ENERGY UTILISATION IN SELECTED INDUSTRIAL SECTORS IN SOUTH AFRICA

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I, Anthony Court Huggett, submit this thesis in fulfilment of the requirements for the degree of Master of Science in Engineering. I claim that this is my original work and that it has not been submitted in this or in a similar form for a degree at any University.

ABSTRACT

This thesis presents the findings of an investigation into the use of energy, between the years 1975 and 1984, in five of the major energy-intensive industries in South Africa. Energy use in all economic sectors, from 1964 to 1974, was surveyed in the report "Energy Utilisation in South Africa", published by the Department of Planning and the Environment in 1978. As this report showed the major primary industries to be the largest single users of energy in South Africa, it was decided to isolate a number of major energy-intensive industries for investigation in this study. The 1979 Census of Manufacturing showed five industrial sectors to have consumed 41% by value of the total industrial energy consumption in that year, and it is those with which this thesis is concerned. The five industries are:

The Structural Clay Products Industry,

The Portland Cement Industry,

The Glass Making Industry,

The Iron and Steel Industry,

The Pulp and Paper Industry.

A survey of energy utilisation was conducted in as large a sample as possible in each of the industrial sectors, in the following manner. The major companies in each sector were invited to participate in the survey. Representatives of the management of each company were visited personally and energy use and energy management in the individual plants discussed. Questionnaires regarding the amounts and types of energy used annually, the production output, energy conservation measures

adopted over the period of the survey, and planned for the future, and the level of energy management practiced at each plant, were then left with the company representative for completion by the relevant personnel for each plant in the company. In many cases, it was possible to visit each plant personally. By conducting the survey in this manner, it was possible to achieve a most satisfactory response to the survey, with seventy two percent of the questionnaires being returned.

The aims of this survey were to establish the patterns of energy consumption in the industries concerned, and the effects of technological change thereon, to identify where performance or technology can be improved and to estimate the energy demand of those industries in the near future. The findings are summarised separately below.

THE STRUCTURAL CLAY INDUSTRY

Total energy consumption in the structural clay industry is estimated to be about 21 million gigajoules. Of this, about 17 million gigajoules is accounted for by clay brickmaking, and the remainder by refractory manufacture.

A large percentage of the country's claybrick production occurs in clamp kilns, which produce bricks of variable quality and are subject to the elements. The use of modern tunnel kilns can be expected to increase as quality requirements increase, if energy cost savings justify the capital expenditure.

The potential for energy saving in the claybrick sector is estimated to be as high as 13% of the total energy input. Increased standards of housekeeping, efficient use of kiln exhaust gases, addition of carbonaceous material to the brick making materials and the optimisation of brick perforations are perhaps the most cost effective opportunities available for energy conservation.

The clay brick industry comprises a large number of small concerns, over half the plants are run by the owners, and a few large companies, dominated by Corobrik. The number of small companies, and the depressed market, reduces the likelyhood of the commissioning of much energy efficient, capital intensive plant in the near future. In addition, the levels of energy management in the smaller concerns may only improve through the services of outside consultants. For these companies to consider such action some financial incentive, beyond energy cost savings will probably be necessary.

Refractory production requires an average of 22 gigajoules of energy per ton of product. The current trend towards the use of monolithic refractories, which are fired in situ, will go a long way to reducing this energy intensity. The market is depressed at the moment, however, and further energy conservation measures are likely to be limited to those requiring little or no capital. Such measures could result in an overall reduction in energy consumption of as much as 10%, judging by performances in the industry in other countries.

THE CEMENT INDUSTRY

The cement industry consumes a large amount of energy, about 47 million gigajoules in 1984, with an industry average of approximately 5 gigajoules required per ton of product. Specific consumption varies according to plant type, however, between 3 GJ per ton and 8 GJ per ton.

Most of the older, less efficient wet plant has been decommissioned, but old long dry plant may be expected to remain in production for some time, as it is not cost effective to either decommission it or replace it. The reduction in average specific energy consumption, due to the transition to newer production systems, evident up to 1977, has therefore not been apparent since then. As the present industry capacity is greater than the expected market demand for a number of years, no new modern dry plant is likely to be built in the near future.

As a result, the most significant energy saving in the cement industry is likely to result from the recent developments in blended cements, using pulverised fuel ash and blast furnace slag. If these cements capture a large percentage of the market, the potential energy saving may be as high as 11%. The introduction of other energy saving cement types may also be expected.

In addition, increasing use of automatic control of kilns may be expected to reduce overall specific energy consumption by as much as 4%.

THE GLASS INDUSTRY

About 65% of the glass made in South Africa is containerware, with the remainder being flatware. Only one company manufactures flatware. Between 9 GJ and 20 GJ of energy are required to produce each ton of glass sold, the production of flatware being the more energy intensive process.

The use of Sasol gas is becoming increasingly predominant in this industry, and the gas may soon be the major fuel source used. The technology that appears to offer great potential for energy efficiency is that of the electric furnace. The electric furnace has the added advantage of facilitating quality control. It cannot be expected to become more prevalent in the industry, however, until electricity prices are commensurate with those of other energy sources.

The trend in the industry has been towards decreasing specific energy consumption, and as energy consciousness is obviously increasing, this trend can be expected to continue. As with all the industries surveyed, at present, measures involving minimal expenditure will be favoured. These can be expected to include more disciplined housekeeping measures, reduction in per unit weight of containerware, increased kiln insulation, and the uprating of combustion control. Judging by the trend in the glass industry in the U.K., an energy saving of up to 6% may be possible in this manner.

THE IRON AND STEEL INDUSTRY

The iron and steel industry is dominated by ISCOR, which produces about 80% of the country's steel. The industry is the largest industrial energy consumer in South Africa, accounting for 230 million gigajoules in 1984.

Over 80% of the energy consumed is in the form of coking coal. In this regard the technological developments in direct reduction are of considerable importance in the South African situation, where the resources of high grade coking coal are low. Direct reduction is gaining popularity here, and the construction of the KR direct reduction plant in Pretoria, which produces liquid iron for conversion to steel using coal, is not only a major step for the South African industry, but reported to be a world first.

Another development in this field, which cannot be passed over, is the production of form coke, which can be expected to extend the resources of coking coal in this country.

The importance of energy management is clearly appreciated in this sector. ISCOR has established a Corporate Energy Policy, and committees responsible for ensuring its correct implementation. Other companies have also instigated energy management programmes with the support of top management.

The energy intensive open hearth steelmaking process has now been phased out in this country, as it is no longer economical, and, for the same reason, the rotor furnace is no longer in use. The trend towards the increased production of steel in electric arc furnaces is significant, in that optimal use of scrap and sponge iron is possible. The electric arc furnace also permits more efficient quality control. The percentage of steel production due to continuous casting is also increasing. The energy consumption via this route to the final product is substantially lower than via traditional steel ingot production. Unfortunately continuous casting plant can only be expected to replace existing plant as the latter becomes uneconomical.

The potential for the industry to increase its energy conservation measures through the generation of electricity from waste heat is great. This would probably result in the plants becoming net energy producers, however, which at present is not justifiable economically, as the sale of excess electricity would not provide adequate return. If the industry continues to develop as it has done in the past, it is reasonable to expect reductions of up to 20% in specific energy consumption by the end of the century, as is the case in some other countries.

The ferroalloy industry consumed an estimated 50 million gigajoules of energy in 1984, with electricity accounting for over half of that amount. The potential for energy conservation in the industry appears considerable, and the level of energy management in the sample surveyed could be greatly improved. Unfortunately, present government policy regarding export of beneficiated materials and energy consumption in their production, does not encourage the institution of any energy conservation programmes. Revision of such policy is essential before energy conservation in this industry becomes financially justifiable.

THE PULP AND PAPER INDUSTRY

The pulp and paper industry consumed about 46 million gigajoules of energy in 1984, of which approximately 70% was purchased and the remainder from recovered or waste fuels and self generated electricity. The potential for decreasing the percentage of purchased energy used, from comparison with such countries as Sweden and Finland, is high, and the trend in South Africa towards increasing the amount of in-house energy used is clearly noticeable.

The industry is conscious of the need for energy conservation, and energy management programmes are evident throughout. However, it is the opinion of some that significant further energy cost savings are possible, and that more detailed energy monitoring is essential. The benefit of in-depth plant audits is generally appreciated.

The amount of electricity generated by the industry has remained fairly constant for a number of years, but increased cogeneration is likely in the near future. Control of boiler furnace efficiency has been receiving a large amount of attention in the recent past, and microprocessor control can be expected to be increasingly prevalent. It is estimated that the potential for energy saving in the industry may be as high as 20% of the total purchased energy input, if currently available technology is fully implemented.

GENERAL

The advantages of separate departments responsible for energy management within a company are clearly appreciated in a number of industrialised countries. A number of companies in South Africa will bear testimony to the benefits afforded. In the majority of cases, however, there is a certain amount of scepticism, as case studies are not available for South African circumstances. Government demonstration projects would encourage industry to adopt such measures.

The analysis of the energy situation in South Africa, in general, suffers from a lack of sufficient statistics. This report provides energy utilisation information about five industries, for which no updated information was available, but a great deal more information is needed, not only from South African industries, but from all economic sectors. To obtain the required information at the lowest cost to the government, and with minimal inconvenience to the energy consumer, compulsory returns of energy data should be called for, to be presented, perhaps, as a section of a company report, or to be included in tax returns.

In all, opportunity exists for energy saving in all the sectors covered by this report. The introduction of new technology involving high capital expenditure cannot, however, be generally expected. The full commitment of top management to energy conservation will accelerate activity in this field.

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LIST OF PARTICIPATING COMPANIES

ALGOA BRICK AND TILE
ANGLO ALPHA PORTLAND CEMENT
BLUE CIRCLE CEMENT
CARLTON PAPER CORPORATION
CONSOL LIMITED
COROBRIK
CULLINAN REFRACTORIES
FERROMETALS
ISCOR
METAL BOX GLASS DIVISION
MONDI BOARD MILLS DIVISION
MONDI PAPER DIVISION
MONDI RICHARDS BAY DIVISION
NATAL PORTLAND CEMENT
PILKINTON FLAT GLASS SA
PRETORIA PORTLAND CEMENT
ROSEMA AND KLAVER

SAPPI LIMITED
TRANSALLOYS
VEREENIGING REFRACTORIES

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CHAPTER ONE

INTRODUCTION

Growing concern over energy prices and reserves has resulted in increased research into future energy resources and the use of energy in a modern economy. The concept of energy conservation is now no longer only the preserve of the conservationist, but also a major economic consideration.

The nature of energy demand in a country is a function of economic structure and the efficiency with which energy supplies are used [(1)]. For the purpose of energy and economic planning, it is necessary that energy consumption and economic information be available for each group of activities contributing to the economy. If the energy intensity of each economic group is known, an order of priority for energy conservation activities on a national scale can be established. In a number of industrialised countries, investigations of energy consumption in major economic sectors are conducted on an ongoing basis. In South Africa, though, there is virtually no information available relating to current energy consumption in individual economic sectors. This is cause for concern in a country whose economy is largely based on the energy intensive activities of mining and primary industry.

A clear indication of the need for detailed energy utilisation information in South Africa is given by comparisons of two of its aggregate energy ratios with those of other countries. Inter-country energy usage comparisons are often made to assess a country's national energy efficiency. Lists of energy usage per unit Gross Domestic Product, and per capita, are usually consulted for this purpose. Table 1.1 gives the ratios of energy consumption per unit Gross Domestic Product for ten countries.

ENERGY CONSUMPTION PER UNIT GROSS DOMESTIC PRODUCT FOR TEN COUNTRIES IN 1979

COUNTRY	ENERGY CONSUMPTION PER UNIT GDP (Tons coal equivalent per Thousand 1979 US$)
Australia	Ø,72
Brazil	Ø,62
Canada	1,1Ø
Costa Rica	Ø,31
Japan	Ø,48
Mexico	Ø,79
New Zealand	Ø,48
South Africa	1,49
Sweden	Ø,43
USA	1,Ø5
Mean	Ø,79

Sources: International Financial Statistics
United Nations Yearbook of Energy Statistics

TABLE 1.1

As can be seen in Table 1.1, the ratio for South Africa is significantly higher than those of the other countries. This has caused a great deal of concern amongst those responsible for energy policy in this country.

Consideration of the ratio of energy consumption per capita reveals that this ratio for South Africa is also high. A typical inter-country comparison of this ratio is given in Figure 1.1, which shows the logarithmic values of the ratio for ten countries plotted against the logarithmic values of the GDP per capita ratios for those ten countries. Countries with similar GDP per capita ratios are assumed to be at similar levels of economic development. Hence, it is considered reasonable to expect that their energy per capita ratios will be similar. As a result, it is expected that the points plotted for all countries for any specific year should approximate a straight line.

LOG OF ENERGY PER CAPITA AGAINST LOG OF GDP PER CAPITA FOR TEN COUNTRIES IN 1979

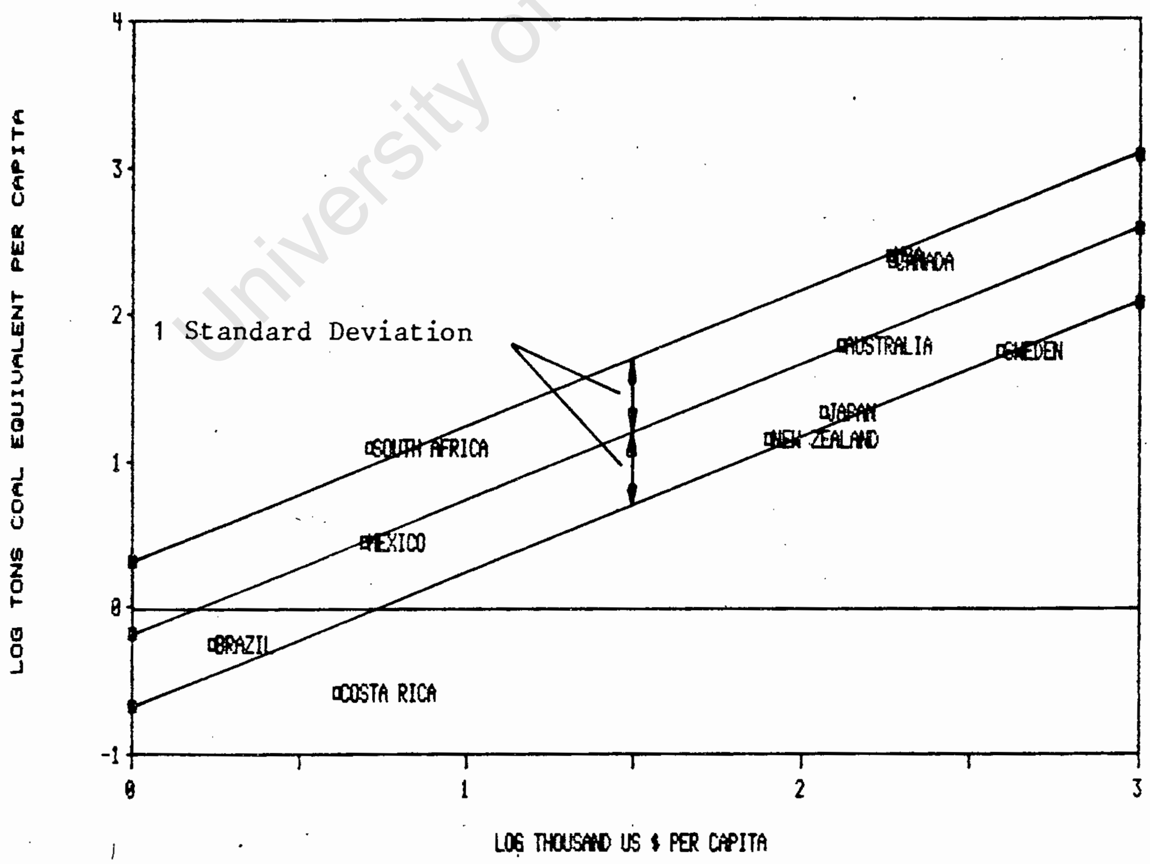


FIGURE 1.1

Numerical data for Figure 1.1 is given in Appendix A. In addition to the points plotted in Figure 1.1, the regression line of these points is given, and on either side of this lines indicating one standard deviation of the differences between the actual dependent variable values, and their corresponding values on the regression line. As can be seen in Figure 1.1, South Africa's energy per capita ratio is higher than those of the countries with similar GDP per capita ratios, and is the point which lies outside the one standard deviation band width.

