21,7	69	991,7	24,7
REDUCTION WORKS	1 069,6	16,2	24	253,3	6,3
PUMPS	1 134,3	17,2	64	724,8	18,0
OTHER	703,6	10,7	54	378,8	9,4

* See Chapter 6 for the derivation of these efficiencies.

APPENDIX I - COMPRESSED AIR USAGE

Compressed Air requirements of eleven gold mines

	1970	1971	1972	1973	1974
Total requirements (10^6 m^3 free air)	5616	6237	7093	7967	8321
Rock-breaking requirements (10^6 m^3 free air)	4843	5389	6123	6873	7146
Rock broken (10^6 tonnes)	29,4	30,0	30,0	32,1	31,6
Specific air usage (m^3/tonne)	164,6	179,6	204,1	214,1	226,1
Percentage increase on previous year (%)	-	8,7	13,6	4,9	5,6

APPENDIX J - COAL AND COKE USAGE

1) Breakdown of Coal Usage in sixteen Gold Mines - 1974

	COAL USAGE	
	TONNES	PERCENTAGE
Small Industrial Boilers	152 421	68,4
Stoves for cooking	21 465	9,6
Stoves for space heating	38 511	17,3
Open grates and braziers	9 937	4,5
Gold smelting	404	0,2
Totals	222 738	100,0

2) Breakdown of Coke Usage in seventeen Gold Mines - 1974

	COKE USAGE	
	TONNES	PERCENTAGE
Blacksmith/boiler maker shops	608	82,9
Open Grates/Braziers	100	13,6
Boilers	25	3,5
Totals	733	100,0

3) Efficiency of conversion of coal

	INPUT ENERGY 10^6 MJ	CONVERSION EFF. (%)	USEFUL ENERGY 10^6 MJ
Small industrial boilers	4 252,5	70	2 976,8
Stoves for cooking	598,9	50	299,5
Stoves for space heating	1 074,5	30	322,4
Open grates and braziers	277,2	10	27,7
Gold smelting	11,3	50	5,7
Totals	6 214,4	58	3 632,1

APPENDIX K - OVERALL EFFICIENCY OF ENERGY CONVERSION - 1974

a) Net energy usage

ENERGY SOURCE	INPUT ENERGY (10^6 MJ)	CONVERSION EFFICIENCY (%)	USEFUL ENERGY (10^6 MJ)
Electricity	46 620	61	28 438
Coal	17 000	58	9 860
Total	63 620	60	38 298

b) Gross energy usage

ENERGY SOURCE	INPUT ENERGY (10^6 MJ)	CONVERSION EFFICIENCY (%)	USEFUL ENERGY (10^6 MJ)
Electricity	170 580	17	28 438
Coal	17 000	58	9 860
Total	187 580	20	38 298

Appendix 4/......

Appendix 4/.......

APPENDIX 4

THE ENERGY REQUIREMENTS OF THE PROCESSED FOOD INDUSTRY

(Formerly issued as Report ESI/8)

SUMMARY

This report deals with the utilization of energy within the processed food and beverage industry. The following sectors are dealt with individually:

1) Bakeries
2) Sugar milling and refining
3) Grain mills
4) Fish products
5) Fruit and vegetable preserving
6) Distillers and wineries
7) Aerated mineral waters
8) Cocoa, chocolate and sugar confectionery
9) Breweries and malt-works

This approach has been adopted since the various sectors have different energy usage patterns as well as varying energy conversion efficiencies. The above list is arranged in descending order of importance with regard to the amount of energy purchased by the sectors; these nine sectors accounting for some 75% of the energy purchases of the processed food and beverage sector.

A summary of the importance of the various fuels in each sector as well as conversion efficiencies is included as Appendix K.

It was found that in most cases small reductions in specific energy requirements can be expected in the future due to increased energy conservation measures. Besides the sugar industry, where a diffusion process is being introduced to replace the conventional sugar milling techniques, no other major changes within the industry are to be expected.

Due to the great degree of fragmentation within the industry, an important development could possibly benefit only a few of the sectors and thus have very little effect on the overall energy demands of the industry.

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INTRODUCTION

The processed food industry produces a large range of products manufactured from different raw materials and using various processing techniques. Consequently the energy requirements of the industry as a whole depend to a large extent on the sector's make-up i.e. the size of various energy intensive subsectors such as bakeries, sugar mills and flour mills, in relation to the size of the sector.

To obtain a picture of the overall energy requirements of the industry, it is therefore necessary to establish which sectors are energy intensvie and to pay closer attention to these sectors.

A recent Industrial Census (1) was used to establish the cost of energy to the various sectors of the food industry. These results are included below in table 1. The cost of energy is expressed as a percentage of the total cost of energy to the South African manufacturing industry, as well as in terms of Rands spent during 1968:

TABLE 1 : THE COST OF ENERGY TO THE FOOD PROCESSING INDUSTRY

SECTOR	TOTAL COST (10^3 R)	TOTAL COST (%)
Bakeries	2 977	2,5
Sugar Mills	2 052	1,7
Grain Mills	2 018	1,7
Fish Products	1 525	1,3
Jam and canning	1 233	1,0
Distilleries/wineries	924	0,8
Aerated waters	803	0,7
Sweets and chocolates	679	0,6
Breweries and Maltworks	650	0,5
Other	4 385	3,6
TOTALS	17 246	14,4

It should be noted that beverages have been included under the processed food industry, which therefore includes all sectors having Standard Industrial Classification Codes(2) between 31 100 and 31 399.

The above/......

The above table only serves as an indicator to the sectors where energy could be used in significant quantities. The cost as stated in the Manufactruing Census includes fuel, light, power, steam and gas purchases, but does not give a direct estimate of the physical quantity of energy used. For example one sector which relies on an expensive energy source could have a higher energy bill than another sector using more energy in terms of megajoules but using a less expensive fuel.

It was therefore necessary to contact the various sectors individually to obtain further data relating to energy purchases and utilization. These results are included in later chapters of this report. While the indivudual sectors were asked to supply information for five different years (1965, 1970, 1973, 1974 and 1975) in some cases data for the earlier years was not available.

All the information that was made available has been included in this report and this explains the fact that in some cases the data stretches back over a longer period than in others.

2) EFFICIENCY OF ENERGY CONVERSION

Since the efficiency of energy conversion is to be calculated for a number of different sectors, it is necessary to ensure that similar efficiencies for the various conversion processes are applied to each industry.

A list of all the conversion efficiencies used in this report is included as Appendix A.

It will be seen that an efficiency of 60% has been assumed for the conversion of energy for direct process heating while 70% has been used for boilers. It was decided to adopt these values after consideration of the applications where direct process heating is used. In a number of cases, the heat is lost to the system (such as bakers' ovens) and the process is not as efficient as the conversion of energy within a steam boiler.
It must be remembered though that there is an efficiency associated with the transfer of the heat in the steam to the product (the efficiency of utilization), and when this efficiency is considered, the use of direct

process/......

process heat will be found in most cases to be more efficient. This report is restricted to the efficiency of energy conversion as opposed to energy utilization and the latter is therefore not considered.

Also listed in Appendix A are the calorific values and conversion factors to relate the indivudual energy sources to common energy units.

Using this data, the large energy using sectors of the processed food industry have been studied and the findings summarized.

3. BAKERIES (SIC 31170)

The fifty largest bakeries in the country were selected from a list obtained from the Bureau of Market Research at Unisa. A questionnaire was formulated and distributed. Four replies were obtained. A follow-up letter resulted in apologies from approximately 20 of the companies, who gave lack of time and manpower as the main reasons for not submitting questionnaires. Subsequently seven further questionnaires were received from smaller baking establishments, resulting in a total sample of eleven. These eleven establishments processed approximately 56 000 tonnes of wheaten products during 1975.

According to the Wheat Board (3) a total of 841 181 tonnes of wheaten products were used in the manufacture of bread, confectionery and other related products in the Republic during the 1974 - 75 season. (The "season" is more accurately defined as the financial year of the Wheat Board from 1st October to 30th September). The eleven companies surveyed therefore represent approximately 7% of the output of the baking industry. It should be mentioned that these eleven bakeries represent only 0,42% of the total of 2 617 registered establishments, and that 77,8% of the registered establishments is made up by producers who individually process less than 25 tonnes of wheat per annum. In other words the industry is made up of a few very large producers and a majority of small concerns. It should also be mentioned that the Wheat Board exercises strict control over the industry, all establishments requiring to be registered with the Board. Since the baking industry is controlled in so much as its profit margin is fixed, the price of bread is controlled by the Government and a Government subsidy is paid on flour and meal to keep down the price of

bread/......

bread. The future development of the industry is thus largely in the hands of the Wheat Board and the Department of Agriculture.

3.1 Energy Inputs

The fuel and energy cost expressed as a percentage of the total cost of production is on the average 5% for the baking industry.

The energy inputs broken down into the various fuels and expressed in original units, common energy units and as percentages are included as Appendix B.

The electricity requirements of the industry are fairly low (only about 15% of the overall requirements) but this is to be expected since most of the energy requirements for heating are supplied by other fuels such as coal (to generate steam) and diesel fuel for direct process heating. Over the three year period considered no significant changes occurred with respect to the percentage mix of the fuels purchased.

In one section of the questionnaire the industry was asked to state its production in terms of tonnes of wheaten products purchased. It is interesting to compare the production with the energy requirements to obtain a specific energy requirement. This has been done in Appendix B part(iv) and the results are summarized below in Table 2.

TABLE 2 : SPECIFIC ENERGY REQUIREMENTS OF THE BAKING INDUSTRY

	1973	1974	1975
Specific energy requirements (MJ/kg)	5,6	5,3	5,3

It will be seen that the specific energy requirements have not changed much in the past three years. From discussions held with representatives of the industry, this is to be expected since there have been no developments within the industry over this period that are likely to have resulted in any change.

Relating/......

Relating the 1975 specific energy requirement to the raw material requirements indicate that the energy requirements of the baking industry were 4 460 x 10^{12}J during 1975.

3.2 Energy Utilization

Details of the utilization of energy and the efficiency of energy conversion within the baking industry are included as Appendix B. The efficiencies were derived by consideration of the values listed in Appendix A and for ease of reference Appendix C has been divided into sections dealing with energy conversion to heat, mechanical energy and light.

The important findings are summarized below:

TABLE 3 : EFFICIENCY OF ENERGY CONVERSION - BAKING INDUSTRY

	Efficiency of energy conversion	Percentage of total input converted
To heat	65,2%	78,4%
To mech. energy	60,7%	20,5%
To light	9,9%	1,1%
Overall	63,7%	100,0%

3.3 Energy Conversions

Of the eleven baking concerns included in the survey, two stated that they were considering converting from coal to light diesel while one was considering conversion from LPG to light diesel for oven firing. The reasons given were modernization and pollution abatement. The trend away from coal in the baking industry can be expected to continue for some time into the future, since diesel fuel allows easier mechanization and greater ease of control of oven temperatures.

3.4 Energy/......

3.4 Energy Conservation

It is evident from the replies received that energy conservation is of importance to the baking industry. Over 50% of the respondents stated that they had undertaken energy saving campaigns during the past five years. The conversion from coal-fired ovens to the more efficient diesel-fired models is one area where this has been evident.

However, although some concern has been shown with regard to rising energy costs, in most cases the concern has not been great enough to have energy usage monitored and as a result only two of the respondents could state what energy savings had been achieved in the past five years. One company that changed from coal-fired to diesel-fired ovens reported a 40% improvement in their specific energy usage while the other stated a 10% improvement. In both cases the modernization of plant can be seen to be the cause of the improvement.

The majority of companies responding to the survey stated that they are planning to introduce energy conservation measures within the next five years. These measures are likely to reduce specific energy requirements by between 5% and 10% and will be brought about mainly by closer control on heat losses and better control of the baking cycle.

3.5 Future Energy Requirements in the Baking Industry

When considering the future energy requirements of the baking industry it is interesting to consider the trends regarding the various types of ovens in use. They are:

3.5.1) Dutch, scotch, side-flue and hot-air ovens

This is the old-type oven and in bakeries equipped with this type of oven the dough is often prepared by hand and there is little mechanization, if any at all.

3.5.2) Static ovens - peel and draw-plate ovens

These are in use in a large number of South African bakeries, only recently having been superseded in larger urban bakeries by travelling ovens.

Although a certain amount of mechanization is usually used in bakeries equipped with static ovens, a large amount of the work associated with the preparation of the dough is done manually.

3.5.3) Travelling ovens - tunnel ovens, reel ovens and swingtray ovens
Although the capital outlay for an installation of this type is large, the amount of manual labour required is small, since the oven is installed together with automatic dough preparation equipment.

The swing towards travelling ovens can be demonstrated by a comparison between the installed capacity of these ovens (expressed as a percentage of the total installed capacity) in bread bakeries in the years 1951/52 and 1974/75 for various centres as shown in Table 4a

TABLE 4(a): PERCENTAGE OF INSTALLED OVEN CAPACITY MADE UP BY TRAVELLING OVENS

CENTRE	TRAVELLING OVEN CAPACITY (% of total capacity)	
	1951/52	1974/75
WITWATERSRAND	11,9%	87,0%
CAPE TOWN	43,5%	86,2%
DURBAN	54,5%	94,1%
PRETORIA	0,0%	90,6%
BLOEMFONTEIN	0,0%	92,0%
PORT ELIZABETH	27,5%	81,7%
EAST LONDON	0,0%	76,3%
THE VAAL TRIANGLE	0,0%	89,6%

Reference : 3

It is evident from the above table that in the last twenty years a major shift has occurred from static to travelling ovens and that within the forseeable future effectively all bread will be baked in the more modern travelling oven.

However/.......

However, considering future reductions in specific energy, no significant changes in overall energy requirements can be expected. Since most of the oven capacity is already made up of efficient units, no large saving can be expected in the future from further conversions.

A factor which would result in an increased energy saving is the improved utilization of ovens. The utilization is defined as the amount of bread baked expressed as a percentage of a value calculated as the maximum production figure considering such parameters as oven capacity and working hours.

If the utilization of ovens could be improved, this would result in an overall energy saving due to lower specific energy losses due to radiation. As a comparison, the utilization of bread ovens is compared in Table 4(b) for the years 1951/52 and 1974/75 for the same centres detailed in Table 4(a)

TABLE 4(b) : UTILIZATION OF BREAD OVENS

CENTRE	UTILIZATION OF BREAD OVENS	
	1951/52	1974/75
WITWATERSRAND	41,2%	43,0%
CAPE TOWN	39,5%	38,8%
DURBAN	45,6%	54,8%
PRETORIA	41,9%	49,7%
BLOEMFONTEIN	57,1%	46,6%
PORT ELIZABETH	55,7%	35,5%
EAST LONDON	48,8%	51,8%
THE VAAL TRIANGLE	64,6%	31,2%

The utilization is defined as the percentage of installed capacity that was required to produce the final products and it can be seen that in most cases this has improved only marginally. (The exception to this is the Vaal triangle, where the utilization has dropped from nearly 65% to 31%. This would seem to run contrary to the Wheat Board's stated policy of preventing "excessive and

wasteful/......

wasteful competition".

One might have expected that the switch to efficient travelling ovens and the consequent lower labour costs would have encouraged bakers to increase the utilization of their ovens, but this does not seem to have been the case to any marked degree. This could once again be the result of the industry being closely controlled. An improved utilization means a higher production, but the Wheat Board may feel that this would allow one company to control too big a share of the market and could provide registration for a further manufacturer thus resulting in a decline in the utilization.

3.6 Summary

It is extremely difficult to forecast the future energy requirements of a controlled industry beyond extrapolating historical data. The introduction of new processes and techniques could be affected by decisions made by the controlling bodies and the control of profits by these bodies would not encourage high risk ventures.

To this though should be added the fact that there do not seem to be any revolutionary processes on the horizon that are likely to have any marked effect on the specific energy requirements of the baking industry.

Existing static ovens are likely to be replaced by travelling ovens in larger bakeries, but there will always be a small percentage of smaller, less efficient ovens. It was mentioned earlier in the report that a large proportion of the industry is made up of small producers and these producers will not be able to change to larger units because of their small volume of production.

Fuel savings can be expected in the future but these are not expected to exceed 10% of present requirements within the next ten years.

No large scale conversion from one fuel type to another is expected.

4. Sugar milling and refining/.....

4. SUGAR MILLING AND REFINING

While the sugar milling industry consumes a large amount of energy it is in the fortunate position that it generates much of its own fuel requirements in the form of bagasse, the fibrous material remaining after the juices have been extracted from sugar cane.