The fact that the values of these two ratios for South Africa are higher than the norm is cause for concern. Yet, without sufficiently detailed energy consumption data, it is not possible to ascertain whether the values are due to inefficient use of energy, or to an energy intensive economic structure. In order to discover this, it is necessary to have a knowledge of the energy consumption in each economic sector and subsector.
As different economic sectors consume different amounts of energy for the same economic output, a change in economic structure can result in changes in national energy consumption. This change does not necessarily imply an increase or decrease in efficiency of energy utilisation, though.

The most recent source of sectorial energy utilisation data, prior to this work, was the three volume publication "Energy Utilisation in South Africa", (2) published by the Department of Planning and the Environment in 1978. That report covered energy use in all South African economic sectors between 1964 and 1975.

In contrast, this study is intended to gather energy utilisation data from five energy intensive industrial sectors in South Africa. The industries selected for investigation in this study are listed below with their Standard Industrial Classifications [3].

1. Manufacture of Structural Clay Products SIC 36910

2. Manufacture of Cement SIC 36920

3. Manufacture of Sheet and Plate Glass, Glass Containers and Other Glass Products SIC 36200

4. Iron and Steel Basic Industries SIC 37100 (includes Ferro-alloys)

5. Manufacture of Pulp, Paper and Paperboard SIC 34110

These sectors are notable for the significant proportion of total industrial energy consumption which they represent and for their high energy consumption per unit economic output. In South Africa in 1979 these industries consumed 41% by value of the total industrial energy consumption [4], whilst contributing only 19% of the nett industrial profit for that year. At the same time they represented only 9% of the total number of installations.

Energy utilisation data can be obtained to different degrees of detail to enable energy studies with different focal points, which can be classified into four groups [5]. They are:

1. To analyse particular processes in detail for the purpose of deducing their energy efficiency and identifying possible energy saving measures.

2. To analyse energy consumption on a large scale either to identify possibilities of reducing energy demand, or to forecast future energy demand.

3. To analyse the energy consumption of basic technologies so as to show some of the future consequences of technological trends or fluctuations in energy supply.

4. To calculate energy inputs per unit product output and to examine energy flows so as to ascertain the use of energy in an industrial system.

The specific aims of this study can be considered to fall into the realms of all these categories to a certain degree.These aims are:

1. To establish the patterns in energy consumption in selected industrial sectors over the period 1975 to 1984.

2. To assess whether the trends in energy usage have changed significantly in that period, paying attention to the connection between energy consumption and technological change, where such change has occurred.

3. To assess the energy efficiency of plants within the industrial sectors, and compare that of the sector as a whole with the same industries in other countries, where such information is available.

4. To identify where performance or technology can be improved.

5. To extrapolate the trends in energy demand in the selected industrial sectors in South Africa, in order to estimate the demand in the near future.

The information necessary to achieve these aims was gathered by a survey of the respective industries, which will be described in the next chapter. Subsequent chapters in this report will cover the following:

A description of the survey procedure used to gather the energy utilisation data is given.

A description of energy use in industry is given, with definitions of some of the terms used in that definition.

The findings of the survey of energy utilisation in each of the five industrial sectors are presented and discussed, in individual chapters. Energy saving opportunities in each of the five industrial sectors are also discussed.

The conclusions reached from the information gathered in the survey are presented, and some general conclusions regarding energy statistics and energy management in South Africa made.

CHAPTER TWO

THE SURVEY

The necessity to obtain information about the energy requirements of individual sectors of the economy in South Africa is obvious to those involved in the forecasting of the country's energy needs, the formulation of energy policy, and the assessment of national energy efficiency. Gathering this information is a task that can be approached in a number of ways. A few alternatives are mentioned below.

Firstly, a nationwide survey of all economic sectors could be conducted, as was the approach adopted in order to produce "Energy Utilisation in South Africa"[2]. This was seen to be a costly and time consuming procedure.

Secondly, a survey of a small number of selected economic subsectors could be conducted, rather than an investigation of all economic sectors in one study, which would result in a substantial delay before the data obtained would become available. It would be desirable that a study of this nature be followed by similar studies of other subsectors, although this is not essential, and has no significance in terms of the value of the initial survey.

Thirdly, legislation could demand energy statistics are submitted by all consumers annually, in a manner that would not inconvenience the consumer to any great extent. This could entail, for example, submitting annual energy consumption figures along with the tax return. A data collection system such as this would ensure reasonably accurate energy statistics would be available. Obviously, such a scheme must first have government approval and support. The manner of collection, and the way in which the information would be collated, would then have to be thoroughly investigated. As a result, even if approval was obtained immediately, some time would pass before statistics would be available.

With the resources available, and the need to obtain sectorial energy consumption data, it was decided, for the purposes of this work, to adopt the second approach, and select a number of economic subsectors for investigation. It was felt that, in this way, valuable updated energy consumption information would be gathered, and in addition, the study could be used as a model for similar studies of further economic subsectors. In this way an operating procedure for an ongoing energy monitoring scheme, along the lines of the Industrial Energy Thrift Scheme conducted in the United Kingdom, could be established.

2.1 THE SELECTION OF THE SURVEY SAMPLES

Upon deciding to investigate energy utilisation in a number of specific economic subsectors, the decision of which of those to investigate had to be made. In "Energy Utilisation in South Africa"[2], it was stated that the industrial sector of the economy is the largest sectorial energy user in South Africa, and energy utilisation studies in other countries focus solely on the industrial sector. As a result it would seem obvious to direct this study at specific industries in the industrial sector.

The next decision to be made was that of which industries to investigate. "Energy Utilisation in South Africa"[2] stated that five industrial sub-groups accounted for approximately two thirds of the energy requirements of the industrial sector. The 1979 Census of Manufacturing[4] stated that the same five sectors accounted for 41% of the total industrial energy consumption by cost. These five sectors were selected for this study. They are:

1. Manufacture of Structural Clay Products SIC 36910

2. Manufacture of Cement SIC 36920

3. Manufacture of Sheet and Plate Glass, Glass Containers and Other Glass Products SIC 36200

4. Iron and Steel Basic Industries SIC 37100 (includes Ferro-alloys)

5. Manufacture of Pulp, Paper and Paperboard SIC 34110

The Standard Industrial Classifications [3] classify establishments according to economic activity, and are intended to provide a common framework for the collection, analysis and presentation of statistical data.

Having established the target industries for the survey, it was necessary to establish which companies to approach to ensure significant survey samples.

STRUCTURAL CLAY PRODUCTS

The clay brickmaking industry is dominated by Corobrik, which, it is estimated by sources within the industry, accounts for nearly half of the countries total production. A few other large companies and numerous small companies account for the balance. As a result, it was decided that, if the cooperation of the large companies was obtained, along with those small companies that were reputed to be of specific interest in terms of energy utilisation, a sufficient sample would have been obtained.

As the refractory industry comprises two manufacturers, both were approached.

PORTLAND CEMENT

Three groups, and one joint venture by those three groups produce all the Portland cement manufactured in South Africa. All groups were approached.

GLASS

At present, three companies produce all the glass manufactured in South Africa, with the exception of specialised glass products, and all three were approached.

IRON AND STEEL BASIC INDUSTRIES

This sector comprises the producers of steel and ferroalloys. The steel sector is dominated by ISCOR, which is responsible for about 80% of the country's total production. ISCOR and the other four steel producers were asked to participate. Five producers of ferroalloys were approached.

PULP AND PAPER

The pulp and paper industry in South Africa is dominated by the two major groups, SAPPI and MONDI. SAICCOR is a large producer of pulp, which is largely exported. SAICCOR does not manufacture paper. All the companies in this sector were invited to participate, with the exception of SAICCOR.

2.2 DATA COLLECTION

In order to fully understand the current use of energy, and the needs and problems encountered within the industries, it was clear that visits to the individual companies would be necessary. In addition to enabling the author to become conversant in the applicable processes and techniques, it was felt that, by establishing personal contact with company personnel in this way, it would be possible to obtain a higher percentage response to the survey than is generally obtained by postal surveys.

Meetings were arranged with members of staff of the individual companies, usually at the level of Senior or Chief Engineer, and sometimes with the Technical Directors. At these meetings, the aims of the study were discussed, and where possible a tour of the plant made. For the first few visits in each industry, a draft questionnaire was discussed with the company official, and constructive criticism of it was invited. In this way a questionnaire of restricted length and complexity could be drawn up in order to facilitate the task of completion, while obtaining all the information necessary for this study. This was then sent to those companies already visited, and left with those company representatives seen subsequently, for completion.

The questionnaires supplied to each industry are included as Appendix G.

2.3. THE RESPONSE TO THE SURVEY

As the survey questionnaires were applicable to single plants, it is possible to assess the overall response to the survey in terms of the number of questionnaires returned as a percentage of those delivered, and in terms of the number of companies participating as a percentage of those approached.

The overall response to the survey provided a statistically satisfactory sample for analysis, and was greater than that generally expected for a postal survey, justifying the survey procedure adopted. A total of 61 questionnaires were delivered for completion, of which 36 were returned, a 59% response. Of the total of 32 companies approached, 20 took part in the survey, 61% of the total approached.

The response by each industry was as follows:

STRUCTURAL CLAY PRODUCTS

Of the eleven questionnaires delivered, eight were returned, a 73% response. In addition to the information obtained from the questionnaires, historical energy utilisation data was supplied for another 44 plants. This resulted in the survey of this sector accounting for an estimated 45% of South Africa's total clay brick production, and 40% of the refractory production. Five of the eight companies approached took part in the survey.

CEMENT

In this sector eleven questionnaires were delivered and eight returned. All the cement manufacturing companies took part in the survey. The response accounted for 70% of the total production of cement in South Africa in 1984.

GLASS

There was a 100% response in this sector, which encompassed all the glass manufacturing plants in the country.

IRON AND STEEL BASIC INDUSTRIES.

Thirteen questionnaires were delivered to this sector and five were returned, a 38% response. This entailed the participation of three out of the ten companies approached. The sample obtained, though, represented about 80% of South Africa's total steel output, and about 30% of the total production of ferroalloys. Production data for the entire industry was available from published reports.

PULP AND PAPER

There are a total of six groups in the industry, five of which were approached to participate in the survey. Three of these five responded. A total of twenty questionnaires were delivered, of which 9 were returned. The plants covered by these nine questionnaires accounted for 74% of the industry's total pulping capacity in 1984, and 80% of the total paper and paperboard production in the same year.

CHAPTER THREE

ENERGY ANALYSIS

A variety of analysis concepts are currently used to assess energy utilisation. Before describing a few of them, the flow of energy in a system is described, and some of the terms used in the description are defined.

3.1 THE FLOW OF ENERGY IN AN INDUSTRIALISED SOCIETY

A modern industrial system is a complex interconnected system with many inputs and outputs. As a result, the total amount of energy required to produce a specific product is a function of all the energy inputs and outputs that are involved in the plant, materials and process. To analyse this total energy input would be an extremely complex task. As a result, energy analysis can only be effectively based on limited sub-systems. A sub-system must have a carefully defined boundary, for which all inputs and outputs are known, encompassing all the operations considered necessary to describe the production of a particular commodity

The simplified flow of energy in a sub-system is shown in Figure 3.1. A number of terms used in this figure require definition.

ENERGY FLOW IN AN INDUSTRIAL SUB-SYSTEM

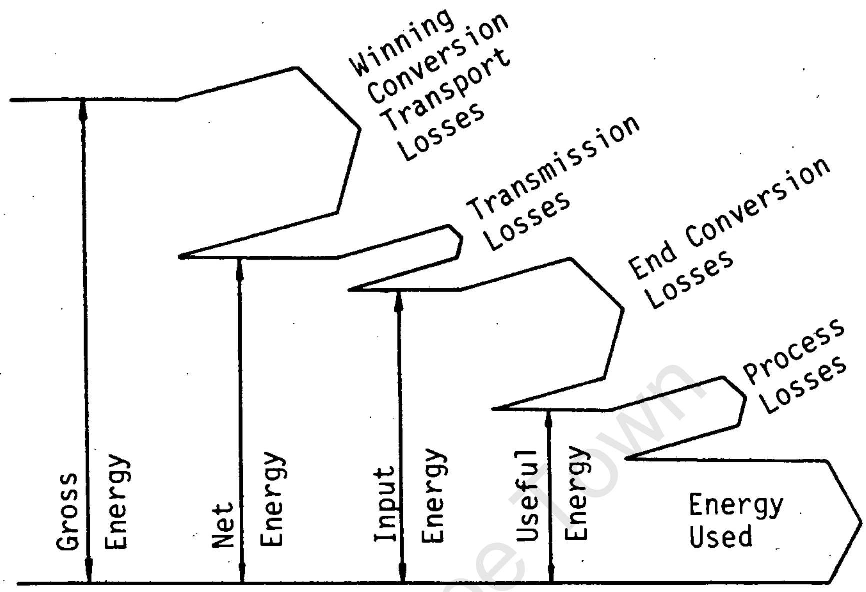


FIGURE 3.1

GROSS ENERGY

A strict definition would have gross energy input to an activity include the energy used directly for the activity, the energy required for the mining, beneficiation and transport of all fuels used, including those used for the production of electricity, the losses in electricity generation and transmission, the energy content of all plant involved in the activity, and in the winning, generation, transmission and utilisation of energy for that activity to take place.

This would be virtually impossible to ascertain. As a result it is more common to omit the energy content of plant, and merely consider the energy used to produce and transmit the energy sources and all losses incurred between base source and end product, as shown in Figure 3.1.

NET ENERGY

Net energy may be defined as the amount of energy that is available for final consumer use, including the energy required to supply that energy. For example, when considering electrical energy supply, the amount of electricity leaving the power station for a specific plant would be the net electrical energy supplied to the plant, which includes losses incurred in transmission.

INPUT ENERGY

The energy which, in physical terms, crosses the boundary of a sub-system is called the input energy. It excludes all inputs involved in the winning of energy sources and materials and subsequent losses in conversion or transmission. It is this amount of energy that is measured and paid for by the end user, and is thus the measure of energy that a large proportion of energy analysis is based on.

3.2 METHODS OF ENERGY ANALYSIS

Methods of energy analysis may be broadly categorised as economically based and non-economically based. The two approaches have become increasingly combined as energy expenses have risen and energy efficiency has become a financial matter. Process analysis and statistical analysis, and input-output analysis are techniques that are worthy of description here.

3.2.1 PROCESS ANALYSIS

Process analysis is considered by some to be the most useful energy analysis technique for industrial purposes [6]. As a rule this technique is carried out in the following distinct stages.

Firstly the system is carefully defined, and the operations of interest within the system boundary identified. Then material and energy inputs and outputs associated with each of these operations are evaluated. These individual material and energy requirements are then combined to give a set of inputs and outputs for the overall system under examination.

3.2.2 STATISTICAL ANALYSIS

A variation of process analysis is statistical analysis.This method involves coupling statistics of production output with data of energy consumption to allow a value for energy input per unit output to be obtained. These statistics are available for a number of industrialised countries in the form of national or sectorial publications.

Unfortunately, although production data and economic data are commonly available to all levels of the system, energy consumption data may not be available to the same degree. This of course prevents detailed analysis.

Assuming, though, that sufficient statistics are available, this method still has limitations.

i. Energy produced as a by-product in and used by a sub-system, for example blast-furnace gas in the steel industry, is seldom accounted for.

ii. It is not possible to consider the energy requirements for producing the energy consumed.

iii. The energy input to raw materials, plant and equipment and transport must be omitted.

iv. The energy requirements of different products in the same sub-system cannot be distinguished in detail.

Despite this, this method can provide an order of magnitude estimate of the energy requirements per unit output for sub-systems. Unfortunately, in South Africa at present, available statistics are of insufficient detail to be of any great value to the energy analyst.

In this study, combined use is made of the process analysis technique and statistical analysis.

3.2.3 INPUT-OUTPUT ANALYSIS

Input-output analysis is a method of summarising the transactions in commodities necessary to produce other commodities. The results are presented in the form of a square matrix, A. Thus element A_{ij}, in the ith row and jth column, is the amount of commodity i required directly to produce one unit of commodity j. Thus all inputs needed to make one unit of j are the items in the jth column of the matrix.

Certain of these rows will refer to energy, and from the matrix it is possible to determine the amount of energy required per unit output of product.

A conventional input-output matrix gives all elements in terms of money value. If scale factors are available to convert money values to energy values (e.g. Rand to MJ), mixed energy-value input-output matrices may be produced. These enable energy transactions to be measured in energy units, while mathematical operations are carried out in an analogous fashion to those in a conventional input-output matrix.

In addition to the specific energy requirement for individual products, the short-term effect of changes in energy prices on commodities can be ascertained from an energy related input-output table.

If the monetary values of elements in the matrix are used, errors can arise where commodity prices are liable to large fluctuations or if some consumers can obtain special prices for certain commodities.

The mixed matrix has the complication that scale factors may vary from sector to sector, and values used in the matrix may be inadequate in their simplicity.

This technique has a number of shortcomings. The smallest system the input-output table can deal with is an entire industry, and this can result in commodities with widely varying energy intensities being included in the same consideration.

The analysis is based on collecting a large amount of data from a number of industries. This is a formidable time consuming task, and because of the varied sources of data, the time necessary to obtain all the information required, possible reluctance to provide information of a confidential nature, and other complications, inaccuracies in the data may occur, which obviously affect the results of the analysis.

CHAPTER FOUR

THE STRUCTURAL CLAY PRODUCT INDUSTRY IN SOUTH AFRICA

Structural clay products include clay bricks, tiles, earthenware pipes and refractories. The manufacture of these products is classified under the Department of Statistics Standard Classification of All Economic Activities as Manufacture of Structural Clay Products, subgroup 36910.

4.1 INTRODUCTION

4.1.1 MANUFACTURE OF STRUCTURAL CLAY PRODUCTS

4.1.1.1 HEAVY CLAY PRODUCTS (CLAY BRICKS, PIPES AND TILES)

The manufacture of heavy clay products essentially comprises five separate processes.

i. The winning of the clay

ii. Clay preparation

iii. The shaping of the products

iv. The drying of the ware

v. The firing of the ware

THE WINNING OF THE CLAY

For economic reasons, heavy clay works are almost always situated as near as possible to the source of clay. Clay is quarried by open-cast methods as it would not be economic to mine clay for building materials, although clay or shale obtained as a result of mining activity is used for brick-making.

Generally, clays can be dug from the clay face directly by machine, using multi-bucket excavators, scrapers, bulldozers and mechanical shovels, but harder shales may require blasting. The clay is usually transported to the plant for preparation, but occasionally to a dump site for weathering.

CLAY PREPARATION

To make bricks, roofing tiles or pipes, the particle size of the clay from the quarry must be reduced and the clay must be blended with the correct proportion of water required for the shaping process. With some clays, the particle size is greatly reduced merely by exposure to the elements (weathering). In most cases, though, the clay must be crushed and ground.

After size reduction, the clay is screened, and blended to obtain uniform composition. It is then mixed with the correct amount of water, and sometimes other ingredients, and transported for shaping.

SHAPING OF PRODUCTS

HAND MOULDING The moulding of clay products by hand produces ware with a good quality finish, but is rarely performed today.

FULL PLASTIC MOULDING This is also known as the Soft Mud Process. It is really a mechanical imitation of hand moulding which involves the extrusion of soft clay into a composite mould, forming a number of bricks at once.

EXTRUSION This is also known as the Wire-cut Process. Plastic clay is forced through a die by some means, for example a screw. Bricks, roofing tiles and pipes can be formed in this way. Extrusion of bricks and tile blanks is usually horizontal, and the clay column is cut into suitable lengths by wire cutters. One of the problems with wire-cutting is that any material sticking to the wire results in poor cut surfaces. As a result the more sophisticated automatic wire-cutting machines include mechanical wire cleaning.

STIFF PLASTIC PROCESS The prepared clay is stiffer and harder than that used in the wire-cut process, but is still plastic. This process enables the ware to be set in the kiln without prior drying, due to the low moisture content. A lower energy requirement per brick is the consequence. The process essentially involves the rough shaping of the clay into a mould by extrusion, followed immediately by pressing into another final mould.

DRY PRESS PROCESS This is also known as the semi-dry process or the semi-elastic process. Some ceramic products are shaped by compressing granular clay at its normal moisture content into the required form. Goods shaped by this method do not need to be dried before firing in the kiln.

RE-PRESSING. It may be required to give a brick or tile a different surface finish from that left from wire-cutting on extrusion. Should this be the case, the ware may be re-pressed after it is shaped. Generally for this the moisture content must be at a specified level.

TILE PRESSING Roofing tile blanks are commonly formed by extrusion and then pressed into the final shape. Often for interlocking roofing tiles, the blank is only a measured quantity of clay in the plastic state, which is then pressed into the mould.

PIPEWARE Straight sections of pipe are generally extruded vertically downwards. The flared socket-end of the pipeware is formed by an integral press. The more complex shapes, such as junctions, are cast in moulds.

DRYING

The purpose of drying heavy clay goods is to make the product sufficiently rigid to withstand being placed in the kiln, and to reduce the water content to the optimum for firing. If the moisture content is too high, product damage due to steam generation in the product results. If the moisture content is too low, the product might crack before being placed in the kiln due to the re-absorption of water. The optimum moisture content is between 8% and 13%. The majority of clay shrinkage occurs above this level.

The ware may be dried by a number of methods.

OPEN AIR DRYING The goods are stacked in roofed sheds and allowed to dry naturally. This labour intensive method is widely used in South Africa.

HOT FLOOR DRYING The goods are set on a floor which is heated from below. A superstructure protects the floor from the weather, but allows the evaporated water to escape.

TUNNEL DRYERS Goods are placed on cars and moved through a tunnel. The tunnel is heated, either by kiln exhaust gases or by direct firing of a heat exchanger. It is a continuous process.

CHAMBER DRYERS These consist if chambers set side by side in batteries. The clay goods may be set on cars which are moved into the chambers, or placed on pallets which rest on ledges on the walls. The dryers are only heated after loading, and it is common today for the heat source to be kiln exhaust gases. The gases are circulated from chamber to chamber so that the goods which are still wet do not encounter the hot gases direct from the kiln, as this would cause cracking. Once the goods are dry the chamber is allowed to cool before unloading.

FIRING

To produce the final products the clay must be fired. The firing proceeds in stages:

i. Up to 150°C the water still mechanically held in the clay is evaporated.

ii. Between 150°C and 950°C the following occur:

a) Any chemically held water is released.

b) Any carbonaceous material held in the clay burns out.

c) Decomposition of the carbonates of calcium, magnesium and iron occurs.

d) Iron pyrites decomposes and iron sulphide oxidizes.

e) Silica converts from alpha quartz to beta quartz. This occurs at 573°C.

iii. From about 950°C to 1200°C the clay is fully fired, at which time it attains its strength, mainly due to the partial melting of the clay. The molten clay, on cooling, bonds the remaining clay particles together. After full firing has been achieved, the clay products are allowed to cool.

KILN TYPES.

The firing is achieved in kilns of which there are many types. The various types of kiln may be classified broadly as being intermittent, continuous or semi-continuous.

INTERMITTENT KILNS

Intermittent kilns are suited to production of small quantities of products of different types, as may be required of small brickfields. As little capital is involved in their construction, the amount of kilns may be adjusted according to demand.

The largest drawback with this type of kiln is that the heat given off while the kilns are cooling generally cannot be recycled.

CLAMP KILNS. The clamp kiln is a temporary updraught kiln. It is probably the simplest type of kiln and is still widely used in South Africa. It consists of a block of green bricks stacked on a floor of fired bricks. Coke breeze or coal is placed amongst the fired bricks forming the floor, and within the stack of green bricks. The fuel may also be included in the brick mix. The stack of green bricks is enclosed by a few layers of fired brick. The fuel is ignited and allowed to burn out.

Lack of control results in uneven firing of bricks, and under-fired bricks are usually reset in a clamp, near the covering layer of fired brick for refiring. The clamp kiln is relatively economical in fuel usage, and involves no investment in capital.

SCOVE KILNS. These are similar to clamps, but consist of green bricks set directly on the ground in a series of arches. Space for fuel is left in the bottom section of the arches. The outer portion of the kiln consists of underfired bricks which are covered with wet clay to make the kiln airtight. This type of kiln is also relatively fuel efficient.

SCOTCH KILNS. The scotch kiln is probably the most primitive of the kilns in use today. It comprises four walls with deep fire-mouths running through their bases. Wood or coal is used as the fuel. This type is still used in some brickfields in South Africa.

DOWNDRAUGHT KILNS. These may be round or rectangular. The principle behind both types is the same. The kiln is a permanent structure with the goods set inside, and surrounded by a number of fires. The combustion products first pass up over the goods and then down through them into openings in the kiln floor, through which they are exhausted. The round kiln has advantages of symmetry which result in improved uniformity of temperature and heat utilisation, but the rectangular kiln has the advantage of regularity of setting space.

SEMI-CONTINUOUS KILNS.

These consist of a number of intermittent kilns built close together and interconnected. They are operated cyclically, so that the exhaust from one kiln, which is being fired, is used to preheat the bricks in subsequent kilns. The hot air from cooling kilns can also be used. When the firing is complete in one kiln, firing begins in the next, where the temperature is already high. This results in a significant decrease in fuel consumption per unit output over individual intermittent kilns.

CONTINUOUS KILNS

Continuous kilns are of two types:

i. The moving fire type, in which the setting is stationary and the zone of maximum temperature advances around the kiln.

ii. The moving ware type, in which the goods are moved through a tunnel where the temperature increases to a maximum at a fixed position, and then falls again to nearly atmospheric.

MOVING FIRE KILNS OR ANNULAR KILNS.

Annular kilns are of two types, longitudinal or barrel arch kilns, and transverse or chamber kilns.

All kilns of the barrel arch type are modifications of the Hoffmann kiln. This comprises two parallel tunnels connected by a semi-circular tunnel at either end (or in its original form, a circular annulus). The tunnel is separated into a number of chambers by pasting sheets of paper over each brick setting and between the setting and the side walls. A complete firing cycle occurs around the annulus. Air for combustion in the firing zone is drawn over cooling fully fired bricks and the combustion exhaust gases are drawn over green bricks to preheat and completely dry them. The paper separating the settings of bricks is destroyed by the waste gases when they are hot enough. Due to the effective use of waste gases this kiln type is very fuel efficient.

The transverse arch kiln is another development of the Hoffmann kiln with the combustion chambers being separate short transverse tunnels with interconnecting holes in the walls. This enables the capacity of the chambers to be increased by lengthening the chambers rather than increasing their span. It is also possible to control the firing of this kiln type better than in the barrel arch type, but the fuel efficiency is not as high.

The use of annular kilns tends to be labour intensive, however, as setting and drawing of brick loads is not readily automated.

CAR TUNNEL KILNS

The ware to be fired is loaded on special refractory lined cars and drawn through a long straight tunnel. In the tunnel the firing zone is a little distance after the entrance, and the air flow through the tunnel is such that the combustion products pass over the entering bricks, preheating them. The air for combustion is drawn over the already fired bricks which are cooling, and is itself preheated.

This type of kiln enables good control over the firing process. Developments in car sealing and air control have resulted in increases in fuel efficiency. The wastage due to handling is also low. In conjunction with tunnel or chamber drying, this type of kiln enables fully automated production.

4.1.1.2 REFRACTORIES

Refractories are materials that remain chemically stable and structurally undeformed for long periods in high temperature environments. They are commonly used to line the inside of high temperature process plant. Refractories are predominantly based on the oxides of aluminium, silicon, magnesium, calcium and chromium.