The bagasse is burned to generate steam which is used both as direct process heat and as an energy source for steam turbines. The turbines are used to generate electricity and to drive some milling equipment directly.

Small amounts of fuel and electricity are purchased for operation of essential plant during shut-downs, but this practice is not encouraged within the industry and wherever possible these purchases are kept to a minimum.

Data relating to the energy requirements of sugar mills is readily available from the annual publication "The South African Sugar Year Book".(4) Unfortunately no data is included for Hullets Refinery, the largest single refinery in South Africa. However the energy requirements for this plant have been estimated by dividing the S.A. mills into two types: one producing raw sugar and the other producing refined products. By comparing the energy requirements of these two types, it is possible to estimate the energy requirements of refining alone.

The picture is further complicated by the fact that certain mills provide electric power for purposes other than sugar treatment (such as irrigation schemes) while in other cases a proportion of the bagasse produced by the mills is converted to particle board or other by-products and is thus not utilized as an energy source. It is therefore necessary to take these factors into account when considering the energy requirements of the industry so that an accurate result can be obtained.

4.1/......

4.1 The Manufacture of Sugar from Cane

Sugar cane is cultivated in South Africa in a 16km - 32km wide coastal strip in Natal, stretching over a length of about 450 km. It is also grown around Mid-Illovo, Wartburg, Greytown, Muden and Melmoth as well as in irrigated areas of the Pongola, in the south-eastern Transvaal and around Malelane in the eastern Transvaal.

The cane is received at the mills after being transported from the farms. A general breakdown of the transport forms used for cane during the 1974-75 season is given below in Table 5.

TABLE 5 : CANE TRANSPORTATION METHOD DURING THE 1974-75 SEASON (4)

TRANSPORTATION MODE	PERCENTAGE TRANSPORTED
Hilo (20-25 tonne truck designed for cane transport)	48,0%
Tram	13,9%
South African Railways	12,6%
Tractor	11,9%
Lorry	9,8%
Trailer	2,8%
Bogey trucks (narrow gauge)	0,7%
	TOTAL 99,7%

There has been a marked shift towards road transport in the past few years. Nine years ago, the South African Railways transported 30% of the cane while trams contributed a further 26%. Today their combined contribution is 26,5%. This has partly been due to the tariff increases imposed by South African Railway and partly by discontent with the inadequacy of the rail service on the part of sugar farmers and millers(5).

There is a possibility that the introduction of mechanized cane cutting could change the transport picture dramatically. In 1974 less than 1% of the cane was being cut mechanically (6) but it has been estimated that between 65% and 80% of South Africa's cane could be harvested using mechanized means. High capital costs of mechanized equipment and resistance to change are expected to slow down the introduction of the harvesting method and large scale changes can only be expected in the relatively long term.

The sucrose content of cane decreases with storage (by up to 3% per day) and consequently the cane must be processed as soon as possible after cutting.

After weighing, the sugar cane is cut into short lengths under a series of rapidly rotating knives. The juice is extracted using one of two processes. The older method is to crush the cane by passing it between hydraulic rollers (often driven by steam turbines). After passing through a series of rollers, the remaining bagasse (plus about 4% of unextracted sugar and a moisture content of about 50%)is conveyed to boilers for burning or to storage for use in the manufacture of by-products.

The newer method of extracting sugar from cane is by diffusion. (7) This process consists of washing the sugar out of the cane rather than squeezing it out. The process was developed at Huletts and after an initial teething period has been adopted in a number of other South African mills. (Seven other mills had installed diffusers by 1974). At first glance it would seem that the energy requirements of the diffusion process are lower than those of conventional mills since the need for steam-driven mills is by-passed. However, from discussions held with representatives of the industry, it would seem that due to the nature of the process this is somewhat counteracted by an increased demand for electricity, and any energy saving would be small. However initial capital and maintenance costs are expected to be much lower and this is where the great advantage of this process lies.

The extracted juice is mixed with lime to precipitate dirt and mud. The mud, after being treated to recover its sugar content, is used as a fertilizer on the cane fields. The clarified juice is passed through a series of evaporators to reduce the moisture content under vacuum. The resultant syrup contains about 65% of sugar. The steam requirements of the evaporators are supplied by the bagasse-fired boilers.

The syrup is boiled in a vacuum pan until crystals are produced. Further crystallization occurs during cooling of the mixture of syrup and already-formed raw sugar (massecuite). The massecuite is centrifuged to separate the raw sugar from the remaining syrup (molasses).

The raw sugar is washed and dried ready for packaging as brown sugar or for shipment to the refinery.

In the refinery, the raw sugar is mixed with a sugar solution to remove adhering molasses. The crystals are then centrifuged to remove surplus syrup and dissolved in hot water. Lime is added and carbon dioxide bubbled through the liquor to purify it. The liquor is further purified by passing it through a filter and decolourized by passing it through bone char.

The liquor is boiled in a vacuum pan until crystallization occurs. When the crystals reach the required size, the adhering syrup is removed in a centrifugal filter.

After washing,the white refined sugar is dried, graded and packed. Golden syrup and treacle are manufactured from the syrup centrifuged from the refined sugar crystals.

It can be seen that the manufacture of sugar requires a large amount of energy both in the form of heat and mechanical energy for the driving of plant. Fortunately, the bagasse can be used as a fuel for the boilers and in this way the fuel bill can be greatly reduced. However in cases where refineries are remote from mills, fuel requirements for the refineries must be purchased. Under present-day conditions it is extremely wasteful that on the one hand there exist mills that are forced to burn excess bagasse while a central refinery must purchase fuel.

It is probable that future mills will be designed to incorporate a refinery to handle their output of raw sugar. During the 1974-75 season only five of the twenty sugar mills refined their own sugar. However this amounted to 37% of the sugar consumed on the local market. A total of 539 785 tonnes of raw sugar (or 49% of the local consumption) was refined remotely from the mills.

4.2 Energy Inputs

The energy inputs considered in this report do not include the energy requirements of the sugar farmers or of the transport of cane from farms to mills or from mills to refineries.

The information has been presented in the following manner. Firstly the energy inputs to all sugar mills over the past five seasons has been summarized in Appendix C, section (a). The units of physical volume have been converted to commom energy units in section (b) and the individual energy inputs are expressed as percentages in section (c).

Secondly, the specific energy requirements for the industry as a whole have been calculated for each of the five seasons in Appendix C section (d).

Finally, the 1974-75 season is considered in detail with data relating to individual mills being listed separately in section (e). This list has been broken down into three parts, namely (i) mills without refineries and with little or no external loads, (ii) mills with refineries and (iii) mills with other large external loads.

From this list it is obvious that one must be careful when quoting energy usage figures for the industry. The mill at Felixton for example also supplied a local paper mill with bagasse, while Amatikulu suppiies bagasse for board manufacture. Other mills, such as the one at Tongaat supply power and bagasse for by-product manufacture or generate electricity for use in irrigation schemes, such as at Malelane.

With regard to electricity requirements, it will be noted that these have not been included in the tables detailing energy usage. The sugar mills purchase very little electricity, the bulk of it being generated in power stations situated at the mills. The only time that electricity is fed into the mill is at start-up or after failure of the local generating plant. For this reason the electricity purchases have been assumed to be negligible in comparison with the overall energy requirements.

Bagasse supplies in excess of 90% of all the energy requirements of the mills. While the demand for coal has increased in the past few years, this is due to the diversification of the industry into board and paper amongst others, rather than as a result of any change in sugar milling technology.

From the data in Appendix C, it is not apparent that the mills operating diffusers are any less energy-intensive than those equipped with conventional milling equipment. However, the picture is complicated by the fact that some of these mills have external loads or refineries (Malelane, Entumeni, Union Co-op).

The specific energy requirements of mills operating with small external loads and without refineries was found to be 21,7 MJ per kilogram of raw sugar processed during the 1974/75 season while mills operating in conjunction with a refinery had a specific energy requirement of 26,3 MJ per kg of raw sugar processed. This would indicate that the energy requirements for refining are of the order of 4,6 MJ/kg. This is only an estimate since some of the mill-refinery complexes also export a percentage of raw sugar. However, a total of 539 785 tonnes of raw sugar was refined in South Africa at refineries remote from mills. The energy requirements of these refineries are therefore estimated to have been 2 500 x 10^{12} MJ and the total energy requirements of the South African sugar industry during the 1974/75 season would therefore have been 48 200 x 10^{12}J. Converted into units of tonnes of coal equivalent this is equal to an amount of some 1,8 million tonnes p.a.

The industry is in the unique position that it generates nearly all its own energy requirements and purchases are kept to a minimum.

4.3 Energy Utilization

Effectively all the energy utilized within the sugar industry is primarily converted to heat. The boilers, designed to burn bagasse, supply the mill with steam for heating, electricity generation and motive power for machinery driven by steam turbines.

The efficiency of utilization is to a degree determined by the amount of bagasse available for burning. That is to say that the steam and electricity requirements can be modified within limits, to use up the available bagasse.

For this reason, and due to the fact that such a high proportion of the fuel requirements are generated internally, the efficiency of energy utilization is of minor importance. It is likely to change only to accommodate the availability of bagasse and is largely unaffected by outside factors. Similarly, energy conservation in the sugar industry is not likely to bring about any significant changes in energy demands in the future. Besides using the bagasse for paper, pulp and other by-product manufacture (and there have been difficulties associated with the plant designed to do this), there is little else use for it, besides as a boiler fuel. The low density and low calorific value makes storage or transport of the fuel unattractive and it is highly unlikely that significant changes in energy demand patterns within the industry will occur within the forseeable future.

The additional fuels used at present could be reduced and in some cases an active programme has been undertaken to bring this about. However since a large amount of this additional fuel is used in mills with external loads, no great savings can be expected.

In conclusion, it should be stated that although the sugar industry uses a large amount of energy, only about 10% of the requirements are purchased. Since it is not economic to store or transport the bagasse which makes up the balance of the energy inputs, it is burned to provide more convenient energy forms. This practice will continue into the forseeable future.

Consequently energy savings amounting to a maximum of 10% could be achieved by using no additional fuels, but since these fuels are in some cases required for external loads, the figure is likely to be somewhat less than this.

5. GRAIN MILL PRODUCTS (SIC 31160)

The response to the survey by this sector was most disappointing. After repeated requests for information only two questionnares were received from flour milling establishments. These two establishments milled 116 658 tonnes of wheat during 1975. According to the Wheat Board (3), a total of 1 542 450 tonnes of wheat was milled during the 1974/75 season. This gives an indication of the degree of representation of the survey, which is calculated to be about 7,5%.

5.1 Energy Inputs

The fuel and energy cost expressed as a percentage of the total cost of production is on the average about 1% for the flour milling industry. The milling industry is controlled and the various companies are required to submit their costs to the Wheat Board to enable the price of their final product to be fixed. The figure of 1% obtained from the industry is therefore likely to be an accurate estimate.

The only direct energy input to the milling process is electricity. Some energy is required for transport purposes but this has not been considered in this report. Details of the energy inputs and the calculation of the specific energy requirements for flour milling are

included/......

included as Appendix D, Section (1).

The specific energy requirements are summarized below in table 6.

TABLE 6 : SPECIFIC ENERGY REQUIREMENTS - FLOUR MILLING

YEAR	1970	1973	1974	1975
Electricity usage (kwh/ tonne)	68,9	72,6	78,4	72,0

The fluctuations seen above have not been brought about by any changes in the processes used and are more likely the result of such factors as operating the plant at low throughputs.

Using the 1975 figure of 72 kWh per tonne of wheat milled, the total electricity requirement to mill the 1 542 450 tonnes of wheat produced during that year is calculated to be 111 000 MWh or 400 x 10^{12}J.

5.2 Energy Utilization

Details of the utilization of energy and the efficiency of energy conversion within flour mills are given in Appendix D section (2) and a summary of the important findings are given below in Table 7.

TABLE 7 : EFFICIENCY OF ELECTRICITY CONVERSION - FLOUR MILLING

	Efficiency of energy conversion	Percentage of total input converted
To heat	55%	0,6%
To mech. energy	80,9%	93,5%
To light	6,7%	5,9%
Overall	76,4%	100,0%

The very high proportion of electricity converted in electric motors results in a high overall efficiency of energy conversion.

5.3 Energy/......

5.3 Energy Conversions

There does not seem to be any scope or incentive to convert from electricity to any other energy source and no change is expected in the forseeable future.

5.4 Energy Conservation

While energy conservation will receive attention it must be remembered that energy only accounts for 1% of the cost of flour production.

Improvements in the design of milling equipment and better utilization of existing equipment could reduce specific energy requirements, but only marginally.

An increased demand for bulk supplied flour would result in savings due to reduced handling, packaging and bag repairing. Once again these savings will be marginal since the major proportion of the electricity is used in the milling process.

In conclusion it can be stated that no significant changes in specific energy requirements within the flour milling industry are expected.

6. FISH MEAL AND FISH OIL (SIC 31140)

Responses were obtained from four manufacturers with a combined production of 32 969 tonnes of fish meal and fish oil during 1975. According to S.A. Fish Meal Producers Association a total of 287 228 tonnes of fish meal and fish oil was produced during that year. The respondents to the survey, therefore, represent 11,5% of the total industry. For comparison purposes, it is interesting to note that South Africa's total fish catch is in excess of 1 000 000 tonnes (8) and the fish meal and fish oil industry thus accounts for some 25% of the total.

6.1 Energy Inputs/......

6.1 Energy Inputs

Fuel and energy purchases account for between 10% and 20% of the total cost of production according to figures obtained from the four respondents.

The energy inputs have been expressed in original units, common energy units and as percentages in Appendix E, sections (a), (b) and (c) respectively.

It will be seen from table 8 below that the specific energy requirements have varied from between 16,5 MJ/kg of fish product to 20,1 MJ/kg over the period 1970 to 1975. The 1975 figure is higher than those obtained for the earlier years, but without data for 1976 it cannot be assumed that this trend will continue. Since energy costs are an important fraction of the overall production costs, one would have expected the specific energy requirements to have diminished, rather than increased.

TABLE 8 : SPECIFIC ENERGY REQUIREMENTS - FISH MEAL AND FISH OIL

	1970	1973	1974	1975
Specific energy requirements (MJ/kg of finished product)	17,4	16,5	17,2	20,1

6.2 Energy Utilization

Details of the utilization of energy by fish meal and fish oil processors are included in Appendix E section (d), and the important findings are summarized below in table 9.

TABLE 9/......

TABLE 9 : EFFICIENCY OF ENERGY CONVERSION-FISH MEAL AND FISH OIL

	Efficiency of energy conversion (%)	Percentage of total input converted (%)
To heat	67,1	78,8
To mech.energy	49,9	21,0
To light	5,9	0,2
Overall	63,4	100,0

6.3 Energy Conversions

None of the respondents envisage any conversion from one energy source to another in the near future. It should be noted though that one producer installed oil-fired heating equipment in 1973.

6.4 Energy Conservation

While none of the companies included in the survey mentioned that they would be undertaking energy conservation programmes, it is very likely that measures could be adopted to reduce specific energy requirements. A fairly large proportion (nearly 20%) of the industry's energy requirement is used in fishing boats. It is not certain that significant savings could be achieved in this area, unless these measures did not interfere with the catch. Reduced speeds to and from fishing grounds would certainly meet with oppostion of fishing concerns eager to make up their allowed quotas. However, it may be possible, through better housekeeping, increased insulation and improved control, to reduce the heat requirements within the fish processing plants. Once again, this cannot be expected to occur until the cost of the extra equipment can be justified in terms of the cost of fuel.

In conclusion, the industry can be expected to look more closely at its energy usage patterns in future, but large scale savings are unlikely.

7) Canning/......

7. CANNING AND PRESERVING OF FRUITS AND VEGETABLES (SIC 31130)

The response to the questionnaire distributed to the canning industry was very good, with data being obtained for factories having a combined production of some 261 619 tonnes during 1975. This is approximately equal to half the total South African production during that year. A total of ten completed questionnaires were received out of the thirty that were distributed.

The processes used to preserve fruit and vegetables depend to some extent on the fruit type, but the variations are not so large as to prevent one producing a reasonable estimate of specific energy demand for the industry as a whole.

7.1 Energy Inputs

The energy cost expressed as a percentage of the total cost of production varies between 0,7% and 3,6%. The spread is partly due to the fact that some fruits require more preparation than others as well as factors such as the geographic location of the factory and the degree of mechanization employed.