Refractory goods may be shaped or unshaped. The former are generally fired in kilns before use and vary greatly in size and shape according to use. Unshaped refractories are called monolithic refractories and include mouldables, ramming mixtures, jointing cements and castables. The latter are typically pre-fired granular mixtures bonded by calcium aluminate cements. The first three all possess some measure of elasticity. Monolithics are formed in situ according to their type, and subsequently fired in use. Users of refractories are moving increasingly toward monolithics.

The manufacturing processes involved in the production of refractories are essentially the same as in the manufacture of clay bricks, with the exception that in refractory production some raw materials are fired before mixing to alter their chemical structure. This commonly occurs in rotary kilns, although tunnel kilns may also be used in some cases.

4.1.2 THE INDUSTRY STRUCTURE IN SOUTH AFRICA

The structural clay industry is dominated by a small number of large companies. Five companies are responsible for more than 50% of the output in the industry. A large number of smaller concerns account for the remaining output.The 1979 Census of Manufacturing[4] gives the number of establishments in the industry as 371, and of these, 216 had working proprietors.

4.1.3 SCOPE OF THE SURVEY OF THE STRUCTURAL CLAY INDUSTRY

As total output figures for the industry are unobtainable, it is not possible to assess accurately the percentage of the industry participating in the survey, and therefore no survey results are extrapolated to estimate the trend in energy consumption in the entire industry. Estimates given by the respondents suggest that 45% of the total clay brick production and 40% of the refractory industry are accounted for by the 52 plants for which information was obtained.

Variation in the types of plant, the type of product made and the raw material used, all affect the energy consumption in production, but the sample investigated included sufficient numbers of plant to be representative of the industry.

4.1.4 ENERGY REQUIREMENTS OF THE STRUCTURAL CLAY INDUSTRY

The consumption of energy in the structural clay industry represents a significant portion of the total costs in production. In clay brickmaking, the percentage of total production costs due to energy purchases, reported by the respondents to this survey for the period 1975 to 1984, varied between 44% and 10%. The average value over the period was 24%. In this sector, this percentage showed a general trend to decrease slightly. In the production of refractories, the percentage of total costs reported over the same period varied between 36% and 5%, with an average of 12%. In this case however, the values tended to increase.

The amount of energy consumed in the manufacture of clay bricks depends on the raw materials used, the method of manufacture, the type of kiln used and the type of brick produced. Of the total energy supply in brick manufacture an average of 95% is consumed in firing and drying the bricks. Use of electricity for preparation of raw materials and brick, and for fans in kilns and dryers represents an average of 3.5% of total energy supply, while transport within the plant accounts for 1.5%.

In the manufacture of refractories, heating represents 82% of total energy input, electricity for process and lighting 16% and transport the remaining 2%.

4.2 INFORMATION OBTAINED FROM THE SURVEY AND DISCUSSION OF RESULTS

As stated previously, no accurate total production figures for the structural clay industry were available for this survey, and therefore the survey data is not extrapolated to estimate trends for the entire industry.

In addition, energy related data regarding clay brickmaking for the years previous to 1983 is scarce, and some of that which is available, is not considered reliable by the respondents. Energy trends within the industry over the last ten years cannot, therefore, be considered.

4.2.1. ENERGY CONSUMPTION IN CLAY BRICKMAKING

Coal is the predominant fuel used in the manufacture of clay bricks (over 80% of the total energy consumption by energy content), with fuel oil, producer gas and Sasol gas accounting for the remaining input of fuels. Electricity is used mainly in the preparation of raw materials.

Specific energy consumption may be based on energy input per thousand bricks, as it is common to consider production output in units of thousands of bricks. Presentation of energy consumption in MJ per 1000 bricks may thus be convenient for members of the industry. However, different grades of bricks have differing unit masses, and thus the energy input per ton is also supplied for analysing energy utilisation.

Energy consumption in the various types of kiln included in this survey per ton of output and per thousand bricks is given in Table 4.1.

RANGE OF SPECIFIC ENERGY CONSUMPTION BY KILN TYPE

KILN TYPE	AVERAGE ENERGY CONSUMPTION (RANGE IN BRACKETS) MJ PER 1000 BRICKS	MJ PER TON
TRANSVERSE ARCH	8310 (4690-11730)	2800 (1470-3800)
HOFFMAN	6720 (4130-11510)	2320 (1390-3840)
TUNNEL	9040 (4650-18450)	3160 (1810-6130)
CLAMP	10190 (5630-15870)	3380 (1510-5670)
DOWNDRAUGHT	25740 (18060-29820)	8620 (5640-10760)

TABLE 4.1

The values recorded above are those of total energy input per unit output, including estimates of energy content of carbonaceous raw materials and additions to the brick body. In two cases, input of "conventional" energy sources was significantly lower. The one plant reported a consumption of "conventional" fuels of as low as 592 MJ per ton of bricks in its tunnel kiln, and the other, a consumption of 954 MJ per ton in Hoffman kilns.

The wide variation in values of energy consumption for each kiln type shown in Table 4.1 is notable, and may be attributed to a number of factors.

Both the firing temperature and the period of firing increase as the quality of the brick produced increases, with subsequent increase in energy input. Firing temperature also varies with kiln type, which contributes to the variation in energy input to the different kilns.

Some raw materials which contain carbon in their natural state, such as carbonaceous shales, have a more effective burn-out than do those which have carbonaceous material, such as coal, added to them. This may be due to the release of the volatiles generally present in such carbonaceous additives, and their escaping from the brick setting, without combusting, due to lack of oxygen.

Heat input for brick drying is included in these figures and therefore, plants where bricks are dried in the open air may be expected to return lower energy consumption figures than those using tunnel or chamber dryers. This need not necessarily be the case, however, if the kiln exhaust gases are used efficiently, where possible. Drying using kiln exhaust gas and no supplementary firing will increase throughput for no increase in energy consumption.

Product waste levels obviously effect energy consumption relative to marketable product, and can account for a substantial variation in energy consumption figures, particularly with regard to intermittent kilns.

It cannot be disregarded that some plants will operate more efficiently than others due to better energy management and general "good housekeeping" and that this will also play a part in the variation in specific energy consumption.

It is of interest to compare the average values and ranges of values of specific energy consumption in clay brickmaking in South Africa with those reported for the British brick industry [(7)].

COMPARISON OF ENERGY CONSUMPTION IN BRICKMAKING BETWEEN SOUTH AFRICA AND BRITAIN

KILN TYPE	ENERGY CONSUMPTION (MJ per ton)	
	BRITAIN	SOUTH AFRICA
TRANSVERSE ARCH	4200 (3600-5500)	2800 (1470-3800)
HOFFMAN	3500 (3200-4400)	2320 (1390-3840)
TUNNEL	3100 (3000-3500)	3160 (1810-6130)
CLAMP	5200 (3900-6400)	3380 (1510-5670)
DOWNDRAUGHT	6000 (5400-7200)	8620 (5640-10760)

TABLE 4.2

The values of energy consumption in the transverse arch, Hoffman and clamp kilns are seen to be significantly lower for the South African industry than its British counterpart. The fact that open-air drying of bricks, which obviously does not involve input of purchased energy, is widely practiced at plants with these kiln types in South Africa, and not in Britain, is likely to be the reason for this.

The average values for tunnel kiln production are of the same order, but the range of values in South Africa is far wider. This would suggest that there is scope for improvement in the operation of a number of tunnel kilns in South Africa. It would also suggest that some kilns in this country are notable for their energy efficient operation.

Table 4.3 shows the net and gross energy consumption in continuous kilns, by brick type, in Britain in 1980 [8]. It should be noted that Fletton bricks are made of Oxford clay with a carbon content averaging 2600 MJ per ton of bricks produced, and are unique to the British brick industry.

ENERGY CONSUMPTION IN BRICK PRODUCTION IN BRITAIN
(CONTINUOUS KILNS)

BRICK TYPE	AVERAGE ENERGY 1980 NET MJ/TON	AVERAGE ENERGY 1980 GROSS MJ/TON
FLETTON	910	3460
COMMON	1600	3810
NON-FLETTON FACING AND ENGINEERING	3090	3510

TABLE 4.3

Net energy in Table 4.3 refers to purchased fuels used in firing in the kiln and not energy in the brick body. This is included in the gross energy. By way of comparison, the average gross energy input per ton of bricks for the survey sample in 1984 was 3456 MJ per ton. This is the average value for all clay brick types and kiln types. It can be seen that this is of the order of the average gross energy consumption in brickmaking in the United Kingdom.

For the larger percentage of brick plants covered in this survey, it was not possible to obtain energy data for the period before 1984. However, overall figures for a tunnel kiln producing common, facing, engineering and paving bricks were available for the period 1975 to 1984. This plant showed a decrease in net energy input per ton of bricks from 1975 to 1984 of 57%. The gross input per ton, however, increased by 30% over the same period. These changes arose from inclusion in the brick body of low cost carbonaceous material, improved kiln firing control and efficient utilisation of exhaust gas for drying, and have resulted in substantial cost savings.

4.2.2 ENERGY CONSUMPTION IN THE REFRACTORY INDUSTRY

The predominant energy sources in refractory production are electricity, Sasol gas and coal. In 1984, electricity accounted for 14% of the total energy consumption in the survey sample, Sasol gas for 53%, coal for 32%, with fuel oils and coal tar fuel oil accounting for the remainder. The relative contribution to total energy consumption by each fuel type has changed over the past ten years, with electricity and Sasol gas both increasing their share. The percentages of total energy usage due to the three major energy sources mentioned above, over the period 1975 to 1984, are shown in Figure 4.1. Percentages of all energy types are given in Appendix B.

It is clear, in Figure 4.1, that Sasol gas is increasingly becoming the predominant fuel in this sector. The use of coal as a fuel in refractory manufacture is largely restricted to firing in rotary kilns for raw material manufacture. In the final firing of refractories, the combustion rate of coal is much less controllable than those of oil or gas, and ash also presents a problem. The price factor is obviously the major reason for the selection of Sasol gas for firing tunnel and intermittent kilns.

PERCENTAGE OF TOTAL ENERGY CONSUMPTION DUE TO ELECTRICITY, SASOL GAS AND COAL, 1975 TO 1984

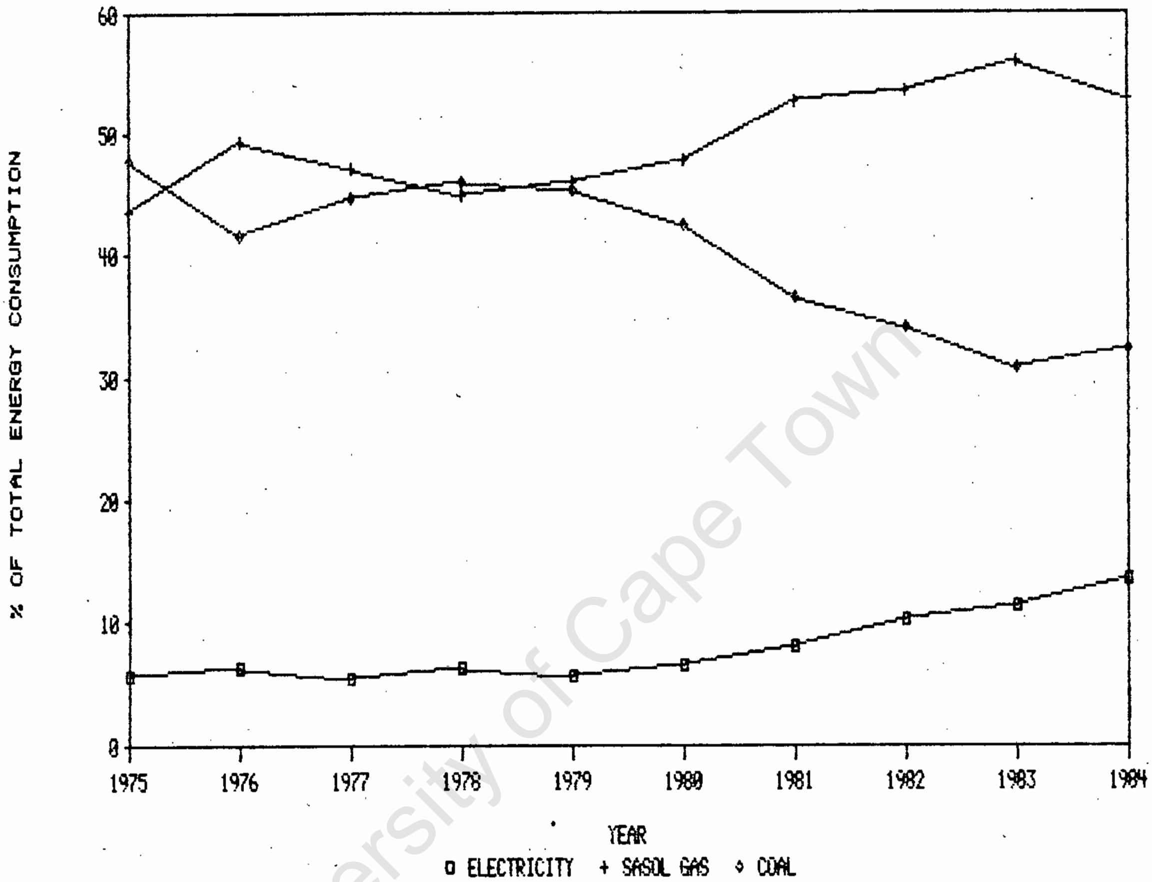


FIGURE 4.1

The energy requirements of refractory firing vary according to the composition of the refractory being produced, as different products require different firing periods and temperatures.

This survey was unable to cover the entire range of refractories manufactured in this country, but an overall energy consumption for some plant types were obtained and are presented in Table 4.4. Specific energy consumption remained fairly constant over the survey period within the sample and as a result, average values for that period are used.

ENERGY CONSUMPTION IN REFRACTORY PRODUCTION

PROCESS	AVERAGE MJ PER TON
BASIC CALCINING	5356
BASIC FIRING (Tunnel kilns)	12666
BASIC TOTAL	18022
FIREBRICK DEAD-BURNING	3094
FIREBRICK FIRING (Down-draught kilns)	17599
FIREBRICK FIRING (Tunnel kilns)	11905
FIREBRICK TOTAL (Down-draught kilns)	20693
FIREBRICK TOTAL (Tunnel kilns)	14999
FUSION PLANT	13737
MONOLITHICS PLANT	827

TABLE 4.4

The fact that the specific energy use in refractory manufacture has remained relatively constant for ten years does not necessarily mean that the industry has made little progress in energy conservation, as the trend in market demand has been toward higher performance products, and these require more energy in their production. The fact that production capacity has been under-utilised, particularly since 1981, may also have been an influencing factor.