Details of the energy inputs to ten factories who returned completed questionnaires are included in Appendix F. Section (a) of the Appendix contains details of the inputs expressed in physical units, while section (b) contains the same data, but expressed in common energy units and section (c) gives an indication of the relative importance of the individual energy sources.

In section (b) of the Appendix, the specific energy requirements have been calculated and for ease of reference have been included below as table 10.

TABLE 10 : SPECIFIC ENERGY REQUIREMENTS - FRUIT AND VEGETABLE PRESERVING

	1973	1974	1975
Specific energy usage (MJ/tonne of preserved product)	4,0	4,1	4,7

The increase/......

The increase in the specific energy requirements during 1975 can be partly ascribed to the fact that the production decreased in the factories surveyed during that year. The equipment would have been under-utilized in comparison with 1974, thus resulting in a worsening of the specific energy requirements. Since there were no marked changes in the plant or processes employed by the industry during 1975, the specific energy requirements cannot be taken as representative when considering the total energy requirements of the industry. This is further borne out by the similarity between specific energy requirements during 1973 and 1974. Using the 1974 figure to estimate the total energy demands of the industry, an amount of 2050 x 10^{12}J is obtained, while the 1975 figure gives 2350 x 10^{12}J. The actual energy requirements of the industry probably lie between these two values.

It is interesting to note that coal and heavy furnace oil account for about 90% of the energy needs, thus indicating the high dependence of the industry on heat.

7.2 Energy Utilization

Details of the utilization of energy and the efficiency of conversion of energy within the preserving industry are given in Appendix F, section (d). The important findings are summarized below in Table 11.

TABLE 11 : EFFICIENCY OF ENERGY CONVERSION - FRUIT AND VEGETABLE PRESERVING

	Efficiency of energy conversion (%)	Percentage of total input converted (%)
To heat	68,9	91,3
To mech. energy	53,2	8,1
To light	6,9	0,4
To chemical energy	50,0	0,2
Overall	67,3	100,0

7.3 Energy Conversions

Of the ten factories included in the survey, conversions have occurred within five in the fields of steam generation and transport. Two factories have converted from heavy furnace oil to coal-fired boilers while one factory converted from coal to heavy furnace oil and then reconverted to coal after the energy crisis.

Electricity and liquid petroleum gas have in some cases replaced petrol and diesel as the fuel for in-factory transport such as fork-lift trucks.

7.4 Energy Conservation

Of the ten factories, eight stated that they had undertaken fuel economy campaigns within the past five years. In most cases these had followed the conventional procedures of improved housekeeping and the installation of power-factor correction equipment. One factory is however carrying out an experiment to utilize peach pips mixed with coal as a boiler fuel. From initial tests it would seem that a mixture of 20% by volume of peach pips to coal results in a coal saving of approximately 5%. Problems were experienced with excessive deposits in the boiler during these experiments, but the tests are to be continued to try to overcome this shortcoming.

Beyond the increase in energy demand associated with the growth of the industry, it does not seem that any developments arelikely to affect the present pattern of usage. Slight improvements in the specific energy usage can be expected as a result of intensified conservation measures, but since energy only accounts for between 0,7% and 3,6% of the production costs, management is more likely to focus its attention on other areas to reduce costs.

While the use of waste products as a fuel could increase, it is doubtful whether they would make a significant contribution to the overall requirements of the industry, due to their poor burning qualities (i.e. low calorific values, high moisture content etc.)

8. SMALL ENERGY USERS/......

8. SMALL ENERGY USERS

The remaining sectors of the processed food and beverage industry individually use less than 1% of the total energy demand of the manufacturing sector of the South African economy. As such, they have little bearing on the future planning of the energy requirements of the country. Details of their energy inputs, specific energy requirements and efficiencies of energy conversion are included in the relevant Appendices. The following sections are included as a guide to these Appendices and to highlight noteworthy occurences within the industries.

9. DISTILLERIES AND WINERIES (SIC 31310)

Information relating to the energy inputs, utilization and the efficiency of energy conversion are to be found in Appendix G. Important findings are summarized below in Tables 12 and 13.

TABLE 12 : SPECIFIC ENERGY REQUIREMENTS - DISTILLERIES AND WINERIES

	1965	1970	1973	1974	1975
Specific energy usage (MJ/kg of product)	2,6	3,0	2,5	2,9	2,8

TABLE 13 : EFFICIENCY OF ENERGY CONVERSION - DISTILLERIES AND WINERIES

	Efficiency of energy conversion	Percentage of total input converted
To heat	99,2%	3,7%
To mech.energy	39,6%	94,7%
To light	7,5%	1,6%
Overall	41,0%	100,0%

Since energy only accounts for about 1% of the costs of production, little change can be expected regarding energy usage patterns in the future.

This is substantiated by the fact that none of the respondents mentioned any plans for converting from one energy source to another. While small savings can be expected due to conservation measures, these will not be large enough to change the overall energy picture to any extent.

10. AERATED WATERS (SIC 31340)

Details regarding energy utilization within this sector are included as Appendix H and the important findings are summarized below in Tables 14 and 15.

TABLE 14 : SPECIFIC ENERGY REQUIREMENTS - AERATED WATERS

	1970	1973	1974	1975
Specific energy usage (MJ/litre of product)	5,4	5,0	4,6	4,7

It should be noted that a large proportion of the energy inputs (45% during 1975) are used for transportation purposes. If the direct energy requirements only are considered, the specific energy requirements listed above must be reduced accordingly.

TABLE 15 : EFFICIENCY OF ENERGY CONVERSION - AERATED WATERS

	Efficiency of energy conversion	Percentage of total input converted
To heat	70,1%	43,9%
To mech. energy	31,0%	55,6%
To light	8,1%	0,5%
Overall	48,1%	100,0%

Once again it should be noted that the overall conversion efficiency is low because of the large proportion of energy used for transportation. If this amount is not included, the efficiency of conversion would rise to above 70%.

No new/......

No new processes are expected to be adopted by the industry, although small savings can be expected due to increased energy conservation measures. These savings will be small, since energy only accounts for between 0,5% and 2% of the total production costs.

11. COCOA, CHOCOLATE AND SUGAR CONFECTIONERY (SIC 31190)

Details regarding the energy requirements of the five factories who responded to the survey are included in Appendix I and the important findings are summarized below in tables 16 and 17.

TABLE 16 : SPECIFIC ENERGY REQUIREMENTS - COCOA, CHOCOLATE AND SUGAR CONFECTIONERY

	1970	1973	1974	1975
Specific energy usage (MJ/kg of product)	18,1	18,2	15,6	12,4

1975 saw a dramatic reduction in the requirements of heavy furnace oil and an increase in the coal requirements. This is undoubtedly an effect of the energy crisis and the general reduction in specific energy requirements has probably also been brought about by a greater interest in energy conservation. One of the large companies stated that they had instituted an Energy Conservation Committee to attempt to reduce their energy requirements and there seems to be a general awareness within the industry of the importance of energy costs. This is a little surprising since the respondents stated that their energy costs only accounted for between 1,5% and 3,0% of their total cost of production. As a result of this awareness, further savings can be expected, but the overall savings, while of great benefit to the industry, will not, on their own, make a noticeable difference to the demands of the food processing sector as a whole.

TABLE 17/......

TABLE 17 : EFFICIENCY OF ENERGY CONVERSION - COCOA, CHOCOLATE AND SUGAR CONFECTIONERY

	Efficiency of energy conversion	Percentage of total input converted
To heat	69,0%	88,3%
To mech. energy	75,9%	8,3%
To light	7,1%	1,4%
To chemical energy	50,0%	0,1%
To other	0,0%	1,9%
Overall	67,4%	100,0%

Besides the conversion from heavy furnace oil to coal already mentioned, one manufacturer converted from light diesel to coal gas for direct process heating. The reasons given for the conversions included the price of fuel and modernisation of plant.

As mentioned earlier, a number of the companies are instituting energy conservation measures, but the effect on the food processing industry as a whole will be minimal, since the sugar confectionery sector accounts for such a small proportion of the industry's total energy demands.

12. BREWERIES AND MALTWORKS (SIC 31330 - 31331)

Details of the energy requirements of the respondents in this sector are to be found in Appendix J and the important findings have been summarized below in Tables 18 and 19.

TABLE 18 : SPECIFIC ENERGY REQUIREMENTS - BREWERIES AND MALTWORKS

	1965	1970	1973	1974	1975
Specific energy usage (MJ/litre of product)	5,6	4,6	4,2	3,5	3,1

It is interesting to note that there has been a gradual decline in the specific energy requirements over the past ten years. This is probably due to the more efficient operation of larger plants, where energy overheads form a smaller percentage of the total energy requirements.

As far as could be ascertained no new processes were adopted over this period and the only significant change was the increased use of coal gas, and the switch from HFO to coal in one case and to light diesel in another. Once again though, the case arises where significant improvements within the brewing industry would have very little effect on the overall energy demands of the food industry.

TABLE 19 : EFFICIENCY OF ENERGY CONVERSION - BREWERIES AND MALT WORKS

	Efficiency of energy conversion	Percentage of total input energy converted
To heat	69,1%	90,1%
To mech. energy	41,3%	9,4%
To light	6,7%	0,5%
Overall	66,1%	100,0%

The industry does not expect new processes or technologies to be introduced within the forseeable future, but if past specific energy requirements can be taken as a guide, further savings in energy are likely to occur in the future.

13. OTHER SECTORS

The sectors of the processed food and beverage industry so far considered in this report account for approximately 75% of the energy requirements of the industry. The other sectors individually account for less than 0,5% of the total expenditure on energy by the industry and will therefore not be considered in this report.

For ease of reference, the findings of the report have been summarised for each sector in Appendix K. The format of the Appendix allows easy comparison of the various sectors.

It will be noted the figures relating to the sugar industry have not been included in this summary. The fact that such a large proportion of the energy requirements of the industry is generated by the industry itself tends to distort the true picture of energy utilization within the industry and must be used with care.

14. DISCUSSION

It is difficult to talk of the efficiency of energy utilization within the processed food industry as a whole, since the industry is made up of a number of small subsectors, each with different energy usage patterns. In general terms it will be seen that the efficiency of energy conversion lies between 60% and 70% for most of the subsectors. Of the subsectors considered, in almost every case, more than 50% of the total energy requirements were converted to heat. The results obtained are therefore very dependent on the efficiency of conversion of energy to heat that is used. If this is reduced, the result will be an almost directly proportional reduction in the overall conversion efficiency. The values adopted for this report are throught to be reasonable estimations of what actually occurs in industry but one should not adopt the values without appreciating that an error of ± 10% is possible.

15. ACKNOWLEDGEMENTS/.......

15. ACKNOWLEDGEMENTS

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4. Bakers Limited
5. Bantu Affairs Administration Board, S. Transvaal
6. Bokomo Limited
7. Brits Confectionery (Pty) Ltd
8. Cadbury Schweppes South Africa Ltd
9. Coca-Cola Export Corporation
10. Coo-Eee Bottling Co. Natal (Pty) Ltd
11. Deepfreezing and Preserving (Firgrove) (Pty) Ltd
12. Diamond Fields Bantu Affairs Admin. Board.
13. Epic Oil Mills (Pty) Ltd
14. Epol (Pty) Ltd.
15. Fromageries des Connoisseurs (Pty) Ltd
16. Geneva Swiss Confectionery (Pty) Ltd
17. Glucose and Starch Products Ltd
18. Groot Eiland Ko-op Wynkelder Ltd
19. Hollandia Confectionery (Pty) Ltd
20. Huletts Sugar Ltd
21. K.D.B. Holdings (Pty) Ltd
22. Kellogg Company of South Africa (Pty) Ltd
23. Langeberg Co-op Ltd
24. Letaba Citrus Processers (Pty) Ltd
25. Mafeking Romery Bpk.
26. Merwesport Koöp Wynmakery Bpk.
27. Model Bakery (Pty) Ltd
28. President Bakery (Pty) Ltd
29. Quix Kandy (Pty) Ltd
30. Reckitt and Coleman (Africa) (Pty) Ltd
31. Rhodes Fruit Farms (Pty) Ltd
32. Rodney and Co (Pty) Ltd
33. Rottcher Wineries (Pty) Ltd

34. Rubin's Bakery (Pty) Ltd
35. Sandy Point Canning Co. (Pty) Ltd
36. Sasko Limited
37. S.A. Breweries Ltd
38. S.A. Milling Co (Pty) Ltd
39. Springs Sorghum Beer Brewery
40. St Helena Bay Fishing Industries Ltd
41. Sugar Milling Research Institute
42. Suid-Oranje Visserye Bpk.
43. Universal Oil Products (Pty) Ltd
44. Vesta Cheese Co (Pty) Ltd
45. Waboomsrivier Koöp Wynkelder Bpk
46. Welmoed Koöp Wynkelders Bpk
47. Wes Transvaal Bantusake Adm. Raad
48. Westcott E.G. (Pty) Ltd
49. Wilson-Rowntree (Pty) Ltd

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16. REFERENCES

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APPENDIX A

Energy Conversion Efficiencies

a) Electricity

Process	Efficiency %
a) HEAT	
1) Direct process heating	100
2) Direct space heating	100
3) Air conditioning	55
4) Refrigeration	55
5) Welding	100
6) Geysers	90
7) Cooking	80
8) Soldering irons	100
9) Heating furnace oil	100
b) MECH	
1) Electric motors above 7 kW	85
2) Electric motors below 7 kW	75
c) LIGHT	
1) Incandescent	2
2) Incandescent halogen	3
3) Fluorescent	10
4) Sodium	20
5) Mercury	7
d) CHEMICAL	
1) Battery charging	50
2) Corrosion protection	50

b) Coal/......

b) Coal

Process	Efficiency %
1) Direct process heating	60
2) Steam generation for process heating	70
3) Steam generation for space heating	70

c) Coal Gas

Direct process heating	60

d) Liquid Petroleum Gas

1) Direct process heating	60
2) Steam generation for process heating	70
3) In-factory transport	14

e) Motor Gasoline (Mogas)

1) In-factory transport	14
2) Ex-factory transport	14

f) Light Diesel (ADO)

1) Direct process heating	60
2) Steam generation for process heating	70
3) Machinery drive	21
4) In-factory transport	21
5) Ex-factory transport	21

g) Power Paraffin/......

g) Power Paraffin

Process	Efficiency %
1) Direct process heating	60
2) Steam generation for process heating	70
3) Steam generation for space heating	70
4) Steam generation for machinery drive	70
5) Cleaning agent	0

h) Light Furnace Oil

1) Steam generation for process heating	70

i) Heavy Furnace Oil

1) Direct process heating	60
2) Steam generation for process heating	70
3) Steam generation for space heating	70

j) Conversion factors and calorific values

1) Electricity	1 KWh = 3,6MJ
2) Coal	27 MJ/kg
3) Coke	30 MJ/kg
4) Coal Gas	18,6 MJ/m^3
5) Liquid Petroleum Gas	26,6 MJ/l
9) Petroleum	34,5 MJ/l
10) Diesel Fuel	38 MJ/l
11) Power Paraffin	37 MJ/l
12) Illuminating Paraffin	37 MJ/l
13) Light Furnace Oil	38,7 MJ/l
14) Heavy Furnace Oil	41,7 MJ/l

Appendix B/.......

APPENDIX B

The Baking Industry

1) Energy Inputs

(i) Physical Units

	1973	1974	1975
Electricity (1000 kWh)	9 505	11 552	12 042
Coal (tonnes)	2 462	2 731	3 100
L.P.G. (kilolitres)	96	104	132
Petrol (kilolitres)	911	907	1 102
Diesel (kilolitres)	1 898	2 084	2 729
Power Paraffin (kilolitres)	260	557	589
Total No. Surveyed	7	8	11

ii) Common/........

ii) Common Energy Units (Terajoules)

	1973	1974	1975
Electricity	34	42	43
Coal	66	74	84
L.P.G.	3	3	4
Petrol	31	31	38
Diesel	72	79	104
Power Paraffin	10	21	22
Total	216	249	294

iii) Energy Sources as a Percentage of the Total Requirements

	1973	1974	1975
Electricity	15,8	16,7	14,7
Coal	30,7	29,6	28,5
L.P.G.	1,2	1,1	1,2
Petrol	14,5	12,6	12,9
Diesel	33,3	31,8	35,3
Power Paraffin	4,5	8,2	7,4
Total	100%	100%	100%

iv) Specific Energy Requirements - Baking Industry

YEAR	1973	1974	1975
Energy requirements (Terajoules)	216	249	294
Wheaten Products Purchased (tonnes)	38 486	47 086	55 479
Specific Energy Usage (MJ/kg purchased)	5,6	5,3	5,3

2) Energy/.........

2) Energy Utilization

(i) Conversion of Energy to Heat

FUEL OR ENERGY SOURCE	CONVERSION PROCESS	PERCENTAGE OF INDIVIDUAL ENERGY SOURCES CONVERTED TO HEAT
Electricity	Direct process heating	2,3%
	Air conditioning and refrigeration	6,7%
	Electricity total	9,0%
Coal	Steam generation for process heating	100%
L.P.G.	Direct process heating	100%
Light Diesel	Direct process heating	80,8%
	Direct space heating	2,2%
	Steam generation for process heating	10,2%
	Diesel total	93,2%
Paraffin	Direct process heating	32,6%
	Steam generation for process heating	57,6%
	Steam generation for space heating	9,2%
	Steam generation for machinery drive	0,5%
	Paraffin total	99,9%

Summary/......

Summary of Energy Inputs to Heat

Total input converted to heat = 199 TJ (78,4%)

Total useful heat energy = 130 TJ

Efficiency of conversion to heat = 65,2%

2) Conversion of inputs to mechanical energy

Fuel or energy source	Conversion Process	Percentage of individual energy sources converted to mechanical energy
Electricity	Electric motors above 7KW	35,7%
	Electric motors below 7 KW	48,8%
	Electricity subtotal	84,5%
Petrol	Transport ex factory	100%
Diesel	Transport ex factory	6,8%

Summary of Energy Inputs Converted to Mechanical Energy

Total input converted to mechanical energy = 52 TJ (20,5%)

Total useful mechanical energy = 32 TJ

Efficiency of conversion to mech energy = 60,7%

3) Conversion of inputs/.......

3) Conversion of Inputs to Light

Energy Source	Conversion Process	Percentage of input converted to light
Electricity	Incandescent	0,1%
	Fluorescent	6,5%
	Electricity subtotal	6,6%

Summary of Energy Inputs to Light

Total input converted to light = 3TJ (1,1%)
Total useful light energy = 0,3 TJ
Efficiency of conversion to light = 9,9%

4) Summary of Conversion Efficiencies by Energy Source

FUEL OR ENERGY SOURCE	EFFICIENCY OF CONVERSION
Electricity	73,6%
Coal	70,0%
L.P.G.	60,0%
Petrol	14,0%
Light Diesel	58,6%
Paraffin	66,7%
OVERALL	63,7%

APPENDIX C - SUGAR MILLING

1) Energy Inputs

a) Energy Inputs - Physical Units

SEASON	BAGASSE PRODUCTION (tonnes)	COKE (tonnes)	FUEL OIL (tonnes)	COAL (tonnes)	WOOD (tonnes)
1970/71	4 203 003	1 150	27	75 061	20 742
1971/72	5 522 842	1 487	37	84 014	26 766
1972/73	5 663 165	695	5 933	87 104	24 844
1973/74	5 305 251	1 513	2 144	131 178	26 362
1974/75	5 831 374	1 628	2 227	156 921	28 224

b) Energy Inputs - Common Energy Units (10^{12}J)

Calorific values:

Bagasse ≈ 7 MJ/kg (dependent on season)
Lower calorific value used since moisture content is of the order of 50%.

Coke = 30 MJ/kg   Coal = 27 MJ/kg
Fuel Oil = 41,7 MJ/kg   Wood = 8,5 MJ/kg

SEASON	BAGASSE	COKE	FUEL OIL	COAL	WOOD	TOTAL
1970/71	29 640	35	1	2 027	176	31 879
1971/72	39 450	45	2	2 268	228	41 993
1972/73	40 203	21	247	2 352	211	43 034
1973/74	37 312	45	89	3 542	224	41 212
1974/75	41 085	49	93	4 236	240	45 703

c) Energy Inputs - Individual/......

c) Energy Inputs - Individual Sources Expressed as a Percentage of the Total Requirements

SEASON	BAGASSE	COKE	FUEL OIL	COAL	WOOD	TOTAL
1970/71	93,0	0,1	negligible	6,4	0,5	100,0
1971/72	93,9	0,1	negligible	5,4	0,6	100,0
1972/73	93,4	negl.	0,6	5,5	0,5	100,0
1973/74	90,5	0,1	0,2	8,6	0,6	100,0
1974/75	89,9	0,1	0,2	9,3	0,5	100,0

d) Specific Energy Requirements

SEASON	TOTAL CANE CRUSHED (tonnes)	TOTAL SUGAR PRODUCTION (tonnes)	TOTAL ENERGY USAGE (10^{12}J)	SPEC. ENERGY REQUIREMENTS	
				MJ/kg cane crushed	MJ/kg of sugar produced
1970/71	12 143 897	1 398 872	31 879	2,6	22,8
1971/72	16 751 114	1 864 665	41 993	2,5	22,5
1972/73	16 804 645	1 914 601	43 034	3,6	22,5
1973/74	15 453 687	1 731 575	41 212	2,7	23,8
1974/75	16 895 372	1 883 195	45 704	2,7	24,3

e) Details of 1974/75 season/......

e) Details of 1974/75 Season

i) Mills operating without refineries and small external loads

MILL NAME	BAGASSE (tonnes)	COKE (tonnes)	FUEL OIL (tonnes)	COAL (tonnes)	WOOD (tonnes)	TOTAL ENERGY USAGE (10^{12}J)	CANE CRUSHED (tonnes)	SUGAR PRODUCT. (tonnes)	SPECIFIC ENERGY USAGE	
									MJ/kg cane crushed	MJ/kg sugar
Umzinkulu	240 936	-	-	-	368	1 678	735 682	81 808	2,3	20,5
Glendale*	66 269	-	-	-	601	497	206 447	24 108	2,4	20,6
Umfolozi	371 505	-	-	12 011	-	2 875	1 179 828	138 246	2,4	20,8
Darnall	422 078	-	-	-	994	2 963	1 211 824	142 018	2,4	20,9
Mt. Edgecombe	327 274	-	-	396	188	2 405	990 840	113 662	2,4	21,2
Union Co-op**	96 534	-	-	1 870	200	755	351 415	35 293	2,1	21,4
Illovo	184 723	-	-	3 382	9 808	1 485	601 703	66 066	2,5	22,5
Renishaw	116 468	-	-	-	548	839	322 179	36 473	2,6	23,0
Jaagbaan	317 118	-	-	-	2 224	2 407	975 448	104 354	2,5	23,1
Doornkop	120 505	-	2 188	-	3 752	949	346 777	40 390	2,7	23,5
Mellville***	122 025	-	-	2 876	296	1 005	356 381	41 032	2,8	24,5
TOTALS	2 385 435	-	2 188	20 535	18 979	17 858	7 278 524	823 450	2,5	21,7

* Irrigation load

** Power to wattle mill

*** Bagasse to by-products

ii) Mills operating/......

ii) Mills Operating Refineries

MILL NAME	BAGASSE (tonnes)	COKE (tonnes)	FUEL OIL (tonnes)	COAL (tonnes)	WOOD (tonnes)	TOTAL ENERGY USAGE (10^{12} J)	CANE CRUSHED (tonnes)	SUGAR PROD. (tonnes)	SPECIFIC ENERGY REQUIREMENTS MJ/ kg cane	MJ/kg sugar
Sezela	442 629	543	39	10 309	194	3 415	1 293 480	140 077	2,6	24,4
Glendhow	473 977	681	-	10 693	1 507	3 663	1 310 416	146 691	2,8	25,0
Entumeni	69 908	-	-	4 022	2 995	609	217 173	23 609	2,8	25,8
Pongola	193 015	404	-	19 967	-	2 014	652 299	72 402	3,1	27,8
Malelane	440 349	-	-	27 305	-	3 716	1 154 560	123 011	3,2	29,0
TOTALS	1 619 879	1 628	39	72 296	4 696	13 417	4 627 928	510 790	2,9	26,3

iii) Mills Operating with Large External Loads

Tongaat	600 005	-	-	14 974	315	4 482	1 658 305	184 803	2,7	24,3
Amatikulu	439 636	-	-	7 830	-	3 265	1 221 551	133 009	2,7	24,5
Empangeni	427 158	-	-	5 760	4 234	3 152	1 147 349	126 465	2,7	24,9
Felixton	359 262	-	-	35 526	-	3 529	961 715	104 678	3,7	33,7
TOTALS	1 826 060	0	0	64 090	4 549	14 428	4 988 920	584 955	2,9	24,7

iv) Industry Totals

All Mills	5 831 374	1 628	2 227	156 921	28 224	45 703	16 895 372	1 883 195	2,7	24,3

Appendix D/......

APPENDIX D - FLOUR MILLING

1) Energy Inputs

	1970	1973	1974	1975
Electricity (MWh)	5500	6802	8253	8401
Electricity (10^6 MJ)	19,8	24,5	29,7	30,2
Total wheat usage (tonnes)	79864	93656	105249	116658
Specific Energy Usage				
MJ/kg	0,25	0,26	0,28	0,26
KWh/tonne	68,9	72,6	78,4	72,0

2) Energy Utilization

(i) Conversion of Electricity to Heat

Air conditioning/refrigeration = 0,6% of total input

Total input converted to heat = 47 MWh

Total useful heat energy = 25,9 MWh

Efficiency of conversion to heat = 55%

(ii) Conversion of Electricity to Mechanical Energy

Electric motors above 7 kW = 55,2% of total input

Electric motors below 7 kW = 38,3% of total input

Total = 93,5%

Total input converted to mech. energy = 7 860 MWh

Total useful mech. energy = 6 359 MWh

Efficiency of conversion to mech. energy = 80,9%.

(iii) Conversion of Electricity to Light

Incandescent = 2,5% of total input

Fluorescent = 3,4% of total input

Total = 5,9%

Total electricity converted to light = 494 MWh

Total useful/.....

Total useful light energy = 32,9 MWh
Efficiency of conversion to light = 6,7%

iv) Summary

PROCESS	INPUT (MWh)	USEFUL (MWh)	CONVERSION EFFICIENCY
Heat	47	25,9	55%
Mech.	7 860	6359,0	80,9%
Light	494	32,9	6,7%
TOTAL	8 401	6417,8	76,4%

APPENDIX E - FISH MEAL AND FISH OIL

1) Energy Inputs

(a) Energy Inputs - Physical Units

	1970	1973	1974	1975
Electricity (1000 KWh)	12 248	11 050	11 024	16 655
Coal (tonnes)	12 957	15 905	13 199	16 374
Petrol (kilolitres)	91	108	89	89
Light Diesel (kilolitres)	3 336	4 079	2 799	3 404
Heavy Furnace Oil (tonnes)	0	0	515	650
TOTAL NO. SURVEYED	3	4	4	4

(b) Energy Inputs - Common Energy Units (10^{12}J)

	1970	1973	1974	1975
Electricity	44	40	40	60
Coal	350	429	356	442
Petrol	3	4	3	3
Light Diesel	127	155	106	129
Heavy Furnace Oil	0	0	21	27
TOTAL	524	628	527	662
Tonnage fish products processed p.a.	30 030	38 172	30 721	32 969
Specific Energy Usage (MJ/kg)	17,4	16,5	17,2	20,1

(c) Energy Inputs as a Percentage/......

(c) Energy Inputs as a Percentage of the Total Requirements

	1970	1973	1974	1975
Electricity	8,4	6,3	7,5	9,1
Coal	66,8	68,4	67,6	66,8
Petrol	0,6	0,6	0,6	0,5
Light Diesel	24,2	24,7	20,2	19,5
Heavy Furnace Oil	0,0	0,0	4,1	4,1
TOTAL	100,0	100,0	100,0	100,0

2. Energy Utilization - Fish Meal and Fish Oil

(i) Conversion of Energy to Heat

Fuel or energy source	Conversion process	Percentage of individual energy sources converted to heat
Electricity	Air conditioning/refrigeration	0,9%
Coal	Direct process heat	24,5%
	Steam generation for process heating	75,5%
	Coal total	100%
Heavy Furnace Oil	Direct process heating	100%

Summary of Energy Inputs Converted to Heat

Total input converted to heat = 470×10^{12}J or 78,8%

Total useful heat energy = 315×10^{12}J

Efficiency of conversion to heat = 67,1%

(ii) Conversion of inputs/......

(ii) Conversion of Inputs to Mechanical Energy

Fuel or Energy Source	Conversion Process	Percentage of Individual Energy Sources Converted to Mech. Energy.
Electricity	Electric motors above 7kW	81,7%
	Electric motors below 7kW	15,5%
	Electricity total	97,2%
Petrol	Transport in-factory	14,9%
	Transport ex-factory	85,1%
	Petrol total	100,0%
Light Diesel	Transport-including fishing boats	98,1%
	Transport in-factory	1,9%
	Diesel Total	100,0%

Summary of energy inputs converted to mechanical energy

Total input converted to mechanical energy = 125×10^{12} J or 21,0%
Total useful mechanical energy = 62×10^{12} J
Efficiency of conversion to mech energy = 49,9%

(iii) Conversion of input energy to light

Incandescent = 1,0% of total electricity requirements
Fluorescent = 1,0% of total electricity requirements

Summary of energy input converted to light

Total input converted to light = 1×10^{12} TJ = 0,2%
Total useful light = 59×10^{9} J
Efficiency of conversion to light = 5,9%

(iv) Summary of conversion/......

(iv) Summary of Conversion Efficiencies by Energy Source

Fuel or energy source	Efficiency of conversion (%)
Electricity	81,6
Coal	67,5
Petrol	14,0
Diesel	21,0
Heavy Furnace Oil	60,0
TOTAL	63,4

APPENDIX F/.......

APPENDIX F - CANNING AND PRESERVING OF FRUITS AND VEGETABLES

1) Energy Inputs

(a) Energy Inputs (Physical Units)

	1973	1974	1975
Electricity (1000 kWh)	14 792	18 623	20 622
Coal (tonnes)	23 892	27 271	29 532
Liquid Petroleum Gas (kilolitres)	865	841	753
Petrol (kilolitres)	209	209	220
Light Diesel (kilolitres)	503	529	575
Power Paraffin (kilolitres)	8	7	8
Light Furnace Oil (tonnes)	45	62	41
Heavy Furnace Oil (tonnes)	6 856	8 418	7 207

b) Energy Inputs/..........

b) Energy Inputs - Energy Units (10^{12}J)

	1973	1974	1975
Electricity	53	67	74
Coal	645	736	797
Liquid Petroleum Gas	23	22	20
Petrol	7	7	8
Light Diesel	19	20	22
Power Paraffin	< 1	< 1	< 1
Light Furnace Oil	2	2	2
Heavy Furnace Oil	286	351	301
TOTAL	1 036	1 207	1 223

Production Tonnes of preserved product	259 664	291 542	261 619
Specific energy usage (MJ/kg product)	4,0	4,1	4,7

c) Energy Inputs Expressed as a Percentage of the Total Requirements

	1973	1974	1975
Electricity	5,1	5,5	6,1
Coal	62,3	61,0	65,2
Liquid Petroleum Gas	2,2	1,9	1,6
Petrol	0,7	0,6	0,6
Light Diesel	1,9	1,7	1,8
Power Paraffin	<0,1	<0,1	<0,1
Light Furnace Oil	0,2	0,2	0,2
Heavy Furnace Oil	27,6	29,1	24,6
TOTAL	100,0	100,0	100,0

2. Energy Utilization/.......

2. Energy Utilization - Fruit and Vegetable Preserving

i) Conversion of Energy to Heat

Fuel or Energy Source	Conversion Process	Percentage of individual energy sources converted to heat
Electricity	Direct space heating	0,2%
	Air conditioning/refrig.	14,5%
	Electricity total	14,7%
Coal	Steam generation for process heating	100%
Light Furnace Oil	Steam generation for process heating	100%
Heavy Furnace Oil	Direct process heating	36,2%
	Steam generation for process heating	63,8%
	H.F.O. Total	100%

Summary of energy inputs converted to heat

Total input converted to heat = 1110×10^{12}J or 91,3% of total energy requirements

Total useful heat energy = 765×10^{12}J

Efficiency of conversion to heat = 68,9%

ii) Conversion of inputs to mechanical energy/.......

ii) Conversion of inputs to mechanical energy

Fuel or energy source	Conversion Process	Percentage of individual sources converted to mechanical energy
Electricity	Electric motors above 7kW	44,1%
	Electric motors below 7kW	30,4%
	Electricity total	74,5%
Liquid Petroleum Gas	Transport in-factory	100,0%
Petrol	Transport in-factory	3,8%
	Transport ex-factory	96,2%
	Petrol total	100,0%
Light Diesel	Transport in-factory	27,8%
	Transport ex-factory	72,2%
	Total light diesel	100,0%

Summary of Energy Inputs Converted to Mechanical Energy

Total input converted to mechanical energy = 98×10^{12} J (or 8,1%)
Total useful mechanical energy = 52×10^{12} J
Efficiency of conversion to mech. energy = 53,2%

3. Conversion of Inputs to Light

Energy Source	Conversion Process	Percentage of electricity converted to light
Electricity	Incandescent	2,8%
	Halogen	0,1%
	Fluorescent	4,4%
	Mercury	0,1%
	Total electricity	7,4%

Summary of energy/........