The large difference in specific energy requirement between firing in tunnel kilns and intermittent kilns is immediately evident. It is accepted that intermittent kilns are less thermal efficient than continuous kilns, but their use is advantageous in certain circumstances. Intermittent kilns offer product flexibility which is not possible with continuous kilns. Products requiring extended firing cycles would need tunnel kilns unacceptably long. Some products require a specific temperature profile to be followed during their firing cycle, which would be difficult to achieve efficiently in tunnel kilns.

Energy consumption in the manufacture of monolithic refractories is significantly lower than that for shaped, fired refractories. If the demand for, and production of monolithics increases in this country, as is expected, substantial energy reductions in this industry should result.

Large variations in energy requirements arise due to variations in the nature and treatment of raw materials. When comparing values of energy input, therefore, differences are not necessarily attributable to varying energy efficiency. In order to satisfactorily assess the relative efficiency of this industry in South Africa, a more detailed energy audit would be necessary. As the total energy consumption in the refractory industry is estimated to be between 5.75 million Gigajoules and 3 million Gigajoules, compared to an estimate of 37 million Gigajoules for the consumption of the claybrickmaking industry, such an audit cannot be considered a priority.

Table 4.5 lists the energy requirements for the manufacture of some refractory products in other countries to compare with the values returned by the survey respondents.

ENERGY REQUIREMENTS FOR REFRACTORY PRODUCTION

PRODUCT TYPE	COUNTRY	AVERAGE ENERGY REQUIREMENT (MJ per ton)
Basic refractories	USA	30950
Fireclay refractories	USA	4940
Fireclay bricks and shapes (Continuous kilns)	UK	7800-9000
Fireclay bricks and shapes (Intermittent kilns)	UK	19300-21200
Monolithic Refractories	USA	1000-13000

Source:
Energy Audit Series No.4 Bulk Refractories Industry [9].

TABLE 4.5

4.2.3 ENERGY MANAGEMENT IN THE STRUCTURAL CLAY INDUSTRY

Of the participants in the survey in both the brickmaking and refractory industries, one company had a designated energy technologist responsible for energy management. The remainder considered energy management an inherent part of the responsibilities of plant staff.

Discussions with employees on energy management are almost universal in the industry, and energy awareness schemes are being carried out by nearly half the respondents.

Energy audits are performed by a number of plants, the majority of them belonging to the major companies in the industry, although some smaller brickmaking plants are also conscious of their value.

Over 50% of the respondents have no equipment for control of maximum demand, while 60% have equipment for improvement of power factor. As few small companies were included in the survey sample, it is quite possible that these percentages will be a great deal lower for the industry as a whole. The power factors reported varied from 0.8 to 0.98, with the lower values being reported mainly from plants paying their electricity bills in kWh rather than in kVAh.

Improved kiln firing control ranked as the most prevalent energy saving measure adopted.

4.3 ENERGY SAVING OPPORTUNITIES

4.3.1 INCLUSION OF CARBONACEOUS ADDITIVES IN RAW MATERIALS FOR BRICKMAKING

Some brick making materials contain carbon, which can reduce the consumption of fuel in conventional brickmaking. This effect is obvious in the manufacture of Fletton Bricks in the U.K., which have an inherent carbon content in the clay of as much as 2600 MJ per ton[8]. The manufacture of these bricks requires the additional energy supply of only 910 MJ per ton of bricks. The addition of carbonaceous materials to raw materials not containing carbon can have the same effect.

There are problems inhibiting the widespread application of such measures, however. The sulphur content in the exhaust gases increases, the appearance of the brick can alter and bricks tend to bloat. In addition, in order to maximise savings of conventional fuels, it is necessary to ensure efficient oxidation of the additive. This can result in a decrease in output capacity [10]. The cost of any additive must also be set off against the fuel saving.

Carbonaceous materials such as duff coal and wastewater sludge are being added to the raw clay in some brickmaking plants in South Africa with successful results. An increase in the use of such additives, particularly the latter [11], has implications for both energy and environmental conservation. By including carbon in the brick body, the final density of the fired product is reduced, due to the burn-out of the carbon, increasing the number of bricks obtained from a fixed quantity of clay. Uniform firing is achieved throughout the brick body, reducing the percentage scrap. With the internal energy source, full firing throughout the brick is achieved more rapidly, reducing the specific energy consumption. Using wastewater sludge as a carbonaceous additive alleviates the problem of disposal experienced by all urban administrations, and makes use of an energy source which is readily available, yet seldom used.

4.3.2 KILN PERFORMANCE

Many of the following points apply to both the manufacture of clay bricks and formed refractories, as the majority of the energy intensive plant is used in both sectors.

Production Capacity

The maintenance of production in individual kilns as close to kiln capacity as possible is essential to optimise energy use in the structural clay industry. About half of the total fuel input to a kiln operating at full capacity is used merely to reach and maintain temperature. This input does not vary with production output, and so maximising output is essential for efficient usage of fuel.

Unfortunately control of kiln capacity is largely a function of market demand for the majority of the smaller manufacturers, who operate only one kiln. This does not apply to those manufacturers using only clamp kilns. If there is more than one kiln at a plant, kilns could be temporarily shut down in times of low demand. Short-term shutdowns of continuous kilns can, however, increase overall fuel consumption, as, if the entire kiln structure is allowed to cool to the ambient temperature, a great deal of heat is required to reheat it before production can be resumed..

Increased Heat Transfer in the Kiln

Heat transfer within tunnel kilns can be improved by the installation of a pulsing fan system. This reverses the flow of hot combustion products from exhaust to inlet for a fraction of the outflow period, increasing gas turbulence and thus convection heat transfer. Fuel savings of 5% have resulted from such an installation, with the cost of the equipment being recovered within a year [12].

Lower density of packing of the goods on tunnel kiln cars will increase heat transfer by radiation and convection, but will reduce output from the kiln. If a setting pattern can be achieved to optimise heat transfer and production output, reduction in specific fuel consumption may be expected.

The increase of turbulence in kilns as a result of the use of high velocity burners greatly improves the uniformity and speed of heat transfer. Production output increases as a result and specific fuel consumption is reduced. Fuel savings of up to 20% have been reported in tunnel kilns [13].

Reduction of Heat Losses From the Kiln

Heat leaves the kiln in the exhaust gases, in the goods, through the walls and crown of the kiln, in the heated cooling air and, in the case of tunnel kilns, in the kiln cars.

Recovery of thermal energy from the exhaust gases from kilns should not be confused with the recovery of heat from the air heated in the process of cooling the ware. Heat recovery from cooling air is already prevalent in the industry. The cooling air is either ducted to driers or used as preheated air for combustion.

A portion of the kiln exhaust gases can be recirculated from the preheater section of tunnel kilns to the end of the firing zone. This increases the rate of gas flow through the setting and decreases the temperature of the gases leaving the kiln. It is possible to improve specific fuel requirements by 8-10% in this manner [9].

To recover some of the heat in the exhaust gases of kilns it is considered necessary to use heat exchangers as the gases generally contain contain sulphur and other compounds that can be extremely corrosive at temperatures below dewpoint.

Heat losses from hot ware leaving the kiln can be minimised by efficient cooling. Heat losses from tunnel kiln cars can be significant, as traditionally constructed kiln cars have high thermal capacities. As with goods leaving the kiln this loss is reduced by efficient cooling and the use of the cooling air in drying or preheating. The loss can be further reduced by the use of new designs of kiln cars and modern lightweight refractory blocks. In addition, the rapid off-loading and re-loading of cars for re-entry to the kiln or tunnel dryer will result in lower heat losses.

Heat loss through the kiln structure can be reduced by improving kiln insulation, and in this regard ceramic fibre insulation materials are becoming increasingly important. A recent report stated that kiln insulation comparable to that which is considered routine in Europe is just getting started in South Africa [14]. Kilns can be effectively retrofitted with additional insulation either internally or externally. In the case of intermittent kilns the use of insulating materials with low thermal mass is a major advantage.

Heat Recovery from Rotary kilns in Refractory Plants

Rotary kilns are used for raw material preparation in the refractory industry. The kilns operate at temperatures of between 1400°C and 2000°C and exhaust gas temperatures can be as high as 800°C. The gases are dusty and contain nitrous and sulphurous oxides, and as a result would require suitable heat exchangers or filtration, but the potential for using such exhaust as process heat or for the generation of electricity is great. Rotary kilns are dealt with in more depth in the chapter on the cement industry.

Use of Oxygen in the Kiln

The use of oxygen in brickmaking tunnel kilns has been shown to result in increased kiln capacity and lower overall energy consumption by allowing an increased rate of car travel through the kiln [15]. At the same time, the kiln draft and the quantity of flue gases are reduced, thus reducing the emission of noxious effluent.

4.3.3 BRICK PERFORATIONS

The inclusion of perforations in a brick reduces the volume of the brick, and increases the surface area. This has a multiple effect. The increased surface area to volume ratio enables a higher rate of heat transfer from the combustion gases to the brick body, and the thickness of clay between two surfaces is also reduced, reducing firing times. The mass of brick to be fired is reduced, resulting in a lower mass per car load of bricks, allowing less robust kiln cars of lower thermal capacity to be used. All of this results in lower specific energy consumption.

Using a greater number of small perforations, rather than a few large ones, while keeping the total brick volume and mass constant, will also result in a reduction of energy requirement per brick. If the perforation size is reduced, the total surface area of the brick is increased, improving heat transfer from gas to brick in the dryer and kiln.

The mass of pressed bricks is reduced by cavities in the brick face, called "frogs". These indentations do not have a significant effect on the surface area available for heat transfer.

4.3.4 PROCESS CONTROL

Measures such as automatic control of kiln temperatures, dryer programming and control of clay moisture content may be expected to reduce energy consumption in both brickmaking and refractory production. Cost effective energy savings can be achieved for moderate capital outlay. In the UK brick industry, it is estimated that 10.9% of the total kiln energy could be saved by process control of this nature [8].

4.3.5 GOOD HOUSEKEEPING

The sealing of kiln leaks, ensuring dryer doors are in good repair and other general good housekeeping measures, involving negligible capital outlay and plant downtime, afford the most economically feasible opportunity for saving energy. Potential energy savings of as high as 5% of total consumption are reported possible for the UK refractories industry [9], and a similar proportion may be expected in this country.

4.4 CONCLUSIONS

Total energy consumption in the structural clay industry is estimated at between 19.7 million Gigajoules and 22.45 million Gigajoules per annum. Of this, between 75% and 85% is consumed by the clay brickmaking industry.

CLAY BRICKMAKING

Of the kiln types used to manufacture clay bricks, the tunnel kiln offers the most potential for economical energy efficient production. The lowest energy consumption per unit production reported in this survey was for a tunnel kiln, although the lowest average values were reported for annular continuous kilns. In the survey sample, annular kilns represented 55% of the total production, clamps 20%, tunnel kilns 15%, and downdraught kilns 10%.

Clamps offer relatively energy efficient production, and do not require capital equipment for firing. The quality of the bricks produced is difficult to control, however, and not necessarily as high as can be achieved in other kilns. Energy recovery is not possible, and production is obviously subject to the elements. Inclement weather can result in great losses. Pollution control is limited with clamp production, and, with time, environmental objections are likely to increase.

The average gross energy consumption per unit product in brickmaking is comparable to that in the British industry, but the greater range of values reported would suggest that there is room for improvement in a number of South African plants.

A reasonable energy saving can be expected to result from an improvement in general standards of plant upkeep and operation, at minimal cost. Sealing of kiln leaks, attention to kiln doors, insulation repair, and increased levels of insulation are areas worthy of attention, and are applicable to 80% of the brickfields covered in this study. It would be reasonable to expect energy savings of up to 3% of total input from such measures. At present levels of consumption this would mean annual savings of up to 0,5 million GJ or R830 000 for the industry as a whole. This and later estimates of energy savings are based on the comparison of the industry in South Africa with that in the U.K.

The introduction of energy saving measures involving large capital expenditure, for example equipment for heat recovery from exhaust gases, is unlikely to be justifiable in brickmaking or refractory production at present in this country. If all available, proven energy conservation equipment for use with continuous kilns were installed, an additional overall energy saving for the industry of 0,71 million GJ or R1,17 million per year could result. The cost of installing such equipment is prohibitive in most cases, at the moment.

Energy monitoring, to identify areas where methods of achieving energy savings at low-cost could be implemented, may be expected to steadily gain popularity. In cost terms, the largest savings may be expected to arise from the control of maximum electricity demand, improvement of power factor and control of combustion. These measures are applicable to both clay brick and refractory manufacture. Overall electrical energy savings of up to 16GWh, and fuel savings of 0,22 million GJ may be expected annually, if achievements in the U.K. are taken as a guideline.

The increased use of carbonaceous additives can reduce the requirements of more costly fuels for firing. The use of carbonaceous waste products by one plant has been shown to reduce energy costs substantially and have no adverse effect on the product, while being environmentally beneficial. The use of this type of additive requires investigation in each case, but could be increasingly adopted.

Energy requirements can also be reduced by reducing the brick mass through increased perforations and burnout of additives. A reduction of more than 5% in specific energy consumption was obtained by one brickfield participating in this survey in this manner. Technical and legislative problems, in regard to standards, could arise from the introduction of non-standard bricks, however, and this requires investigation. Considering reported performance, an annual saving of 1,12 Million GJ or up to R1,85 million could be possible.

The potential energy savings identified by this survey may be as high as 13% in the clay brickmaking industry, implying an annual saving of up to 2,87 million GJ or about R4,74 million. However, measures involving substantial capital investment are unlikely to be implemented in the near future, and therefore this potential cannot be expected to be realised. A reduction of about 8% may be achieved through the implementation of non-capital intensive measures. This could mean an annual saving of 1,8 million GJ or R3 million.

It is possible that the opportunity for energy conservation in clay brickmaking is even higher than identified in this study. The potential for energy saving in the brickmaking industry in the U.K. is estimated to be of the order of half the current consumption. Energy utilisation in the industry in South Africa is similar to that in the U.K., and therefore it is possible that the overall potential for energy saving in this industry in South Africa may be similar.

REFRACTORIES

With an energy input of between 1 GJ and 22 GJ per ton of product, and the majority of products requiring an input of more than 14 GJ per ton, refractory production is energy intensive. The largest areas of energy use are calcining, deadburning and firing. The trend towards monolithic refractories which are fired in situ can be expected to decrease energy requirements substantially.

In common with the brickmaking industry, energy saving measures in each process in the industry are likely to be limited to those that involve little or no expenditure.Judging by performance in other countries, improving standards of housekeeping, combustion control and levels of insulation could result in a reduction in energy consumption of as much as 10%. In the refractory industry this would imply a saving of about 0,5 million GJ or about R900 000.