Summary of energy inputs converted to light

Total input energy converted to light	=	5×10^{12} J (or 0,4%)
Total useful light energy	=	$0,3 \times 10^{12}$ J
Efficiency of conversion to light	=	6,9%

4. Conversion of Inputs to Chemical Energy

Energy Source	Conversion Process	Percentage of input energy converted to chemical energy.
Electricity	Battery charging	3,5%

Summary of energy inputs converted to chemical energy

Total input energy converted to chemical energy	=	3×10^{12} J (or 0,2%)
Total useful chemical energy	=	1×10^{12} J
Efficiency of conversion to chemical energy	=	50%

5. Summary of Conversion Efficiencies by Energy Source

Fuel Source	Efficiency of conversion
Electricity	70,6%
Coal	70,0%
L.P.G.	14,0%
Petrol	14,0%
Light Diesel	21,0%
Power Paraffin	see note below
Light Furnace Oil	70,0%
Heavy Furnace Oil	66,4%
Overall	67,3%

Note: The use of power paraffin was not specified by respondents, but since it accounts for less than 0,1% of the energy requirements of the industry, this is of little importance.

APPENDIX G - DISTILLERIES AND WINERIES

1) Energy Inputs

a) Energy Inputs - Physical Units

	1965	1970	1973	1974	1975
Electricity (1000 kWh)	3 320	4 495	5 743	6 848	8 469
Liquid Petroleum Gas (kilolitres)	9	10	11	12	14
Petrol (kilolitres)	5	5	5	5	5
Light Diesel (kilolitres)	1 000	1 200	1 400	1 560	1 650
Illuminating Paraffin (kilolitres)	0,4	0,4	0,4	0,4	0,4

b) Energy Inputs - Common Energy Units (10^{12} J)

	1965	1970	1973	1974	1975
Electricity	12	16	21	25	30
Liquid Petroleum Gas	<1	<1	1	1	1
Petrol	<1	<1	<1	<1	<1
Light Diesel	38	46	53	59	63
Illuminating Paraffin	<1	<1	<1	<1	<1
Total	50	62	74	84	94

	1965	1970	1973	1974	1975
Total production (tonnes of product)	19 436	20 653	30 327	29 174	33 877
Specific energy usage MJ/kg of product	2,6	3,0	2,5	2,9	2,8

c) Energy Sources as a/......

c) Energy Sources as a Percentage of the Total Requirements

	1965	1970	1973	1974	1975
Electricity	23,7	26,0	27,8	29,2	32,5
Liquid Petroleum Gas	0,4	0,4	0,4	0,4	0,4
Petrol	0,5	0,3	0,3	0,2	0,2
Light Diesel	75,4	73,3	71,5	70,2	66,9
Illuminating Paraffin	<0,1	<0,1	<0,1	<0,1	<0,1
TOTAL	100,0	100,0	100,0	100,0	100,0

d) Energy Utilization - Distilleries and Wineries

1) Conversion of energy to heat

Fuel or energy source	Conversion Process	Percentage of individual energy source converted to heat
Electricity	Direct process heating	9,2%
	Air conditioning/ Refrigeration	0,1%
	Electricity total	9,3%
Liquid petroleum gas	Direct process heating	100,0%

Summary of Energy Inputs to Heat

Total input converted to heat = 3×10^{12} J or 3,7% of total energy requirements

Total useful heat energy = 3×10^{12} J

Efficiency of conversion to heat = 99,2%

2) Conversion of inputs/......

2) Conversion of Inputs to Mechanical Energy

Fuel or energy source	Conversion process	Percentage of individual energy sources converted to mechanical energy
Electricity	Motors above 7kW	79,9%
	Motors below 7kW	5,8%
	Electricity total	85,7%
Petrol	Transport in-factory	10,0%
	Transport ex-factory	90,0%
	Total petrol	100,0%
Light Diesel	Transport	100,0%

Summary of energy inputs converted to mechanical energy

Total input converted to mechanical energy = 89×10^{12} J or 94,7%

Total useful mech. energy = 35×10^{12} J

Efficiency of conversion to mech. energy = 39,6%

3) Conversion of Input Energy to Light

Energy Source	Conversion Process	Percentage of input energy source converted to light
Electricity	Incandescent	0,2%
	Fluorescent	1,0%
	Mercury	2,9%
	Electricity total	4,1%

Summary of energy inputs/......

Summary of Energy Inputs Converted to Light

Total input converted to light = 1×10^{12} J or 1,6%

Total useful light energy = 75×10^{9} J

Efficiency of conversion to light = 7,5%

4. Summary of Conversion Efficiencies by Energy Source

Fuel or energy source	Efficiency of conversion
Electricity	82,3%
L.P.G.	60,0%
Petrol	14,0%
Light Diesel	21,0%
Illuminating paraffin	not specified
Overall	41,0%

APPENDIX H/.......

APPENDIX H - . AERATED WATERS

1) Energy Inputs

a) Energy Inputs - Physical Units

	1970	1973	1974	1975
Electricity (1000 kWh)	2 751	3 041	3 248	3 951
Coal (tonnes)	1 599	1 740	1 804	1 892
Liquid Petroleum Gas (kilolitres)	44	32	14	11
Petrol (kilolitres)	216	321	399	489
Light Diesel (kilolitres)	547	790	868	978

b) Energy Inputs - Common Energy Units (10^{12} J)

	1970	1973	1974	1975
Electricity	10	11	12	14
Coal	43	47	49	51
Liquid Petroleum Gas	1	1	< 1	< 1
Petrol	7	11	14	17
Light Diesel	21	30	33	37
TOTAL	82	100	108	120

Total production (kilolitres)	15 729	20 072	23 298	25 303
Specific energy usage (MJ/litre)	5,4	5,0	4,6	4,7

c) Energy sources/........

c) Energy Sources as a Percentage of the Total Requirements

	1970	1973	1974	1975
Electricity	12,0	11,0	10,9	11,9
Coal	52,4	47,0	45,3	42,7
Liquid Petroleum Gas	1,4	0,8	0,3	0,3
Petrol	9,0	11,1	12,8	14,0
Light Diesel	25,2	30,1	30,7	31,1
Total	100,0	100,0	100,0	100,0

d) Energy Utilization - Aerated Waters

1) Conversion of energy to heat

Fuel or energy source	Conversion Process	Percentage of individual energy source converted to heat
Electricity	Direct space heating	1,9%
	Air conditioning/ refrigeration	1,1%
	Electricity total	3,0%
Coal	Steam generation for process heating	100,0%

Summary of energy inputs to heat

Total input energy converted to heat = 52×10^{12} J or 43,9% of total energy requirements

Total useful heat = 36×10^{12} J

Efficiency of conversion to heat = 70,1%

2) Conversion of inputs/......

2) Conversion of Inputs to Mechanical Energy

Fuel or energy source	Conversion process	Percentage of individual energy sources converted to mech. energy
Electricity	Electric motors above 7 kW.	40,2%
	Electric motors below 7 kW.	52,6%
	Electricity total	92,8%
Petrol	Transport in-factory	2,0%
	Transport ex-factory	98,0%
	Petrol total	100,0%
Diesel	Transport ex-factory	100,0%

Summary of energy inputs converted to mechanical energy

Total input converted to mech.energy = 65×10^{12} J or (55,6%)

Total useful mech.energy = 20×10^{12} J

Efficiency of conversion to mech.energy = 31,0%

3) Conversion of Input Energy to Light

Fuel or energy source	Conversion Process	Percentage of input energy source converted to light
Electricity	Incandescent	1,0%
	Fluorescent	3,2%
	Electricity total	4,2%

Summary of energy inputs/.......

Summary of Energy Inputs Converted to Light

Total input converted to light = 1×10^{12} J (or 0,5%)
Total useful light energy = 81×10^{9} J
Efficiency of conversion to light = 8,1%

4) Summary of Conversion Efficiencies by Energy Source

Fuel or energy source	Efficiency of conversion (%)
Electricity	76,5%
Coal	70,0%
Liquid Petr. Gas	not specified
Petrol	14,0%
Light Diesel	21,0%
Overall	48,1%

APPENDIX I - COCOA, CHOCOLATE AND SUGAR CONFECTIONERY

1) Energy Inputs

a) Energy Inputs - Physical Units

	1970	1973	1974	1975
Electricity (1000 kWh)	16 547	22 702	25 040	27 230
Coal (tonnes)	7 898	7 000	6 290	14 707
Coke (tonnes)	0	0	0	7
Coal Gas (cubic metres)	226 838	306 515	310 040	327 311
Liquid Petroleum Gas (kilolitres)	11	11	14	12
Petrol (kilolitres)	0	0	0	15
Light Diesel (kilolitres)	22	23	59	477
Illuminating Paraffin (kilolitres)	2	2	2	3
Heavy Furnace Oil (tonnes)	3 483	8 626	7 890	2 291
Number surveyed	2	2	3	5

b) Energy Inputs - Common/......

b) Energy Inputs - Common Energy Units (10^{12} J)

	1970	1973	1974	1975
Electricity	60	82	90	98
Coal	213	189	170	397
Coke	0	0	0	< 1
Coal Gas	4	6	6	6
Liquid Petroleum Gas	< 1	< 1	< 1	< 1
Petrol	0	0	0	1
Light Diesel	1	1	2	18
Illuminating Paraffin	< 1	< 1	< 1	< 1
Heavy Furnace Oil	145	360	329	96
Total	423	637	597	616

Total production (tonnes of product)	23 436	34 948	38 273	49 588
Specific energy usage (MJ/kg of product)	18,1	18,2	15,6	12,4

c) Energy sources as a percentage/.......

c) Energy Sources as a Percentage of the Total Requirements

	1970	1973	1974	1975
Electricity	14,1	12,8	15,1	15,9
Coal	50,3	29,7	28,4	64,5
Coke	0,0	0,0	0,0	< 0,1
Coal Gas	1,0	0,9	1,0	1,0
Liquid Petroleum Gas	0,1	0,1	0,1	0,1
Petrol	0,0	0,0	0,0	0,1
Light Diesel	0,2	0,1	0,4	2,9
Illuminating Paraffin	< 0,1	< 0,1	< 0,1	< 0,1
Heavy Furnace Oil	34,3	56,4	55,0	15,5
Total	100,0	100,0	100,0	100,0

d) Energy Utilization - Cocoa, chocolate and sugar confectionery

1) Conversion of energy to heat

Fuel or energy source	Conversion Process	Percentage of individual energy sources converted to heat
Electricity	Direct process heating	2,2%
	Direct space heating	1,0%
	Air conditioning/refrigeration	35,5%
	Electricity total	38,7%
Coal	Steam generation for process heating	92,7%
	Steam generation for space heating	4,5%
	Coal total	97,7%
Coal Gas	Direct process heating	100,0%

Conversion of energy to heat cont./......

Fuel or energy source	Conversion Process	Percentage of individual energy sources converted to heat
Liquid petroleum gas	Steam generation for process heating	77,0%
Light Diesel	Steam generation for process heating	100,0%
Heavy Furnace Oil	Steam generation for process heating	91,1%
	Steam generation for space heating	5,5%
	Direct process heating	0,7%
	HFO total	97,3%

Summary of energy inputs converted to heat

Total input converted to heat = 543×10^{12} J or 88,3% of total energy requirements

Total useful heat energy = 375×10^{12} J

Efficiency of conversion to heat = 69,0%

2) Conversion of Inputs to Mechanical Energy

Fuel or energy source	Conversion Process	Percentage of Individual energy sources converted to mechanical energy
Electricity	Motors above 7 kW	8,5%
	Motors below 7 kW	43,1%
	Electricity total	51,6%
Liquid Petroleum Gas	In-factory transport	23,0%
Petrol	Ex-factory transport	100,0%

Summary of inputs converted/.........

Summary of Inputs Converted to Mechanical Energy

Total input converted to mech. energy = 51 x 10^{12} J (or 8,3%)
Total useful mech. energy = 39 x 10^{12} J
Efficiency of conversion to mech. energy = 75,9%

3) Conversion of Input Energy to Light

Energy Source	Conversion Process	Percentage of input energy source converted to light
Electricity	Incandescent	3,9%
	Fluorescent	3,8%
	Sodium	0,7%
	Mercury	0,7%
	Electricity total	9,0%

Summary of Input Energy Converted to Light
Total input converted to light = 9 x 10^{12} J (or 1,4%)
Total useful light energy = 1 x 10^{12} J
Efficiency of conversion to light = 7,1%

4) Conversion of Input Energy to Chemical Energy

Energy Source	Conversion Process	Percentage of electricity converted to chemical energy
Electricity	Battery charging	0,7%

5) Summary of Conversion/.......

5) Summary of Conversion Efficiencies by Energy Source

Fuel or energy source	Efficiency of conversion
Electricity	63,3%
Coal	68,4%
Coke	not specified
Coal Gas	60,0%
L.P.G.	57,1%
Petrol	14,0%
Light Diesel	70,0%
Illuminating Paraffin	not specified
H.F.O.	68,0%
Overall	67,4%

APPENDIX J/........

APPENDIX J -. BREWERIES AND MALT WORKS

1) Energy Inputs

a) Energy Inputs - Physical Units

	1965	1970	1973	1974	1975
Electricity (1000 kWh)	1 689	2 597	4 492	6 837	11 534
Coal (tonnes)	17 255	23 443	29 513	34 356	27 508
Coal gas (cubic metres)	0	0	1 074 262	1 022 895	1 042 943
Liquid Petroleum Gas (kilolitres)	398	467	544	594	689
Petrol (kilolitres)	135	138	140	140	142
Light Diesel (kilolitres)	650	821	859	1 230	1 313
Heavy Furnace Oil (tonnes)	0	1 211	1 841	2 067	3 380
Total No Surveyed	2	3	4	7	7

b) Energy Inputs - Common Energy/......

b) Energy Inputs - Common Energy Units (10^{12} J)

	1965	1970	1973	1974	1975
Electricity	6	9	16	25	42
Coal	466	633	797	928	743
Coal Gas	0	0	20	19	19
L.P.G.	11	12	14	16	18
Petrol	5	5	5	5	5
Light Diesel	25	31	33	47	50
H.F.O.	0	50	77	86	141
Total	512	741	962	1 125	1 018

Total production (kilolitres of product)	90 972	160 915	230 922	322 172	329 133
Specific energy usage (MJ/litre of product)	5,6	4,6	4,2	3,5	3,1

c) Energy Sources as a Percentage of the Total Requirements

	1965	1970	1973	1974	1975
Electricity	1,2	1,3	1,7	2,2	4,1
Coal	91,0	85,4	82,8	82,5	73,0
Coal Gas	0,0	0,0	2,1	1,7	1,9
L.P.G.	2,1	1,7	1,5	1,4	1,8
Petrol	0,9	0,6	0,5	0,4	0,5
Light Diesel	4,8	4,2	3,4	4,2	4,9
H.F.O.	0,0	6,8	8,0	7,6	13,8
Total	100,0	100,0	100,0	100,0	100,0

d) Energy Utilization/......

d) Energy Utilisation - Breweries and Maltworks

1) Conversion of energy to heat

Fuel or energy source	Conversion Process	Percentage of individual energy source converted to heat
Electricity	Direct process heating	0,6%
	Air conditioning/ refrigeration	0,7%
	Other	1,1%
	Electricity total	2,4%
Coal	Direct process heating	11,4%
	Steam generation for process heating	86,6%
	Steam generation for space heating	2,0%
	Coal total	100,0%
Coal Gas	Steam generation for process heating	100,0%
Light Diesel	Direct process heating	0,1%
	Steam generation for process heating	14,6%
	Diesel total	14,7%
Heavy Furnace Oil	Steam generation for process heating	100,0%

Summary of Energy Inputs Converted to Heat

Total input converted to heat = 911×10^{12} J or 90,1% of total energy inputs

Total useful heat energy = 629×10^{12} J

Efficiency of conversion of energy to heat = 69,1%

2) Conversion of Inputs/........