GENERAL

There are a number of barriers to energy conservation in the structural clay industry. Firstly, unawareness of energy saving possibilities, due to the absence of energy monitoring is common in the industry. Lack of available capital, and incentive, rank highly. A factor that cannot be ignored is resistance to change traditional practice. Significant improvements cannot be expected until these barriers no longer exist.

CHAPTER FIVE

THE CEMENT INDUSTRY IN SOUTH AFRICA

The cement manufacturing industry is classified under the Department of Statistics Standard Industrial Classification of All Economic Activities (SIC) as Manufacture of Cement, subgroup 36920.

5.1 INTRODUCTION

5.1.1 THE CEMENT MANUFACTURING PROCESS

Portland cement is the generic name for a hydraulic cement, composed mainly of high-limed calcium silicates with lesser amounts of high-limed calcium aluminates and ferrites, which are ground, together with an amount of gypsum, and often other materials, to a fine powder.

On drying after combination with water, the hydration product of Portland cement becomes the binder which joins sand, stone, bricks and other construction materials. Different types of Portland cement are manufactured according to requirements for use. The type of cement depends on the blend of materials from which it is made.

Portland cement is made from some of earth's most abundant materials. The major constituents of cement are generally derived from limestone, while other ingredients, silica, alumina and iron oxide are derived from materials such as shales, clays, blast furnace slags and iron ore.

The individual ingredients must first be reduced to a finely divided state, in order to enable the raw materials to be blended to the correct composition. The composition must be held within narrow limits which are necessary to obtain a useful product and satisfy standards. After blending, the ingredients are ground in mills to a fine powder so that they will react within a reasonable time in the kiln. The product from the raw mills is known as raw meal.

The raw meal is introduced into a kiln, which in virtually all cases is a rotary kiln. The feed may be introduced as a slurry, dry or "semi-wet". "Semi-wet" feed results from spraying a small amount of water onto the feed in a rotating cylinder, allowing it to form nodules. Water added to the raw meal plays no part in the cement making process, and heat is needed to evaporate the water before any further reactions take place. As a result, wet and semi-wet process kilns have higher specific energy requirements than dry process kilns, and are being phased out internationally. Existing wet kilns are being decommissioned in this country.

In the kiln the feed is heated to about 1500 $^{\circ}$C. At this temperature, complex chemical reactions take place that transform the raw meal into dull grey nodules, called clinker.

This product is cooled and ground in mills with a small amount of gypsum, and other additives, to a fine powder which is known as Portland cement. Cooling takes place in one of three types of cooler, rotary, planetary or grate coolers.

The cement produced is despatched, either in bulk or in packages. Due to the increasing cost of packaging, and the introduction of mini-bulk systems, supply of cement in bulk is becoming more prevalent .

The major trend in the manufacture of Portland cement has been the emphasis on reduction of energy consumption for production. This has resulted in the decommissioning of wet and semi-wet kiln plants, and the introduction of new, more energy efficient plant.

Preheating of the raw meal using the kiln exhaust gases has become standard practice. Preheaters may be of the cyclone suspension, commonly four stage, or travelling grate type, with the suspension preheater being the more efficient of the two.

Decarbonation of the limestone prior to introduction to the kiln using auxiliary burners or kiln exhaust gases is another energy saving development. This is commonly called precalcining. It is not possible to have a precalciner on kilns equipped with planetary coolers.

Preheating and precalcining enable much shorter kilns to be used for the same production output, with resultant energy savings.

The use of kiln exhaust gases to dry material in the raw feed mills and cement mills is also common practice and high capacity, high efficiency mills are being installed in increasing numbers.

5.1.2 THE INDUSTRY STRUCTURE IN SOUTH AFRICA

Three concerns account for all the cement produced in South Africa. They are; Anglo Alpha Cement, Blue Circle Cement and Pretoria Portland Cement. A fourth company, Natal Portland Cement, is a joint venture by the other three groups. At the beginning of 1984 there were twenty eight kilns in production. This represented an installed production capacity of 9,5 million tons per annum [16]. The cement sold in the calendar year of 1984 totalled 8,188 million tons.

By the beginning of 1986, installed capacity will be 11,9 million tons. This includes the new 600 000 ton Dwaalboom plant of Pretoria Portland Cement, which is not expected to be fully commissioned until 1987, as a result of present market trends. With the current expansion programmes, the industry considers that it has sufficient production capacity to fully satisfy the local market for a substantial period [16].

5.1.3 SCOPE OF THE SURVEY OF THE CEMENT INDUSTRY

The sample of the industry participating in the survey comprised six combined clinker and cement milling plants, one clinker plant and one cement milling plant. These plants contributed 70% of the the total cement production in 1984.

5.1.4 ENERGY REQUIREMENTS OF THE CEMENT INDUSTRY

As the manufacture of cement involves chemical and physical reactions at high temperatures, it is highly energy intensive. On average, 92% of the energy consumed by the industry in South Africa (in energy content terms) is in coal, used in calcining and drying. Included in this figure is the use of other fuels, generally diesel or fuel oil for starting up the kiln. Electricity, used for grinding, driving kilns and fans, and materials handling, acounts for 7% of the total energy consumption. Transport within the plant (0.6%), and lighting, office and ancillary requirements (0.4%) account for the remainder.

These figures are all averages of those reported by individual plants in the industry.

5.2 INFORMATION OBTAINED FROM SURVEY AND DISCUSSION OF RESULTS

In this section, data obtained from the survey is presented along with previously collected data for the period from 1964 to 1974 [2], where available, to provide a larger data sample for forecasting purposes. Data presented graphically in this chapter is given in numerical form in Appendix C.

5.2.1 PRODUCTION IN THE CEMENT INDUSTRY

Cement production figures obtained from the survey were totalled and compared with published total cement production figures for the period 1975 to 1984 [16]. From this comparison total production figures of clinker were derived. Total cement and clinker production for the period 1964 to 1984 is shown in Figure 5.1.

The output from the industry shows clearly the post 1975 recession period which affected the building industry greatly, and the subsequent boom in 1979/1980.

CEMENT AND CLINKER PRODUCTION IN SOUTH AFRICA
1964 TO 1984

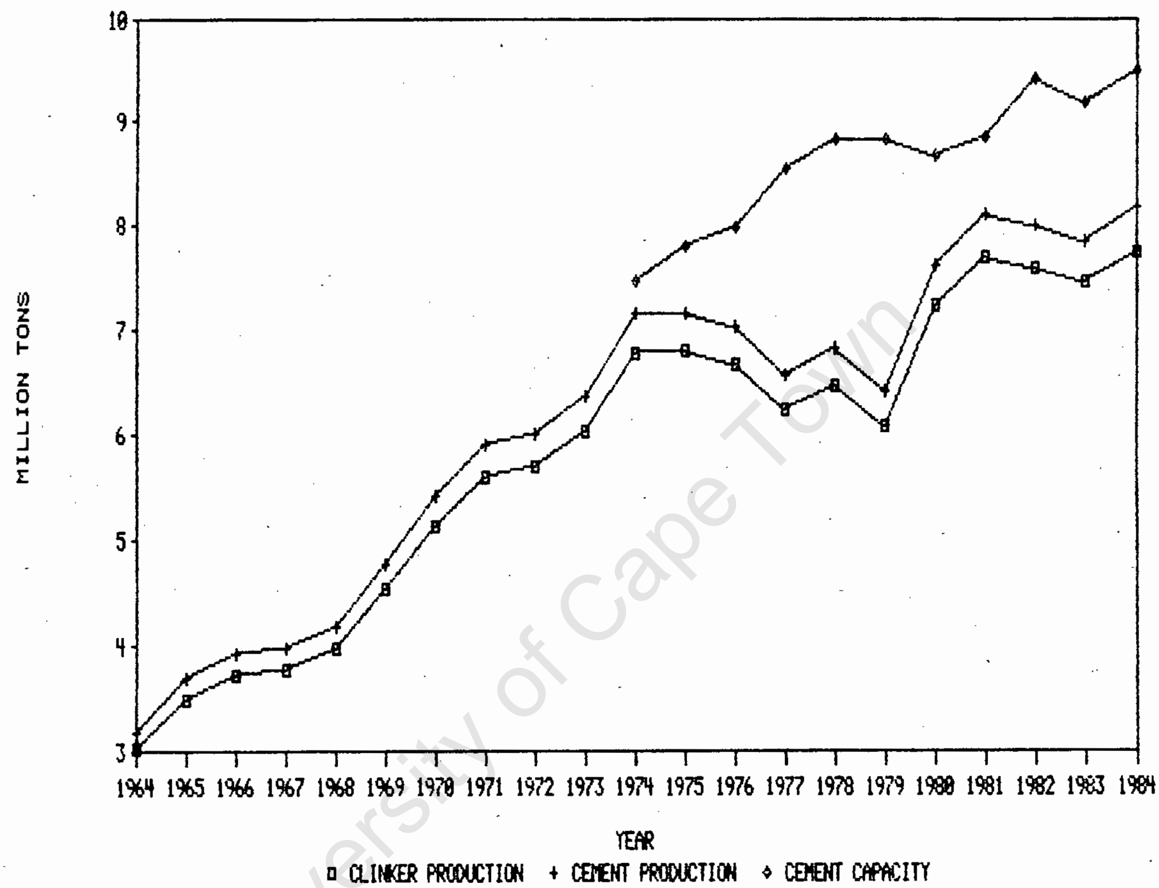


FIGURE 5.1

5.2.2 ENERGY CONSUMPTION IN THE CEMENT INDUSTRY

The production figures obtained from the respondents to the survey were compared with the total production of the whole industry (16) and the energy consumption data for that sample extrapolated to provide an estimate of the total energy consumption in the industry for the period 1975 to 1984.

The total energy consumption in the cement industry for the period 1964 to 1984 is shown in Figure 5.2.

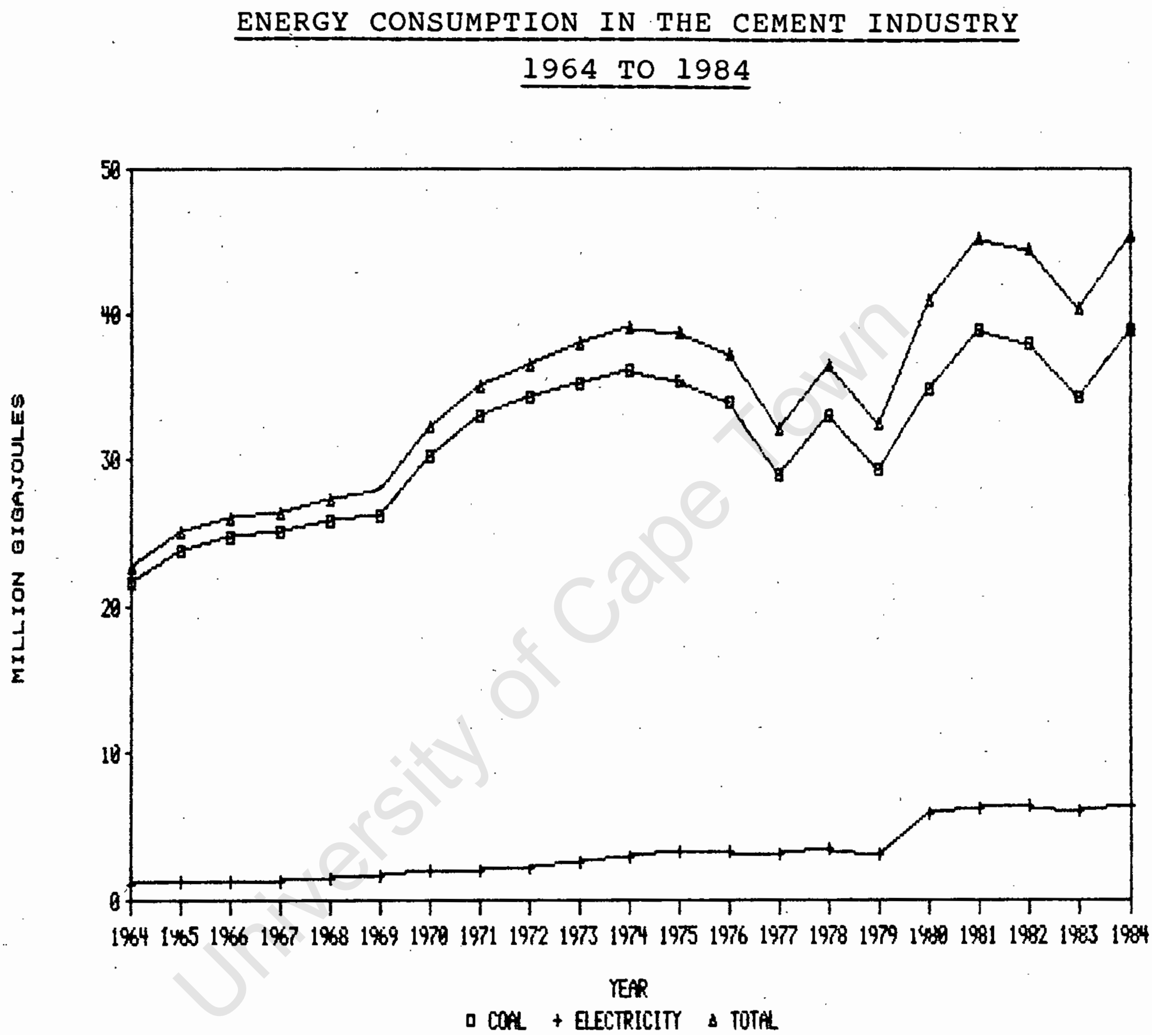


FIGURE 5.2

There are several features of interest in this graph. The most obvious is the sharp decrease in total energy requirements over the period 1975 to 1979, coinciding with the drop in production at that time.

If the rates of increase in production and energy consumption over the twenty year period are compared, however, it is clear that over the period 1964 to 1974, total energy requirements did not increase in proportion to production. Yet, after 1979, the rates of increase are proportional. This is accounted for by the increasing production in dry process kilns over the period 1964 to 1979 compared to wet process. From 1979 to 1984, the ratio of production in wet to dry process kilns did not change to any significant degree, and as a result, the energy requirements changed proportionally to production.

It is interesting to note that electricity demand appears largely to be a function of production output. In this investigation, it is not possible to see if technological innovations have had significant affect on specific electricity requirements.

From the figures obtained for production and energy consumption in the survey sample, an average specific energy consumption (in MJ per ton) for the industry as a whole is obtained. This value is a weighted average taking into account the proportional production by plants with different specific energy consumptions.

It should be noted here that the theoretical energy consumption per ton of cement produced is between 1758 and 1842 MJ/ton [17].

In addition, ideal specific energy consumption in clinker production for various kiln types, quoted by Betterton [18], is given in Table 5.1.

SPECIFIC ENERGY CONSUMPTION IN CLINKER PRODUCTION
1964 TO 1984

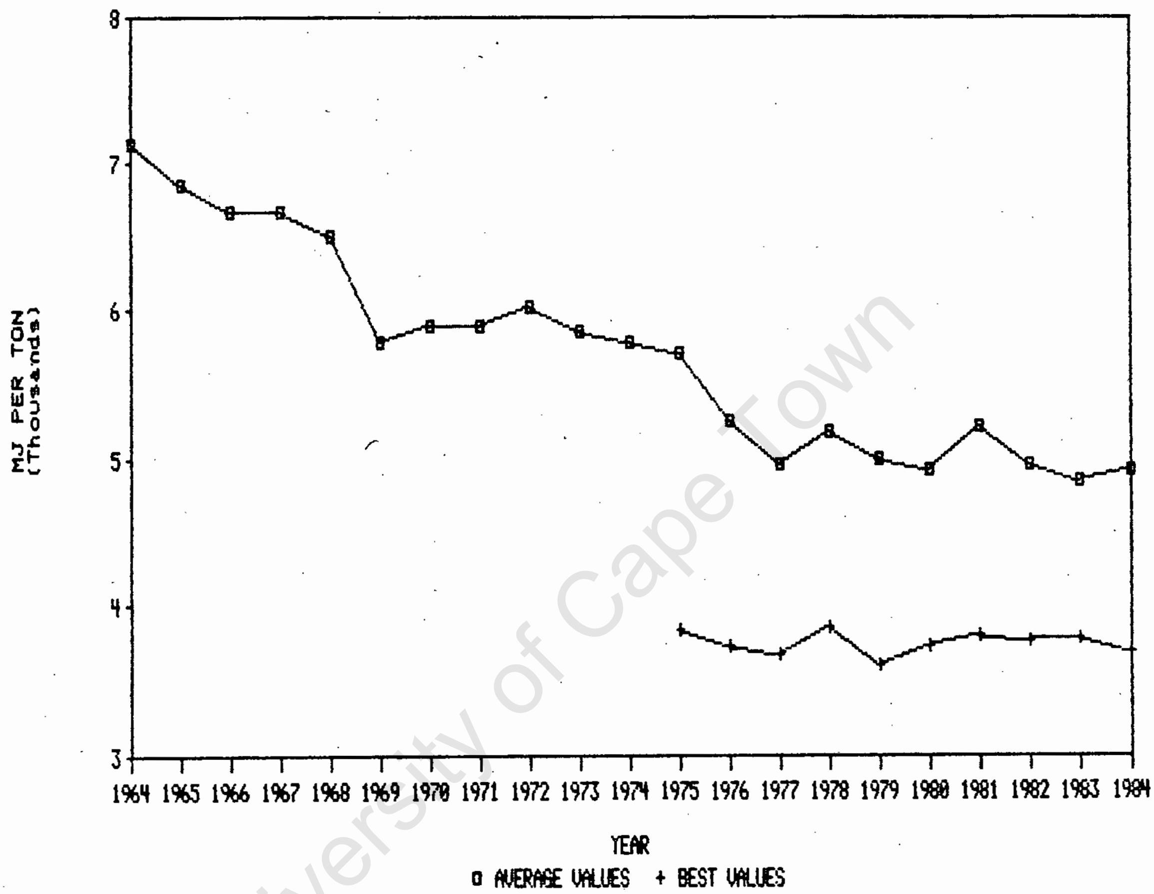


FIGURE 5.3

The effect of changing technology on the specific energy requirements for clinker production can be seen in Figure 5.4. The average specific energy consumption of each of the kilns in the survey sample was plotted against the year the kiln was commissioned. To maintain the anonymity of the plants concerned, a curve was fitted to the data points. This curve shows the trend in specific energy consumption clearly.

THE TREND IN SPECIFIC ENERGY CONSUMPTION IN CLINKER PRODUCTION IN SOUTH AFRICA, 1948 TO 1984

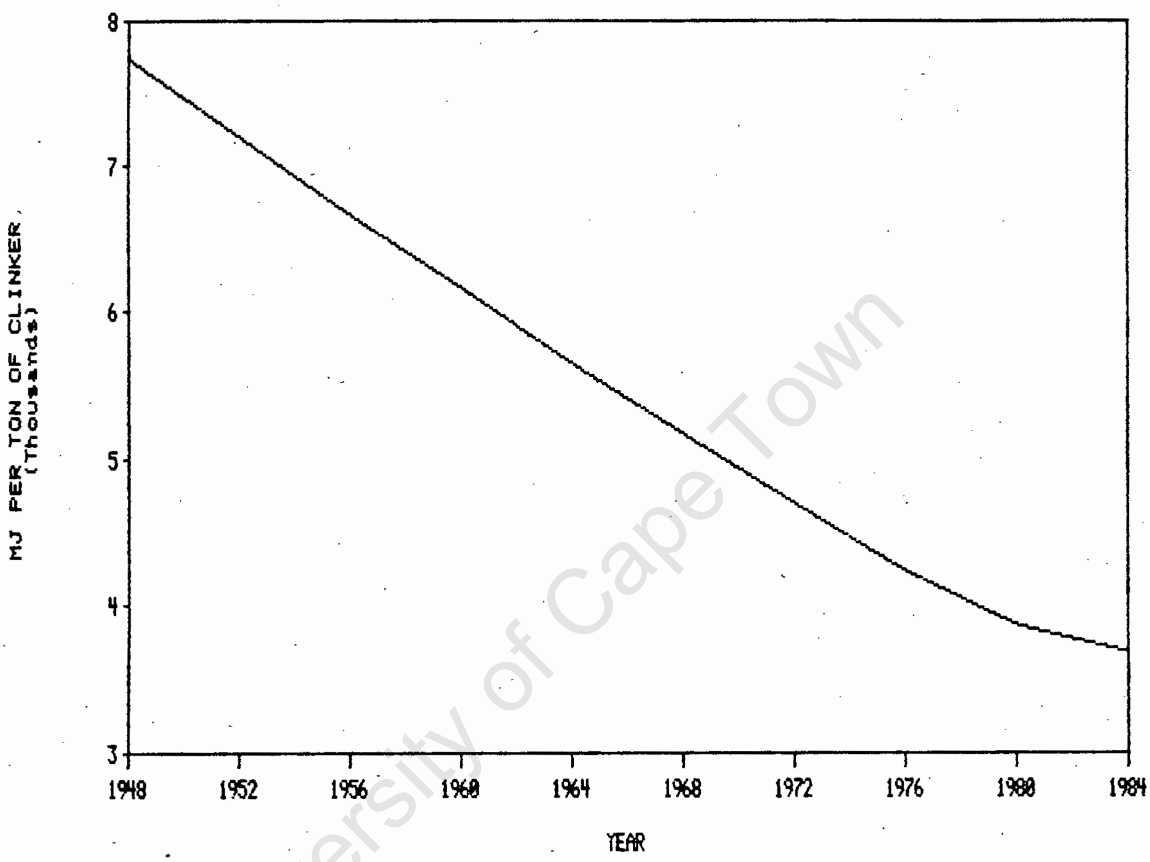


FIGURE 5.4

It is of interest to note the trend in production swing from wet to dry process as this trend obviously has had, and will still have, a significant effect on the energy requirements of this industry, until all kilns of this type have been decommissioned. The proportion of total clinker production capacity due to wet, semi-wet, and dry kilns for the period 1964 to 1984 is given in Figure 5.5.

PERCENTAGE OF TOTAL PRODUCTION CAPACITY BY KILN TYPE 1964 TO 1984

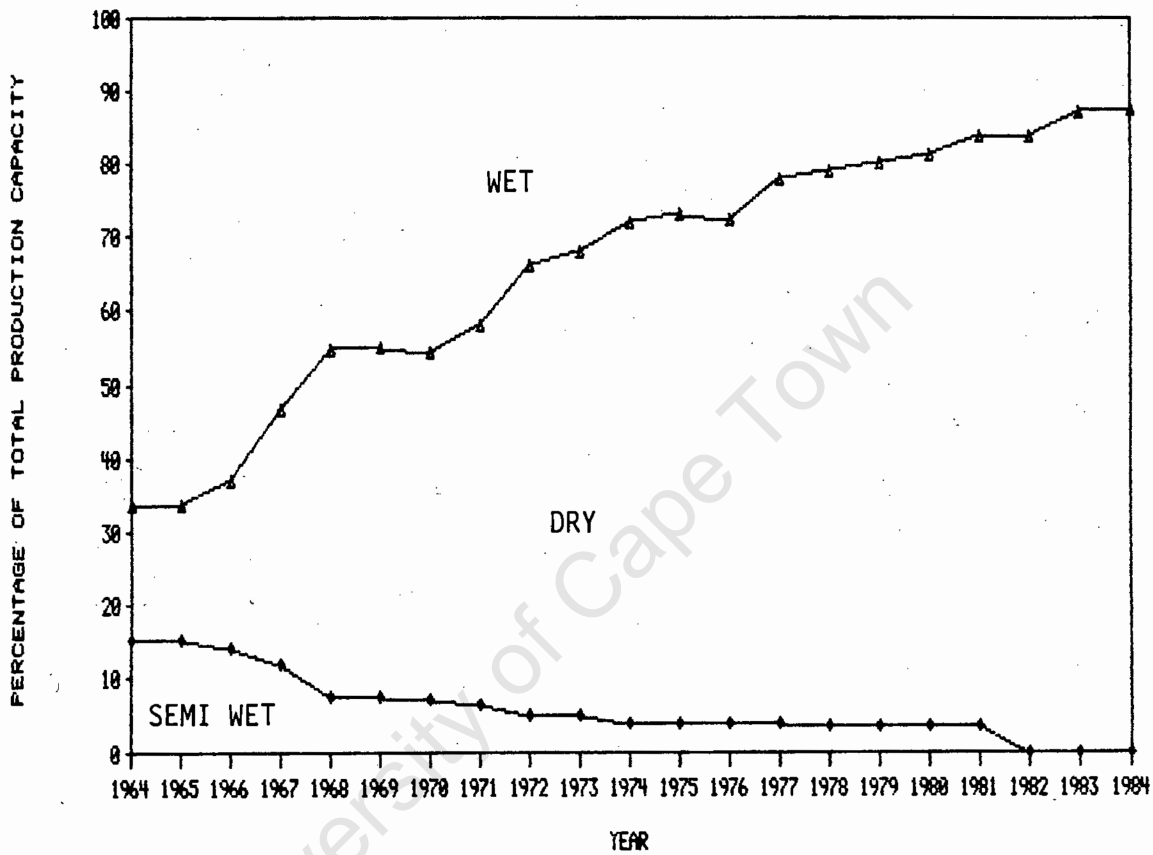


FIGURE 5.5

The average total energy consumption per ton of cement produced, including electricity, and other fuels used for starting of kilns and ancillary purposes at cement plants, for the survey sample for the period 1975 to 1984 is given in Table 5.2.

TOTAL SPECIFIC ENERGY CONSUMPTION IN CEMENT PRODUCTION

YEAR	TOTAL SPECIFIC ENERGY MJ PER TON OF CEMENT
1975	5872
1976	5387
1977	5097
1978	5319
1979	5133
1980	5058
1981	5359
1982	5090
1983	4979
1984	5061

TABLE 5.2

The mean specific energy consumption for this ten year period is 5236 MJ/ton. It can be seen that the energy saving measures introduced during this period, involving improvements in thermal and electrical energy utilisation, have resulted in a general decrease in the overall specific energy consumption for the industry.

As the incentive for reducing energy consumption per unit product output is financial, it is of interest to note the variation in energy cost as a percentage of total production cost for the survey period. This is given in Table 5.3. The values given here are the averages of values given by the respondents in the survey.

ENERGY COST AS A PERCENTAGE OF PRODUCTION COST

(Average values for survey sample)

YEAR	PERCENTAGE
1975	31.2
1976	32.2
1977	35.7
1978	39.2
1979	38.3
1980	36.5
1981	34.5
1982	34.3
1983	41.3
1984	44.0

TABLE 5.3

The increasing percentage of total production costs represented by energy costs is clearly seen in this table. As this trend can be expected to continue, the investigation of energy saving measures is a major consideration in the industry. In view of the present economic climate, however, few measures involving large capital expenditure can be expected to be implemented in the near future.

The breakdown of energy costs into cost of coal, electricity and other fuels is unfortunately not available, but the high cost of electricity relative to coal may well provide increasing incentive in the future for serious consideration of the generation of electricity using exhaust gases, already an established practice in the industry [19].

5.2.3 ENERGY MANAGEMENT IN THE CEMENT INDUSTRY

It is a reflection of the attitude towards efficient energy utilisation in the cement industry that in all of the plants participating in the survey, the task of energy monitoring and optimisation of energy consumption is allocated as the inherent responsibility of at least one member of the engineering staff. As yet, though, no plant reports a member of staff whose sole responsibility is the management of energy utilisation.

All plants conduct energy audits to some degree, and hold discussions with employees concerning energy conservation and management.

Less than half of the plants are conducting awareness drives by way of posters, notices or newsletters indicating measures for energy conservation or past and current energy related performance. Programmes of this nature are reported to demonstrate management commitment to energy management and encourage workforce participation with positive results [20].

All but one of the plants in the survey sample have installed equipment to improve electrical load distribution in order to reduce excessive maximum demand charges.

Half of the plants have automatic or semi-automatic power factor correction. The power factor reported by the respondents varies from 0.83 to 0.99, with the mean being 0.95.

Other measures adopted include rationalising passenger transport, conversion from fuel oil to electricity for some applications and automatic control of plant lighting,.

5.3 COMPARISON WITH CEMENT INDUSTRY IN OTHER COUNTRIES

The comparison of specific energy consumption ratios obtained in an individual industry in different countries gives an idea of the status of energy efficiency within that industry in a specific country. It must be kept in mind, however, that the specific energy consumptions obtained need not necessarily be derived in exactly the same manner.

A number of specific energy consumption ratios in the cement industries of various countries quoted by Jankowski [21] are compared with those recorded in the South African industry in the same year in Table 5.4. It is assumed that the published data quotes the average specific heat input for clinker production under normal operating conditions.

The specific energy requirements as quoted per ton of clinker for the industry in the Federal Republic of Germany and Italy in 1974 reflect the extent of production due to dry and semi-dry process kilns in those countries at that time (92% in FRG and 96% in Italy). Considering the ideal kiln fuel consumption given by Betterton [4] and shown in Table 5.1, the values given for the two countries above appear incorrect. Assuming, in the case of the F.R.G., that the 92% of production occurs in dry process kilns with four stage suspension preheaters operating at ideal efficiency and the remaining 8% occurs in wet kilns operating at ideal efficiency, an overall specific energy requirement per ton of clinker of 3526 MJ/ton is obtained. This is higher than the figure quoted in Table 5.4.