2) Conversion of Inputs to Mechanical Energy

Fuel or energy source	Conversion Process	Percentage of individual energy sources converted to mechanical energy
Electricity	Motors above 7 kW	42,0%
	Motors below 7 kW	41,5%
	Electricity total	83,5%
L.P.G.	Transport in-factory	100,0%
Light Diesel	Transport in-factory	6,2%
	Transport ex-factory	79,1%
	Diesel total	85,3%

Summary of energy inputs converted to mechanical energy

Total input converted to mech.energy = 95×10^{12} J (or 9,4%)
Total useful mech.energy = 39×10^{12} J
Efficiency of conversion to mech.energy = 41,3%

3) Conversion to Input Energy to Light

Energy Source	Conversion Process	Percentage of electricity input converted to light
Electricity	Incandescent	2,8%
	Fluorescent	3,4%
	Mercury	7,9%
	Electricity total	14,1%

Summary of Energy Inputs Converted to Light

Total input energy converted to light = 6×10^{12} J or (0,5%)
Total useful light energy = 36×10^{9} J
Efficiency of conversion to light = 6,7%

4) Summary of conversion/.......

4) Summary of Conversion Efficiencies by Energy Source

Energy Source	Efficiency of conversion (%)
Electricity	69,4
Coal	68,9
Coal Gas	70,0
L.P.G.	14,0
Petrol	14,0
Diesel	28,2
Heavy Furnace Oil	70,0
Total	66,1

APPENDIX K/.......

APPENDIX K - SUMMARY OF ENERGY UTILIZATION DATA RELATING TO THE PROCESSED FOOD AND BEVERAGE INDUSTRY

(1) Efficiency of conversion by energy source and by sector (%)

Fuel or energy source	Bakeries	Grain Mills	Fish Products	Jam and Canning	Distiller-ies Wineries	Aerated Waters	Sweets Chocolate	Breweries/ Maltworks
Electricity	73,6	76,4	81,6	70,6	82,3	76,5	63,3	69,4
Coal	70,0	-	67,5	70,0	-	70,0	68,4	68,9
Coal Gas	-	-	-	-	-	-	60,0	70,0
L.P.G.	60,0	-	-	14,0	60,0	-	57,1	14,0
Petrol	14,0	-	14,0	14,0	14,0	14,0	14,0	14,0
Light Diesel	58,6	-	21,0	21,0	21,0	21,0	70,0	28,2
Power Paraffin	66,7	-	-	-	-	-	-	-
Light Furnace Oil	-	-	-	70,0	-	-	-	-
Heavy Furnace Oil	-	-	60,0	66,4	-	-	68,0	70,0
Total	63,7	76,4	63,4	67,3	41,0	48,1	67,4	66,1

Efficiency of Energy Conversion/......

Efficiency of Energy Conversion

Sector	Bakeries	Grain Mills	Fish Products	Jam and Canning	Distilleries & Wineries	Aerated Waters	Sweets Chocolates	Breweries/ Maltworks
Efficiency of Energy Conversion								
To heat	65,2	55,0	67,1	68,9	99,2	70,1	69,0	69,1
To mech. energy	60,7	80,9	49,9	53,2	39,6	31,0	75,9	41,3
To light	9,9	6,7	5,9	6,9	7,5	8,1	7,1	6,7
To chemical	-	-	-	50,0	-	-	50,0	-
Other	-	-	-	-	-	-	0,0	-
Total	63,7	76,4	63,4	67,3	41,0	48,1	67,4	66,1
Percentage of total input converted								
To heat	78,4	0,6	78,8	91,3	3,7	43,9	88,3	90,1
To mech. energy	20,5	93,5	21,0	8,1	94,7	55,6	8,3	9,4
To light	1,1	5,9	0,2	0,4	1,6	0,5	1,4	0,5
To chem. energy	-	-	-	0,2	-	-	0,1	-
Other	-	-	-	-	-	-	1,9	-
Total	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0

APPENDIX 5

THE ENERGY REQUIREMENTS OF THE TEXTILE INDUSTRY

(Formerly Report No ESI/17)

SUMMARY

This report details energy usage within the South African textile industry. The main findings of the report are summarized below:

Spinning and Weaving

1) The overall efficiency of energy conversion is 69%.
2) The three major energy inputs are coal (47%), electricity (26%) and heavy furnace oil (22%). Small quantities of other fuels such as liquid petroleum gas, petrol, light diesel and paraffin are also used.
3) Approximately three-quarters of the energy requirements of this sub-sector are converted to heat.
4) Since 1973, the industry has replaced or reconverted some of its oil-firing boilers to coal.
5) The widespread interest in energy conservation shown by the industry is likely to result in a reduction of the specific energy requirements in future.

Manufactured Textile Goods

1) The overall efficiency of energy conversion was 61% during 1975.
2) The largest proportion of the inputs (61%) was converted to mechanical energy.
3) Electricity (55% of the total energy requirements) and light diesel fuel (38%) were the two major energy inputs during 1975.

Knitting Mills

1) Energy was converted at an overall efficiency of 67% by the mills surveyed during 1975.
2) Light diesel fuel (57%) and electricity (39%) were the two major energy inputs over the same period.
3) Over 60% of the energy inputs were converted to heat, while 34% was converted to mechanical energy and 4% to light.

Cordage, Rope and Twine

1) Energy was converted at an efficiency of 73% by this subsector during 1975.

2) Seventy percent of the inputs were converted to heat while nearly 30% were converted to mechanical energy.

3) The major energy inputs during 1975 were heavy furnace oil (42%), electricity (32%) and coal (23%).

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LIST OF APPENDICES

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LIST OF TABLES

1. INTRODUCTION

According to the most recent Census of Manufacturing (1), the textiles industry accounted for about 5% of the total energy purchases by the manufacturing sector of the economy during 1968.

Approximately 45% of the textile industry's energy requirements were utilized in cotton spinning and weaving factories.

After meetings with representatives of the industry, a questionnaire, similar to the one drawn up for small industrial energy-users, was distributed to more than fifty factories in the textile industry. Ten completed questionnaires were received and apologies were received from most of the other companies. A lack of detailed statistics and a shortage of manpower were the two most common excuses given for not completing the questionnaire.

In the following sections of this report the energy requirements of the responding factories in the following sub-sectors of the textile industry have been considered:

i) Spinning and Weaving
ii) Manufactured textile goods
iii) Knitting Mills
iv) Cordage, rope and twine

2. SPINNING, WEAVING AND FINISHING OF TEXTILES (SIC 32110 - 32119)

This sector of the economy includes such activities as wool scouring and combing, cotton ginning, fibre working, dyeing, bleaching, printing and finishing of textiles as well as blanket manufacture.

Ten factories with a combined 1975 production of some 37 500 tonnes of product responded to the survey.

The industry is an energy-intensive one as is shown by the specific energy requirements extracted from Appendix A and presented in table 1 below.

TABLE 1/.......

TABLE 1 : SPECIFIC ENERGY USAGE - SPINNING AND WEAVING

YEAR	1965	1970	1973	1974	1975
Specific energy usage (MJ/kg of product)	41,6	48,6	48,4	45,0	51,9

The specific energy requirements have shown some fluctuations over the past ten years. This is the result of a number of factors including conservation programmes, conversions of energy sources and operating factories at below full-capacity.

It is interesting to note that in 1965 and 1970 coal accounted for over 50% of the energy requirements of the factories surveyed. (Appendix A, part c). By 1973, this figure had dropped to 20%, while heavy furnace oil increased in popularity from 1970 (14% of the total energy requirements) to 1973 (46% of the total requirements). Since 1973 there has been a reversal of this trend and in 1975 coal once more accounted for nearly half the requirements and heavy furnace oil only 22%.

The main reason given for the reconversion was the price of heavy furnace oil although the insecurity of supply of oil-based products was also mentioned.

Details of the utilization of energy in this sector are included as Appendix A, part 2 and the main findings are summarized below in table 2.

TABLE 2 : EFFICIENCY OF ENERGY CONVERSION - SPINNING AND WEAVING

	Efficiency of energy conversion (%)	Percentage of total input converted (%)
To heat	69,4	74,2
To mech.energy	72,9	24,3
To light	9,4	1,4
To chemical energy	50,0	0,1
To cleaning agents	0,0	$\angle$ 0,1
Overall	69,4	100,0

Six/.......

Six of the companies surveyed stated that they have already undertaken energy conservation programmes while the other four intend introducing similar measures in the near future.

Further specific energy savings can be expected in the future as larger, more efficient machinery is installed.

New techniques of yarn twisting are being developed and it is hoped that these will further reduce the energy demands of the industry. Unfortunately the responding companies were unable to estimate the savings that would result from the introduction of these new techniques.

As a result of these new techniques and increased interest in energy conservation, the overall specific energy requirements of the industry can be expected to drop slightly in the near future.

3. MANUFACTURED TEXTILE GOODS (SIC 32120 - 32129)

This sector of the economy is responsible for the manufacture of made-up textile goods such as soft furnishings, bags, sacks, tents, tarpaulins, sails and automotive textile goods.

Details of the energy requirements of the six factories included in this survey are included as Appendix B.

It will be seen that electricity (55%) and light diesel (38%) account for the major portion of the energy requirements of this sector. However, there has been a marked shift away from light diesel over the past few years since in 1973 it accounted for over 60% of the energy requirements of the factories surveyed.

This shift has resulted in an improvement in the specific energy requirements as can be seen below.

TABLE 3 : SPECIFIC ENERGY USAGE - MANUFACTURED TEXTILE GOODS

YEAR	1973	1974	1975
Specific energy usage (MJ/kg of product)	8,6	5,7	5,4

Prior to/...........

Prior to 1974, two of the factories surveyed generated their own electricity requirements and consequently suffered the losses associated with the generation. However, since converting to purchased electricity, these losses have been transferred to central power stations and the specific energy usage has improved.

The overall efficiency of energy conversion within this sector has been calculated in section 2 of Appendix B and the main findings are summarized below.

TABLE 4 : EFFICIENCY OF ENERGY CONVERSION - MANUFACTURED TEXTILE GOODS

	Efficiency of energy conversion (%)	Percentage of total input converted (%)
To heat	68,3	34,3
To mech. energy	60,5	61,2
To light	9,2	4,5
Overall	60,9	100,0

None of the companies have as yet undertaken any definite energy conservation programmes and only one stated that they intend to introduce such a programme within the next five years.

Since no new technologies or processes are likely to be introduced in the near future and due to seeming lack of interest in energy conservation measures, no significant changes in the efficiency of energy conversion can be expected in the near future.

4. KNITTING MILLS (SIC 32130 - 32139)

The sector manufactures hosiery and other knitted clothing. Details of the energy usage pattern within this sector are included as Appendix C. Light diesel is the major energy input to this sector, accounting for some 57% of the total energy requirements. Electricity accounts for a further 39%. Unfortunately data was only obtained for 1975

so it was /.......

so it was not possible to identify trends in energy usage in this sector.

The specific energy requirements, as calculated in Appendix C, are summarized below in table 5.

TABLE 5 : SPECIFIC ENERGY USAGE - KNITTING MILLS

YEAR	1975
Specific energy usage (MJ/kg of product)	13,6

The efficiency of energy conversion has been calculated in section 2 of Appendix C and for convenience, the main findings are summarised below in table 6.

TABLE 6 : EFFICIENCY OF ENERGY CONVERSION - KNITTING MILLS

	Efficiency of energy conversion (%)	Percentage of total input converted (%)
To heat	68,9	61,8
To mech.energy	71,6	34,1
To light	10,0	4,2
Overall	67,4	100,0

Neither of the companies surveyed stated that they had converted from one energy source to another in the past five years and neither intends such a conversion within the next five years.

One company has undertaken an energy conservation programme within the past five years, but was unable to estimate the savings resulting from this.

Neither of the companies expect new processes or technologies to be introduced within the next five years and any change in the efficiency of energy conversion would therefore only result from increased energy conservation measures.

5. CORDAGE, ROPE AND TWINE (SIC 32150)

Replies were obtained from four manufacturers in this sector and the details of their energy requirements are included as Appendix D.

Of the total input requirements approximately 70% are converted to heat and this accounts for the high proportion of the input requirements made up by heavy furnace oil (41,9%) and coal (22,9%). The popularity of heavy furnace oil has declined over the past three years from 72% of the total energy requirements in 1973 to 42% in 1975.

The specific energy requirements of the sector are summarized below:

TABLE 7 : SPECIFIC ENERGY USAGE - CORDAGE, ROPE AND TWINE

YEAR	1973	1974	1975
Specific Energy Usage (MJ/kg of product)	17,6	14,2	15,8

The variations in the specific energy requirements over the past three years are due partly to fluctuations in the demand for electricity. In 1974 for instance electricity accounted for 37,8% of total requirements and this declined to 32,4% in 1975. Since electricity is converted at the highest conversion efficiency of all the energy inputs to the industry (see Appendix D, section 2), it can be expected that the specific energy requirements would be reduced as the electricity requirements (expressed as a percentage of the overall energy requirements) increased.

Further details of the efficiency of energy conversion are included below in table 8:

TABLE 8 : EFFICIENCY OF ENERGY CONVERSION - CORDAGE, ROPE AND TWINE

	Efficiency of energy conversion (%)	Percentage of total input converted (%)
To heat	71,8	69,7
To mech. energy	78,7	28,6
To light	10,0	1,6
Not stated	0,0	0,1
Overall	72,8	100,0

It was mentioned earlier that the popularity of heavy furnace oil as an energy source has declined over the past three years. This is borne out by the fact that two of the four companies have converted to coal in that period. The main reason given for the conversion was the increased cost of heavy furnace oil.

None of the companies have actively undertaken any energy conservation programmes within the past five years, although the conversion from heavy furnace oil to coal could be considered as a (imported energy) conservation measure.

Although increased attention will be paid to energy costs in the future, none of the companies stated that they intend instituting a co-ordinated conservation programme in the near future.

Similarly none of the companies expect new technolgies or processes to be adopted within the forseeable future and consequently, the future specific energy requirements and energy conversion efficiency are not expected to change by any significant amount.

6. DISCUSSION

According to the factories surveyed energy accounts for between 5% and 10% of the overall manufacturing costs and it is therefore not surprising that every responding company is showing interest in methods to reduce their energy requirements.

This interest/.........

This interest includes such measures as the installation of solar water heating equipment and the appointment of energy consultants. Although these steps will undoubtedly bring about savings both in money and energy, they are likely to be small (5% - 10%). It would need the introduction of new technology to significantly change the energy requirements of the industry as a whole.

Such a technology could be man-made fibres. The manufacturers of cotton and wool-based fabrics now have to compete with synthetic fibres which in some cases are cheaper to produce. The capture of a portion of the market by synthetic fibres has an adverse effect on the growth rate of the natural fibre industry and thus slows down the increased demand for energy.

7. ACKNOWLEDGEMENTS/........

7. ACKNOWLEDGEMENTS

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6) David Whitehead and Sons (S.A.) Ltd
7) Esludo Mills (Pty) Ltd
8) Hebox Textiles Ltd
9) Mooi River Textiles Ltd
10) Nigel Textile Works (Pty) Ltd
11) Pan Prints (Pty) Ltd
12) Pan Textured Yarns (Pty) Ltd
13) Romatex Mills Ltd
14) SBH Cotton Mills (Pty) Ltd
15) Spilo/Platex (Pty) Ltd
16) Standerton Mills (Pty) Ltd
17) Sunnyside Hosiery Co (Pty) Ltd
18) Tapes and Laces (Pty) Ltd
19) Toga Linings (Pty) Ltd
20) Transkei Textiles and Plastics (Pty) Ltd
21) Wellington Industries (Pty) Ltd

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8. REFERENCES

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Appendix A/........

APPENDIX A - SPINNING AND WEAVING

1) Energy Inputs - Spinning and Weaving

a) Energy Inputs - Physical Units

ENERGY SOURCE	1965	1970	1973	1974	1975
Electricity (1000 kWh)	28 400	73 264	90 261	133 953	143 135
Coal (tonnes)	7 683	20 132	8 926	13 818	33 981
Liquid Petroleum Gas (kilolitres)	314	396	421	493	507
Petrol (kilolitres)	998	1 347	1 522	1 638	1 625
Light Diesel (kilolitres)	18	426	469	348	292
Power Paraffin (kilolitres)	1	2	3	3	4
Illuminating Paraffin (kilolitres)	1	2	3	3	4
Light Furnace Oil (kilolitres)	8	49	47	58	45
Heavy Furnace Oil (tonnes)	751	3 399	13 087	13 708	10 401
No. surveyed	5	8	8	10	10

b) Energy Inputs/.......

b) Energy Inputs - Common Energy Units (10^{12}J)

ENERGY SOURCE	1965	1970	1973	1974	1975
Electricity	102	264	325	482	515
Coal	207	544	241	373	917
Liquid Petroleum Gas	8	11	11	13	13
Petrol	34	46	53	57	56
Light Diesel	1	16	18	13	11
Power Paraffin	<1	<1	<1	<1	<1
Illuminating Paraffin	<1	<1	<1	<1	<1
Light Furnace Oil	<1	2	2	2	2
Heavy Furnace Oil	31	142	546	572	434
Total	385	1 024	1 195	1 512	1 949
Production (tonnes of product)	9 255	21 070	24 707	33 575	37 550
Specific Energy Usage (MJ/kg of product)	41,6	48,6	48,4	45,0	51,9

c) Energy inputs expressed/........

c) Energy inputs expressed as a percentage of the total energy requirements

ENERGY SOURCE	1965	1970	1973	1974	1975
Electricity	26,6	25,8	27,2	31,9	26,4
Coal	53,9	53,1	20,2	24,7	47,1
Liquid Petroleum Gas	2,2	1,0	0,9	0,9	0,7
Petrol	9,0	4,5	4,4	3,7	2,9
Light Diesel	0,2	1,6	1,5	0,9	0,6
Power Paraffin	<0,1	<0,1	<0,1	<0,1	<0,1
Illuminating Paraffin	<0,1	<0,1	<0,1	<0,1	<0,1
Light Furnace Oil	0,1	0,2	0,2	0,2	0,1
Heavy Furnace Oil	8,1	13,8	45,7	37,8	22,3
Total	100,0	100,0	100,0	100,0	100,0

2) Energy Utilization - Spinning and Weaving

a) Energy Inputs Converted to Heat

ENERGY SOURCE	CONVERSION PROCESS	PERCENTAGE OF INDIVIDUAL ENERGY SOURCES CONVERTED TO HEAT
Electricity	Direct process heat Direct space heat Air-conditioning	2,4% 0,3% 13,0%
	Electricity total	15,7%
Coal	Steam generation for process heat Steam generation for space heat	98,7% 1,3%
	Coal total	100,0%
Liquid Pet. Gas	Direct process heat Direct space heat	94,7% 1,7%
	L.P.G. total	96,4%
Light Furnace Oil	Steam generation for process heat	100,0%
Heavy Furnace Oil	Direct process heat Steam generation for process heat Steam generation for space heat	3,9% 95,6% 0,5%
	Heavy Furnace Oil total	100,0%

Summary of energy/......

Summary of energy inputs converted to heat

Total input converted to heat = 1 446 x 10^{12}J (or 74,2%)
Total useful heat energy = 1 000 x 10^{12}J
Efficiency of conversion to heat = 69,4%

b) Inputs converted to mechanical energy

ENERGY SOURCE	CONVERSION PROCESS	PERCENTAGE OF INDIVIDUAL ENERGY SOURCES CONVERTED TO MECH. ENERGY
Electricity	Motors above 7kW	40,3%
	Motors below 7kW	38,4%
	Electricity total	78,7%
Liquid Petroleum Gas	Transport in-factory	3,6%
Petrol	Transport	100,0%
Light Diesel	Transport	100,0%

Summary of inputs converted to mechanical energy

Total input converted to mechanical energy = 473 x 10^{12}J (or 24,3%)
Total useful mech. energy = 331 x 10^{12}J
Efficiency of conversion to mech. energy = 72,9%

c) Energy Inputs Converted to Light

ENERGY SOURCE	CONVERSION PROCESS	PERCENTAGE OF INDIVIDUAL ENERGY SOURCES CONVERTED TO LIGHT
Electricity	Incandescent	0,4%
	Fluorescent	4,8%
	Mercury	0,2%
	Electricity total	5,3%

Summary of inputs converted to light

Total input energy converted to light = 27 x 10^{12}J (or 1,4%)
Total useful light energy = 3 x 10^{12}J
Efficiency of conversion to light = 9,4%

d) Energy Inputs/.....

d) Energy Inputs Converted to Chemical Energy

ENERGY SOURCE	CONVERSION PROCESS	PERCENTAGE OF INDIVIDUAL ENERGY SOURCES CONVERTED TO CHEMICAL ENERGY
Electricity	Battery Charging	0,3%

Summary of inputs converted to chemical energy

Total input converted to chemical energy = 2×10^{12}J (or 0,1%)
Total useful chemical energy = 1×10^{12}J
Efficiency of conversion to chemical energy = 50,0%

e) Energy inputs utilized for other purposes

ENERGY SOURCE	CONVERSION PROCESS	PERCENTAGE OF INDIVIDUAL ENERGY SOURCES UTILIZED FOR OTHER PURPOSES
Power Paraffin	Cleaning Agent	100,0%
Illuminating Paraffin	Cleaning Agent	100,0%

Summary of inputs utilized for other purposes

Total input utilized for other purposes = 1×10^{12}J (or $<$0,1%)
Total useful energy = 0
Efficiency of conversion = 0

f) Summary of conversion/.......

f) Summary of Conversion Efficiencies by Energy Source

ENERGY SOURCE	CONVERSION EFFICIENCY
Electricity	72,9%
Coal	70,0%
Liquid Petroleum Gas	58,5%
Petrol	14,0%
Light Diesel	21,0%
Power Paraffin	0,0%
Illuminating Paraffin	0,0%
Light Furnace Oil	70,0%
Heavy Furnace Oil	69,2%
Overall	69,4%

APPENDIX B - MANUFACTURED TEXTILE GOODS

1) Energy Inputs - Manufactured Textile Goods

a) Energy Inputs - Physical Units

ENERGY SOURCES	1973	1974	1975
Electricity (1000 kWh)	10 789	11 529	11 874
Petrol (kilolitres)	4	5	5
Light Diesel (kilolitres)	1 916	781	778
Heavy Furnace Oil (kilolitres)	131	173	135
No. surveyed	6	6	6

b) Energy Inputs - Common Energy Units (10^{12}J)

ENERGY SOURCE	1973	1974	1975
Electricity	39	42	43
Petrol	< 1	< 1	< 1
Light Diesel	73	30	30
Heavy Furnace Oil	5	7	6
Total	117	79	78
Production (tonnes of product)	13 609	13 834	14 536
Specific Energy Usage (MJ/kg of product)	8,6	5,7	5,4

c) Energy Inputs as a Percentage/.......

c) Energy Inputs as a Percentage of the Total Energy Requirements

ENERGY SOURCE	1973	1974	1975
Electricity	33,1	52,8	54,7
Petrol	0,1	0,2	0,2
Light Diesel	62,1	37,8	37,8
Heavy Furnace Oil	4,7	9,2	7,2
Total	100,0	100,0	100,0

2. Energy Utilization - Manufactured Textile Goods

a) Energy Inputs converted to Heat

ENERGY SOURCE	CONVERSION PROCESS	PERCENTAGE OF INDIVIDUAL ENERGY SOURCES CONVERTED TO HEAT
Electricity	Direct process heat Air-conditioning	7,5% 9,4%
	Electricity total	16,9%
Light Diesel	Direct process heat	27,8%
	Steam generation for space heating	15,3%
	Humidity control	4,2%
	Light Diesel total	47,3%
Heavy Furnace Oil	Steam Generation for process heat	80,0%
	Steam generation for space heat	20,0%
	Heavy Furnace Oil total	100,0%

Summary of Inputs Converted to Heat

Total input energy converted to heat = 27×10^{12}J (or 34,3%)

Total useful heat energy = 18×10^{12}J

Efficiency of conversion to heat = 68,3%

b) Energy Inputs converted to/......

b) Energy Inputs Converted to Mechanical Energy

ENERGY SOURCE	CONVERSION PROCESS	PERCENTAGE OF INDIVIDUAL ENERGY SOURCES CONVERTED TO MECH.ENERGY
Electricity	Motors above 7kW	36,9%
	Motors below 7kW	38,1%
	Electricity total	75,0%
Petrol	Transport	100,0%
Light Diesel	Machinery Drive	52,7%

Summary of Inputs Converted to Mechanical Energy

Total input converted to mechanical energy = 48×10^{12}J (or 61,2%)

Total useful mechanical energy = 29×10^{12}J

Efficiency of conversion to mechanical energy = 60,5%

c) Energy Inputs Converted to Light

ENERGY SOURCE	CONVERSION PROCESS	PERCENTAGE OF INDIVIDUAL ENERGY SOURCES CONVERTED TO LIGHT
Electricity	Incandescent	0,1%
	Halogen	0,5%
	Fluorescent	6,7%
	Mercury	0,9%
	Electricity total	8,2%

Summary of inputs converted to light

Total input energy converted to light = 3×10^{12}J (or 4,5%)

Total useful light energy = $<1 \times 10^{12}$J

Efficiency of conversion to light = 9,2%

d) Summary of Conversion Efficiencies by Energy Source

ENERGY SOURCE	CONVERSION EFFICIENCY
Electricity	73,3%
Petrol	14,0%
Light Diesel	41,4%
Heavy Furnace Oil	70,0%
Overall	60,9%

Appendix C/......

APPENDIX C - KNITTING MILLS

1) Energy Inputs - Knitting Mills

a) Energy Inputs (Physical Units)

ENERGY SOURCE	1975
Electricity (1000 kWh)	517
Petrol (kilolitres)	5
Light Diesel (kilolitres)	72
No. Surveyed	2

b) Energy Inputs - Common Energy Units (10^{12}J)

ENERGY SOURCE	1975
Electricity	2
Petrol	<1
Light Diesel	3
Total	5
Production (tonnes of product)	369
Specific Energy Usage (MJ/kg of product)	13,6

c) Energy Inputs as a Percentage of the Total Energy Requirements

ENERGY SOURCE	1975
Electricity	39,0
Petrol	3,6
Light Diesel	57,4
Total	100,0

2) Energy Utilization - Knitting Mills/.

2) Energy Utilization - Knitting Mills

a) Energy Inputs Converted to Heat

ENERGY SOURCE	CONVERSION PROCESS	PERCENTAGE OF INDIVIDUAL ENERGY SOURCES CONVERTED TO HEAT
Electricity	Air-conditioning	11,3%
Light Diesel	Steam generation for process heat	100,0%

Summary of inputs converted to heat

Total energy input converted to heat = 3×10^{12}J (or 61,8%)

Total useful heat energy = 2×10^{12}J

Efficiency of conversion to heat = 68,9%

b) Inputs Converted to Mechanical Energy

ENERGY SOURCE	CONVERSION PROCESS	PERCENTAGE OF INDIVIDUAL ENERGY SOURCES CONVERTED TO MECHANICAL ENERGY
Electricity	Motors above 7kW Motors below 7kW	26,4% 51,6%
	Electricity total	78,0%
Petrol	Transport	100,0%

Summary of inputs converted to mechanical energy

Total input converted to mechanical energy = 2×10^{12}J (or 34,1%)

Total useful mechanical energy = 1×10^{12}J

Efficiency of conversion to mechanical energy = 71,6%

c) Energy Inputs converted to light/......

c) Energy Inputs Converted to Light

ENERGY SOURCE	CONVERSION PROCESS	PERCENTAGE OF INDIVIDUAL ENERGY SOURCES CONVERTED TO LIGHT
Electricity	Fluorescent	10,6%

Summary of Inputs converted to Light

Total input energy converted to light = $<1 \times 10^{12}$J (or 4,2%)

Total useful light energy = $<1 \times 10^{12}$J

Efficiency of conversion to light energy = 10,0%

d) Summary of conversion efficiencies by energy source

ENERGY SOURCE	CONVERSION EFFICIENCY
Electricity	68,5%
Petrol	14,0%
Light Diesel	70,0%
Overall	67,4%

APPENDIX D/........

APPENDIX D - CORDAGE, ROPE AND TWINE

1) Energy Inputs - Cordage, Rope and Twine

a) Energy Inputs - Physical Units

ENERGY SOURCE	1973	1974	1975
Electricity (1000kWh)	26 048	28 962	24 777
Coal (tonnes)	60	60	2 338
Liquid Petroleum Gas(kilolitres)	67	53	59
Petrol(kilolitres)	120	132	136
Light Diesel (kilolitres)	10	12	18
Illuminating Paraffin (kilolitres)	22	17	15
Heavy Furnace Oil (tonnes)	6 548	3 904	2 769
No surveyed	4	4	4

b) Energy Inputs - Common Energy Units (10^{12}J)

ENERGY SOURCE	1973	1974	1975
Electricity	94	104	89
Coal	2	2	63
Liquid Petroleum Gas	2	1	2
Petrol	4	5	5
Light Diesel	< 1	< 1	1
Illuminating Paraffin	1	1	1
Heavy Furnace Oil	269	163	115
Total	372	276	275
Production (tonnes of product)	21 103	19 458	17 359
Specific energy usage (MJ/kg of product)	17,6	14,2	15,8

c) Energy Inputs as a percentage/......

c) Energy Inputs as a Percentage of the Total Energy Requirements

ENERGY SOURCE	1973	1974	1975
Electricity	25,2	37,8	32,4
Coal	0,4	0,6	22,9
Liquid Petroleum Gas	0,5	0,5	0,6
Petrol	1,1	1,7	1,7
Light Diesel	0,1	0,2	0,3
Illuminating Paraffin	0,2	0,2	0,2
Heavy Furnace Oil	72,4	59,0	41,9
Total	100,0	100,0	100,0

2) Energy Utilization - Cordage, Rope and Twine

a) Energy Inputs converted to heat

ENERGY SOURCE	CONVERSION PROCESS	PERCENTAGE OF INDIVIDUAL ENERGY SOURCES CONVERTED TO HEAT
Electricity	Direct process heat	12,8%
Coal	Steam generation for process heat	85,4%
	Steam generation for space heat	14,6%
	Coal total	100,0%
Heavy Furnace Oil	Steam generation for process heat	85,0%
	Steam generation for space heat	15,0%
	Heavy Furnace Oil Total	100,0%

Summary of energy inputs converted to heat

Total energy input converted to heat = 190×10^{12}J (or 69,7%)

Total useful heat energy = 136×10^{12}J

Efficiency of conversion to heat = 71,8%

b) Inputs converted/......

b) Inputs converted to mechanical energy

ENERGY SOURCE	CONVERSION PROCESS	PERCENTAGE OF INDIVIDUAL ENERGY SOURCES CONVERTED TO MECHANICAL ENERGY
Electricity	Motors above 7 kW	64,9%
	Motors below 7 kW	17,4%
	Electricity total	82,2%
Petrol	Transport	100,0%

Summary of inputs converted to mechanical energy

Total input converted to mechanical energy = 78×10^{12}J (or 28,6%)

Total useful mechanical energy = 61×10^{12}J

Efficiency of conversion to mechanical energy = 78,7%

c) Energy Inputs converted to Light

ENERGY SOURCE	CONVERSION PROCESS	PERCENTAGE OF INDIVIDUAL ENERGY SOURCES CONVERTED TO LIGHT
Electricity	Fluorescent	5,0%

Summary of energy inputs converted to light

Total input converted to light = 4×10^{12}J (or 1,6%)

Total useful light energy = $< 1 \times 10^{12}$J

Efficiency of conversion to light = 10,0%

d) Summary of conversion efficiencies by energy source

ENERGY SOURCE	CONVERSION EFFICIENCY
Electricity	81,5%
Coal	70,0%
Liquid Petroleum Gas	Use not stated
Petrol	14,0%
Light Diesel	Use not stated
Illuminating Paraffin	Use not stated
Heavy Furnace Oil	70,0%
Overall	72,8%

APPENDIX 6

ENERGY USAGE IN THE CLOTHING INDUSTRY

(Formerly Report No ESI/1)

INDEX

LIST OF TABLES

1) INTRODUCTION

Before the National Energy Survey was undertaken, it was decided to carry out a pilot survey. This pilot survey would give an indication of the information readily available to manufacturers, as well as the response we could expect from them in the future.

The clothing industry was selected since it is well represented in Cape Town, there being close to 300 factories. However, to illustrate the high degree of fragmentation within the clothing industry (1) a recent survey noted that only 16% of the total manufacturing establishments were responsible for about 85-90% of total gross production.

Since the clothing industry is a relatively small energy user, it was to be expected that records of energy use would be scant and little attention would have been given to methods of energy conservation. Partly for this reason the Cape Town City Council was approached to obtain annual electricity consumption figures. It was found that these figures are compiled on an annual basis for all bulk consumers.

The Industrial Council for the Clothing Industry was approached and they supplied a list of factories broken down according to the number of employees. From this list and annual electricity consumption figures, a list of sixteen manufacturers was drawn up.

Each of the manufacturers was visited personally. The purpose of the survey was explained and a questionnaire relating to energy consumption was left with them. After a series of follow-up telehone calls, it became apparent that the larger companies were going to provide information while the smaller concerns gave a number of excuses, the most popular being that they were too busy.

A deadline for the return of the completed questionnaire was set and after this date nine completed questionnaires were received, of which two had insufficient information for analysis purposes.

Since there are approximately 1 500 clothing factories in South Africa (1), the seven questionnaires relate to 0,47% of the total. Six of the companies visited would be included in the top 16% of companies and thus account for at least 2,1% of total South African Production.

The remaining seven questionnaires representing 44% of the companies originally approached were processed and the results are included in this report.

2) INPUT ENERGY

The fuel and electrical energy consumed by the seven selected factories for the years 1973 and 1974 are detailed below in Table 1:

	1973				1974			
Factory Number	Electricity (kwh)	Diesel Oil (l.)	Fuel Oil (l.)	Coal (tonnes)	Electricity (kwh)	Diesel (l.)	Fuel Oil (l.)	Coal (tonnes)
1	621 000	-	68 300	-	795 000	-	61 600	-
2	1 898 491	1 440	370 512	-	2 118 349	1 360	392 922	-
3	7 319 960	-	-	-	7 577 600	-	475	-
4	636 800	-	720 000	-	668 000	-	1 080 000	-
5	190 280	1 037	-	-	134 240	1 000	-	-
6	9 681 000	-	-	1 880	11 694 000	-	-	1 728
7	1 422 308	7 500	1 396 161	-	1 470 943	19 400	1 457 290	-

TABLE 1

ENERGY INPUT TO SELECTED CLOTHING FACTORIES IN

CAPE TOWN

Using the gross calorific values as shown below the values in the above table were converted to megajoules.

Gross Calorific Values:

Industrial Diesel Fuel	-	45,6 MJ/kg	Specific Gravity 0,85
Fuel Oil	-	43,85 MJ/kg	Specific Gravity 0,93
Bituminous Coal (Grade A)	-	28,00 MJ/kg	

The results of this are shown in Table 2.

Factory Number	1973				1974			
	Electricity	Diesel Oil	Fuel Oil	Coal	Electricity	Diesel Oil	Fuel Oil	Coal
	MEGAJOULES				MEGAJOULES			
1	2 235 600	-	2 785 308	-	2 862 000	-	2 512 079	-
2	6 834 568	55 814	15 109 664	-	7 626 056	52 714	16 023 555	-
3	26 351 856	-	-	-	27 279 360	18 411	-	-
4	2 292 480	-	29 361 960	-	2 404 800	-	44 042 940	-
5	685 008	40 194	-	-	483 264	38 760	-	-
6	34 851 600	-	-	52 640 000	42 098 400	-	-	48 384 000
7	5 120 309	290 700	56 936 142	-	5 295 395	751 944	59 429 014	-
Totals	78 371 421	386 708	104 193 070	52 640 000	88 049 275	861 829	122 007 588	48 384 000
Percentage Breakdown	33,27	0,16	44,23	22,34	33,96	0,33	47,06	18,65

TABLE 2

ENERGY INPUT IN MEGAJOULES FOR SELECTED CLOTHING FACTORIES IN CAPE TOWN

A summary of the above table, showing gross energy inputs to the different factories is given as Table 3 :

FACTORY NUMBER	1973	1974	PERCENTAGE INCREASE
	MEGAJOULES		
1	5 020 908	5 374 079	7,03
2	22 000 046	23 702 325	7,74
3	26 351 856	27 298 731	3,59
4	31 654 440	46 447 740	46,73
5	725 202	522 024	-28,03
6	87 491 600	90 482 400	3,42
7	62 347 151	65 476 353	5,02
TOTALS	235 591 203	259 303 652	10,07

TABLE 3

SUMMARY OF INPUT ENERGY TO SELECTED CLOTHING FACTORIES IN CAPE TOWN

3) METHODS OF ENERGY CONVERSION

From the questionnaires which were received it was possible to identify all major items of plant as well as the time that they were in operation.

Details of plant for the seven factories are to be found in Appendix A.

Using the above information, it was possible to determine where the different forms of input energy were converted in the factories.

Appendix B shows the sample calculation for Factory 1.

To calculate the useful energy consumption, it is necessary to know the efficiency of conversion. Reference has been made to engineering handbooks (2), (3) to establish efficiencies of electric motors, belt drives and other standard equipment. This information was further supplemented by reference to technical articles (4) and by personal approaches to plant manufacturers.

A list of conversion efficiencies for plant found in the clothing factories is included as Appendix C.

Calculations similar to those detailed in Appendix B were carried out on all items of plant and these results in tabular form are included as Appendix D. From the calculations in Appendix D it is possible to calculate the overall efficiency of conversion of electricity to other energy forms.

Appendix E details the conversion of coal and oil and similarly an efficiency of conversion for these fuels is calculated.

The conversion of energy into either heat, light or mechanical energy is considered in Appendix F. Conversion efficiencies for these three energy forms are calculated.

Finally, in Appendix G, an overall efficiency of energy conversion considering all forms of input and useful energy is calculated, and Appendix H details the products of the companies visited.

4) RESULTS

The energy used by the clothing industry in the Western Cape is obtained from three principal sources, namely fuel oil, electricity and coal. Diesel fuel is used for space heating purposes but only constitutes a fraction of one percent of the total energy input. About 47% of the energy input is derived from fuel oil, used to fire boilers. A large proportion of this process heat is used to dye fabrics. This is carried out in large stainless steel vessels with little or no thermal insulation and is therefore an area where energy conservation measures could be applied.

Fractional horse-power electric motors are used widely for machinery drives and this together with the lighting load accounts for much of the electricity consumption, which amounts to about 34% of the total energy consumption. Only one of the factories visited had electric boilers installed, and they justified this by making use of off-peak electricity tariffs.

Coal-fired boilers were only installed at one factory, although this situation will change within the next few years. This aspect is dealt with more fully in the section dealing with trends in energy consumption.

Oil-fired boilers have been favoured in the past because of their rapid load-changing characteristics and the fact that there is no ash disposal problem. The cost of railing coal to the Western Cape was another factor which in the past made oil an attractive alternative.

The efficiency of conversion of the input energy (detailed in Appendices D and E) is very dependent on the type of plant installed. Due to the large number of small electric motors and the high ratio of factory lighting power consumption to the overall electricity consumption (13,96%), the efficiency of electricity conversion is fairly low, being 65,8%.

The conversion of oil and coal on the other hand is higher (75%) since most of this energy is converted in industrial boilers with an efficiency of about 75%.

Of the total input energy, 70% is converted to heat, 5% to light and the remaining 25% to mechanical energy.

The conversion of input energy to heat takes place with a 76% efficiency, to light at 17% and to mechanical energy at 70%.

After conversion to useful energy, the ratio of usage is as follows ; heat 75%, light 1% and mechanical energy 24%.

The overall conversion of input energy to useful energy, considering all forms of fuel takes place at an efficiency of 71,8%.

For ease of reference, the above figures are summarized below in Table 4 :

		CONVERSION EFFICIENCY	PERCENTAGE OF TOTAL INPUT ENERGY
1)	INPUT ENERGY		
	Electricity	65,8%	34%
	a) Coal & b) Oil	75,0%	a) 19% b) 47%
	Conversion to heat	76%	70%
	Conversion to light	17%	5%
	Conversion to mechanical energy	70%	25%
2)	USEFUL ENERGY		
	Used as heat	-	75%
	Used as light	-	1%
	Used as mechanical energy	-	24%
3)	OVERALL ENERGY CONVERSION EFFICIENCY	72%	

TABLE 4

SUMMARY OF ENERGY CONVERSION DETAILS FOR SELECTED CLOTHING FACTORIES IN CAPE TOWN

5) TRENDS IN ENERGY CONSUMPTION

The first point to be noted is that the fuel bill of the factories visited accounted for about 1% of the overall manufacturing costs. The industry is very labour intensive, so any increase in productivity has a far greater effect than any energy saving measures.

In the past there has been no reason to change over from oil to coal, but with the present insecurity of oil supplies, this situation is changing.

Of the companies who returned questionnaires, the one who is at present using coal had been considering conversion to oil before the so-called "oil crisis" - since then they have dropped the idea.

The factory which has electric boilers installed was using oil until 1974, when with the price increases, it was decided to convert to electricity.

Of the remaining five companies, two intend converting from oil to coal in 1975. This will result in the percentage of input energy derived from coal increasing by about 24% to 43% while oil energy will decrease from 47% to 23%. The other three companies have no immediate plans to convert from oil.

Since the industry is extremely labour intensive, a possible method to increase productivity is to introduce automation. However, the small length of run of most clothing does not warrant the installation of expensive automation equipment, even though labour problems are experienced in this industry. These problems have been discussed elsewhere. (See Appendix I).

The cutting of cloth using laser equipment is in its infancy overseas and is not likely to be introduced to South Africa on any significant scale for many years to come.

6) CONCLUSIONS

The pilot survey has indicated that due to increased wage bills, an increased amount of low cost automation will be used. However, the widespread installation of automatic equipment will be hindered by the shortness of runs, but could make an appearance in factories producing overalls and other non-fashion garments, since it has been predicted (1) that by 1976 there will be a market for 9 410 000 overalls, boiler suits and dust coats.

Considering the points above, it is not expected that the energy consumption per unit of output will alter significantly in the near future.

The Western Cape still has the largest percentage of weekly paid persons in the industry i.e. 35% in comparison with 26% in the Transvaal, 19% in Natal and 20% in the rest of the country in 1970 (1). For this reason it is thought that the results of this report are representative of the South African clothing industry as a whole.

7. REFERENCES

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APPENDIX A

DETAILS OF ELECTRICAL PLANT

CODE NUMBER	PLANT DETAILS	RATED POWER	NOTES	ENERGY CONVERSION EFFICIENCY.
MANUFACTURER NO 1				
1-1	Air Compressor	37	Elec motors & belt drive	60
1-2	Shirt Presses	19	" " " " "	82
1-3	Boiler-Feed Pumps	2	Electric Motors	82
1-4	Sewing machines	49	0,37kw motors & belt	66
1-5	Cutting machines	25	0,84kw motors & belt	72
1-6	Lighting	151	Neon	17
1-7	Air Conditioners	10		57
MANUFACTURER NO 2				
2-1	Air Compressor	50	Elec motors & belt drive	55
2-2	Vacuum pumps	76	40 & 25 H.P. units	55
2-3	Boiler-Feed Pumps	20	Water & fuel feed	82
2-4	Band knife m/cs	45	Direct coupled motor	80
2-5	Sewing machines	448	½ H.P. units & belts	66
2-6	Lighting	311	Neon	17
MANUFACTURER NO 3				
3-1	Automatic m/cs	87	Knitting etc.	65
3-2	Manual m/cs	2409	Sewing cutting etc	65
3-3	Lighting	220	Neon	17
3-4	Heating equip	278	Boilers, irons etc.	100
MANUFACTURER NO 4				
4-1	Air Compressors	10	Belt drive	50
4-2	Sewing machines	400	800 x ½ HP, 400 x ⅓ HP	66
4-3	Band knife cutters	36	16 x 3 HP motors	75
4-4	Plasticising m/cs	a) 6 b) 30	a) Drive b) Drying elements	a) 74 b)100
4-5	Extraction fans	14		46
4-6	Air conditioners	37		57
4-7	Mixing machines	27	1 x 10 HP, 2 x 3HP motors	76
4-8	Lighting	a)108 b) 4	Neon a) 52,5 hr week b) 100 hr week	17
MANUFACTURER NO 5				
5-1	Sewing m/cs	62	3/4 HP motors	66
5-2	Air conditioners	2		57
5-3	Lighting	30	Neon	17

CODE NUMBER	PLANT DETAILS	RATED POWER	NOTES	ENERGY CONVERSION EFFICIENCY
MANUFACTURER NO 6				
6-1	Circ. Knitting m/cs	582	2 HP motors	74
6-2	Texturisers	389	a) 389 kw drive	a) 78
		201	b) 201 kw heaters	b) 100
6-3	Air Conditioners	67		57
6-4	Lighting	32	Neon - 46 hr week	17
6-5	Lighting	72	Neon - continuous	17
6-6	Sewing m/cs	50	½ and 1/4 HP motors	63
MANUFACTURER NO 7				
7-1	Knitting m/cs	88		74
7-2	Hosiery m/cs	51	Multiple drive	63
7-3	Circular Knitting m/cs	25		74
7-4	Linkers	37	1/3 HP motors	62
7-5	Sewing m/cs	75	½ HP motors	66
7-6	Lighting	48	Neon	17

APPENDIX B

SAMPLE CALCULATION

MANUFACTURER NO 1

General Information:

Hours worked per week = 61,25
Air Compressor utilization = 75%
Boiler operating time = 68 hours/week

Lighting Load:

Installed power = 151 kw

∴ Energy used per annum = 151 x 61,25 x 52 x 3,6 MJ
= 1 731 366 MJ

Efficiency of neon lighting = 17%

∴ Useful energy consumption per annum = 294 332 MJ

Air Compressors:

Installed power = 37kw
Hours in operation per annum = 0,75 x 61,25 x 52
= 2389 hours

∴ Energy used per annum = 37 x 2389 x 3,6 MJ
= 318 215 MJ

Efficiency of the air compressors = 60%
∴ Useful energy consumption per annum = 190 929 MJ

Boiler-Feed Pumps:

Installed power = 2kw
∴ Energy used per annum = 2 x 68 x 52 x 3,6 MJ
= 25 459 MJ

Efficiency of the boiler-feed pumps = 82%
∴ Useful energy consumption per annum = 20 877 MJ

Air Conditioners:

Installed Power = 10 kw

∴ Energy used per annum = 10 x 24 x 365 x 3,6 MJ
= 315 360 MJ

Appendix B/continued

Efficiency of the air conditioners = 57%

∴ Useful energy consumption per annum = 179 755 MJ

Input energy accounted for at this point = 2 390 400 MJ

Total electrical energy consumption in 1974 = 2 862 000 MJ

Energy unaccounted for = 471 600 MJ

The energy so far unaccounted for is consumed by sewing, cutting and pressing machines, as well as other small items not identified on the questionnaire, such as kettles, portable heaters, etc. These small items have been ignored and the utilization time of the other machines is calculated as follows :

Installed power of sewing, cutting and pressing m/cs = 93 Kw

Energy consumed per hour = 93 x 3,6 MJ
= 334,8 MJ

To account for 471 600 MJ, these machines need to be in operation for :

$$\frac{471\ 600}{334,8} = 1408,6 \text{ hours per annum}$$
$$= 27,09 \text{ hours/week}$$

Total working hours per annum = 61,25 x 52
= 31 85 hours

$$\therefore \text{Machine utilization time} = \frac{1408,6}{31\ 85} \text{ Hr/Hr}$$

$$= 0,44 \text{ Hr/Hr}$$

Sewing Machines :

Installed power = 49 Kw

∴ Energy used per annum = 49 x 1408,6 x 3,6 MJ
= 248 477 MJ

Efficiency of sewing m/cs = 66%

∴ Useful energy consumption per annum = 163 995 MJ

Cutting Machines :

Installed power = 25 Kw

∴ Energy used per annum = 25 x 1408,6 x 3,6 MJ
= 126 774 MJ

Efficiency of the cutting machines = 72%

∴ Useful energy consumption per annum = 91 277 MJ

Shirt Presses :

Installed power = 19 Kw

∴ Energy used per annum = 19 x 1408,6 x 3,6 MJ
= 96 348 MJ

Efficiency of the shirt presses = 82%

∴ Useful energy consumption per annum = 79 006 MJ