OVERALL KILN FUEL INPUT PER TON OF CLINKER

YEAR	COUNTRY	MJ/TON	AVERAGE MJ/TON IN SOUTH AFRICA IN THE SAME YEAR
1970	INDIA	7876	5900
1973	BANGLADESH	7084	5870
1974	F.R. OF GERMANY	3446	5500
1974	ITALY	3726	5500
1974	NETHERLANDS	5414	5500
1974	UNITED KINGDOM	5426	5500
1974	UNITED STATES	6239	5500
1975	JAPAN	5008	5727
1975	SWEDEN	5849	5727
1975	EGYPT	6783	5727
1975	KENYA	6331	5727
1976	PERU	4652	5254
1977	INDIA	7105	4971
1977	KENYA	5594	4971
1978	HAITI	8332	5187

TABLE 5.4

In the same article Jankowski [21] notes that overall kiln fuel use per ton of cement in Germany and Italy in 1974 was 4091 MJ/ton and 4430 MJ/ton respectively. One ton of clinker is commonly taken to produce 1,05 tons of Portland cement [4], and using this conversion factor the energy consumption per ton of clinker is 3896 MJ/ton in Germany and 4219 MJ/ton in Italy. These values would appear to be correct for the circumstances in those countries.

Table 5.4 indicates that the level of development of the cement industry in South Africa in the 1970's may be considered above average in terms of energy consumption, and it is accepted in international circles that fuel conservation measures taken by the industry in this country are on the increase [22]. It is necessary to have more recent data to compare with, as well as an idea of the energy requirements of the latest technology in kiln design.

The average specific energy requirement in the cement industry in the United Kingdom in 1981 was found to be 5050 MJ/ton [8] in comparison with 5227 MJ/ton for South Africa in the same year. Comparing these values with those in 1974, it would appear that the industry in the two countries has developed at roughly the same rate. The same report also gives a "best practice" value for the industry in the U.K. as 3310 MJ/ton, which is significantly less than any value reported in the survey.

Developments in kiln technology have a significant effect on the specific energy consumption in clinker production. A few examples of such developments, as reported in the literature, are listed below. It is of interest to compare the values of specific energy consumption listed below with the lowest specific energy requirement for clinker production in South Africa for the period 1975 to 1984, recorded by this survey, of 3607 MJ/ton.

Singh [17] reports 3370 MJ of heat required per ton of clinker produced in a pilot single stage fluidised bed calciner.

A production of 2300 tons per day with a specific energy input of 3241 MJ/ton is reported by Kreisberg [23] for a kiln of length 41.15 metres long and 4.88 metres in diameter, claimed to be the smallest length to diameter ratio in the world. The plant comprises a grate cooler, four stage suspension preheater and precalciner.

Conversion of a wet process kiln to a dry process kiln using the Onoda/Reinforced Suspension Preheater system (RSP) resulted in a reduction in specific energy consumption from 5860 MJ/ton to 3370 MJ/ton firing with coal [24]. Conversions of this type have been investigated in some cases in South Africa, but are considered unlikely. The cost of such a conversion is high, and it is generally considered that it would be more economical to use existing wet kilns as they are, when additional production capacity is required to produce small quantities special cements on demand, rather than convert the kilns to dry process.

Development of fluidised bed precalciner technology has reduced kiln energy requirements to 3061 MJ/ton [25]. This value is reported for a rotary kiln incorporating a five stage suspension preheater and fluidised bed precalciner. It is considered likely by some, that future development in kiln technology will lead to rotary kiln length being continually reduced, until the rotary kiln is replaced entirely by fluidised bed calcining.

5.4 ENERGY SAVING OPPORTUNITIES

It is clear that the introduction of new technology can be expected to reduce the specific energy requirements of the industry substantially. The commissioning of new plant, conversion of existing plant, or adoption of any energy saving measure will only come about if such action can be rationalised.

The production capacity of the industry is greater than the present demand, and the predicted demand for the short to medium term future. As a result, it is highly unlikely that any new plant will be commissioned for a number of years. In addition, economic considerations would suggest that alterations to existing plant involving large capital expenditure are equally unlikely in the short term. Energy savings are, therefore, more likely to come about as a result of product alterations and energy management in this industry in the near future.

Listed below are some developments in the industry resulting in improved energy utilisation. These are presented as a resume of available technology, all of which has been investigated by the industry in this country.

KILNS, PREHEATERS AND PRECALCINERS

In this country, the decommissioning of all wet plant will result in a significant reduction in the overall specific energy consumption for the industry. Based on figures obtained from this survey, it is estimated that the industry's average specific energy consumption will fall from the 1984 level of 4936 MJ/ton to around 4350 MJ/ton, once all wet plant is decommissioned.

In this event, conversion of wet kilns to dry kilns in the manner quoted by Champonnois[24] may be a viable proposal, keeping in mind the anticipated future market situation. A case is quoted of a wet kiln operating at 750 tons of clinker per day with a heat consumption of 5860 MJ per ton of clinker being converted to a dry kiln with a reinforced suspension precalciner. Output increased to 1700-1800 tons per day and the average heat consumption was reduced to below 3350 MJ per ton of clinker. Numerous other conversions using various precalciner systems indicate similar improved performance [26]. The general opinion in the industry, however, is that kiln conversion will not be cost effective and that the existing wet kilns would probably be used to produce smaller outputs of special cements.

In the case of existing long dry kilns and newer kilns with four stage suspension preheaters, the cost of adding preheaters or precalciner systems is not expected to be justified by the expected fuel cost saving in the foreseeable future. It must also be remembered that precalciners cannot be retrofitted to kilns with planetary coolers.

Precalciner systems undoubtedly exhibit a number of advantages over standard plant. These include improved kiln output, reduced refractory consumption, lower specific energy consumption, lower heat losses and more compact design.

The reduction of pressure losses in cyclone preheaters has also achieved significant reductions in fan electrical power consumption in clinker production [27]. Modification of cyclone inlet and outlet ducts and the replacement of fans by more efficient fans have lead to reductions of greater than 34% in fan power consumption.

GRINDING

In general, between 60% and 75% of electrical power consumption in cement plant is expended on grinding of raw materials, clinker and coal. The optimisation of energy consumption in the grinding system can therefore result in significant energy cost saving.

The effectiveness of tube mill systems, favoured for their simplicity of design and operation and reasonable price can be increased by ensuring the correct ball charge, and installing adjustable lifting diaphragms and ball charge classifying liners, as has occurred in one plant in South Africa [25]. To increase efficient energy use, grinding systems should be equipped with high efficiency separators or air-classifiers. Introduction of the latter has been found to reduce specific energy consumption in the grinding system by as much as 13% over systems equipped with conventional air-classifiers [28].

Reduction of energy consumption and increase in output has been achieved with the grinding roll [25]. Its additional advantages are improvement in product quality, low noise emission and adaptability to product requirements.

BURNERS

The effect of excess air on the energy efficiency of cement kilns is considerable. Increasing the excess oxygen level from 1% to 5% can increase specific heat consumption by more than 10% [29]. Design of the burner as an integral part of the kiln and cooler system to achieve optimal combustion, and maintaining the excess oxygen level within the optimum operating range of 0.5% to 1.5% can result in large energy savings.

KILN LINING

Heat losses from rotary kilns can be reduced by up to 25% by lining the transition and safety zones of the kiln with modified standard shape lining bricks incorporating appropriate insulating material at the cold surface [30]. This is possible without damage, even in the tyre zones with their high mechanical stress and shear forces, provided the modified shapes are used in kiln zones where there is no stable coating.

PRECIPITATORS

Electrical energy savings of up to 90% and stack emission reductions of up to 75% have been reported possible using a new pulse energisation system for electrostaic precipitators, according to performance data from field tests of the system [31]. Installation of such equipment could enable significant electrical energy cost savings.

COMPUTER CONTROL

Automatic control of cement kilns has been shown to increase fuel efficiency by up to 4%, and can be expected to become increasingly prevalent in the industry [32]. The applicability of micro-processor control can be extended to electrostatic precipitators where energy savings and reduction of electrode damage due to spark erosion have been reported [33].

COGENERATION

If electricity prices continue to escalate, power generation from waste heat may become an increasingly attractive option to the industry. It has been shown that the waste heat in the exhaust gases of a 1600 ton per day four stage suspension preheater kiln can be converted into useful electrical and thermal energy [19]. This is possible even though the gases are heavily dust laden.

NEW CEMENTS

Investigations have been made into altering the composition of Portland cement to reduce the energy consumption necessary for its production [34]. Modified Portland cements, containing a calcium sulpho-aluminate and a reactive calcium alumino-ferrite, have been found to have satisfactory strength and water resisting qualities, yet require 25% less energy cost in manufacture than Portland cement clinker. Other blended cements, containing small proportions of Portland cement (20%) and larger proportions of Plaster of Paris and reactive pozzolans (between 30% and 50% of each), can offer up to 75% energy savings, while possessing strength and water-resisting qualities similar to those of Portland cement.

The major obstacles to this development are current operating practices and specifications, and lack of consumer confidence in new products. Once these are overcome, it can be seen that the potential for energy saving in this area is great.

Developments have already been made in the area of blended cements in this country with the introduction of the blends of Portland cement and pulverised fuel ash and blast furnace slag, PC15FA and PC15SL. The use of pozzalan extenders in this manner both reduces the energy input per ton of product, and increases the output capacity. Production of these cements can be expected to increase. Development of further modified Portland cements is also likely.

5.5 TRENDS IN ENERGY CONSUMPTION IN THE CEMENT INDUSTRY

This work does not attempt to make a detailed economic analysis of production and energy consumption. Instead, the overall trends in production and energy consumption over the period 1964 to 1984 are identified and extrapolated, taking into consideration expected improvements in technology and additional information obtained from respondents to the survey.

5.5.1 TRENDS IN PRODUCTION

Production levels in the cement industry are strongly dependent on the health of the construction industry. Unfortunately, in times of economic instability this sector is commonly one of the earliest to suffer. As a result production of cement declines, as is clearly shown in Figure 5.1. The industry is at present suffering a decline in demand which is expected to continue until mid-1987. From that time onwards the industry expects demand to increase at approximately 5% per annum.

ESTIMATES OF PRODUCTION IN THE CEMENT INDUSTRY TO 1992

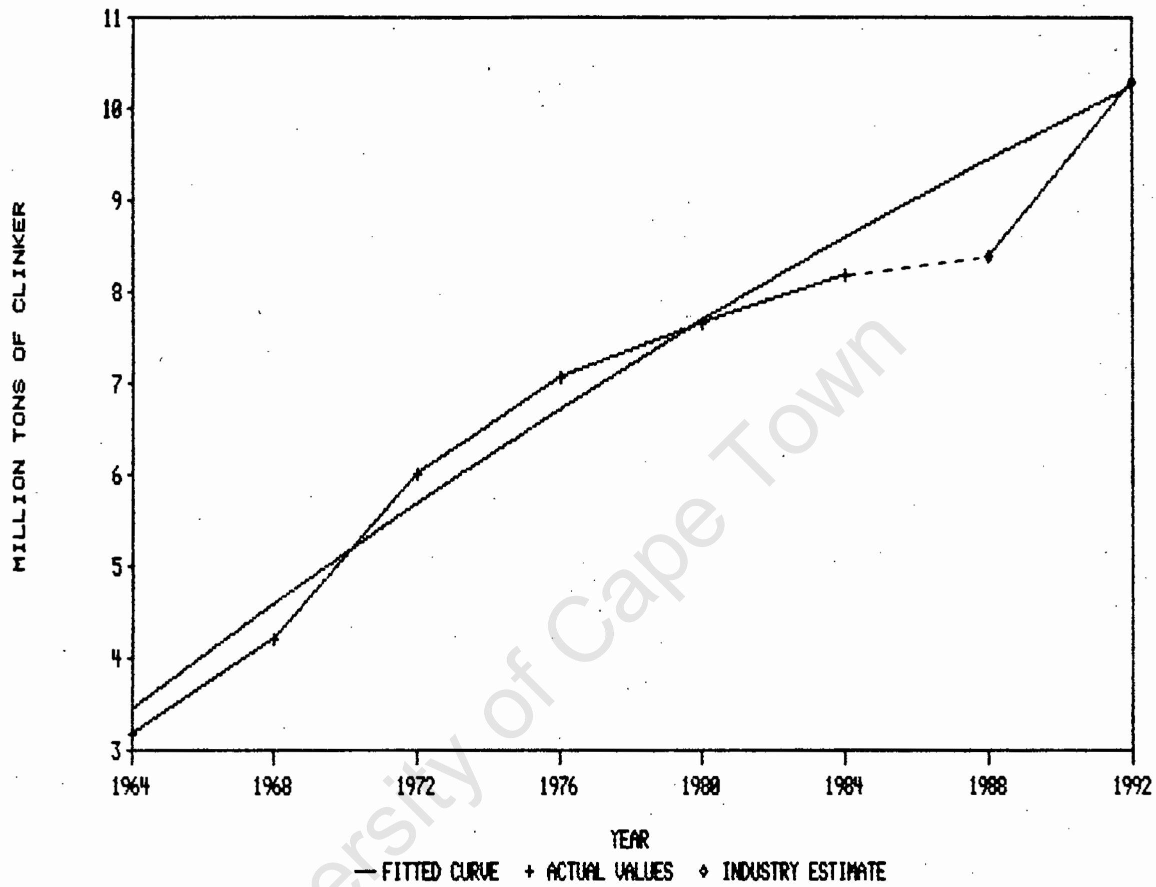


FIGURE 5.6

Two estimates of the overall production growth in the industry are given here. The first is obtained merely by fitting a curve to the production data from 1964 to the present and extrapolating the curve for a period of five years. The second is obtained from a forecast of demand supplied by the South African Cement Producers Association. This information is given in Figure 5.6, along with the trend in production to date.

5.5.2 TRENDS IN ENERGY CONSUMPTION

As the industry has sufficient production capacity for projected demand for the short to medium term future, no significant plant commissioning can be expected within the next few years. Wet process plant represents less than 20% of production capacity, and if the downward economic trend continues further wet plant may be de-commissioned. This will result in a decrease in specific energy consumption.

The swing towards blended cements can be expected to increase, because of the price factor and increased consumer confidence. This move implies increased cement production from the same clinker capacity, with resultant decreases in specific energy consumption to be expected in the future.

Taking only these two factors into consideration, a projection of the average specific energy consumption for clinker production in the industry may be made. This is shown in Figure 5.7.

ESTIMATE OF AVERAGE SPECIFIC ENERGY CONSUMPTION
IN CLINKER PRODUCTION

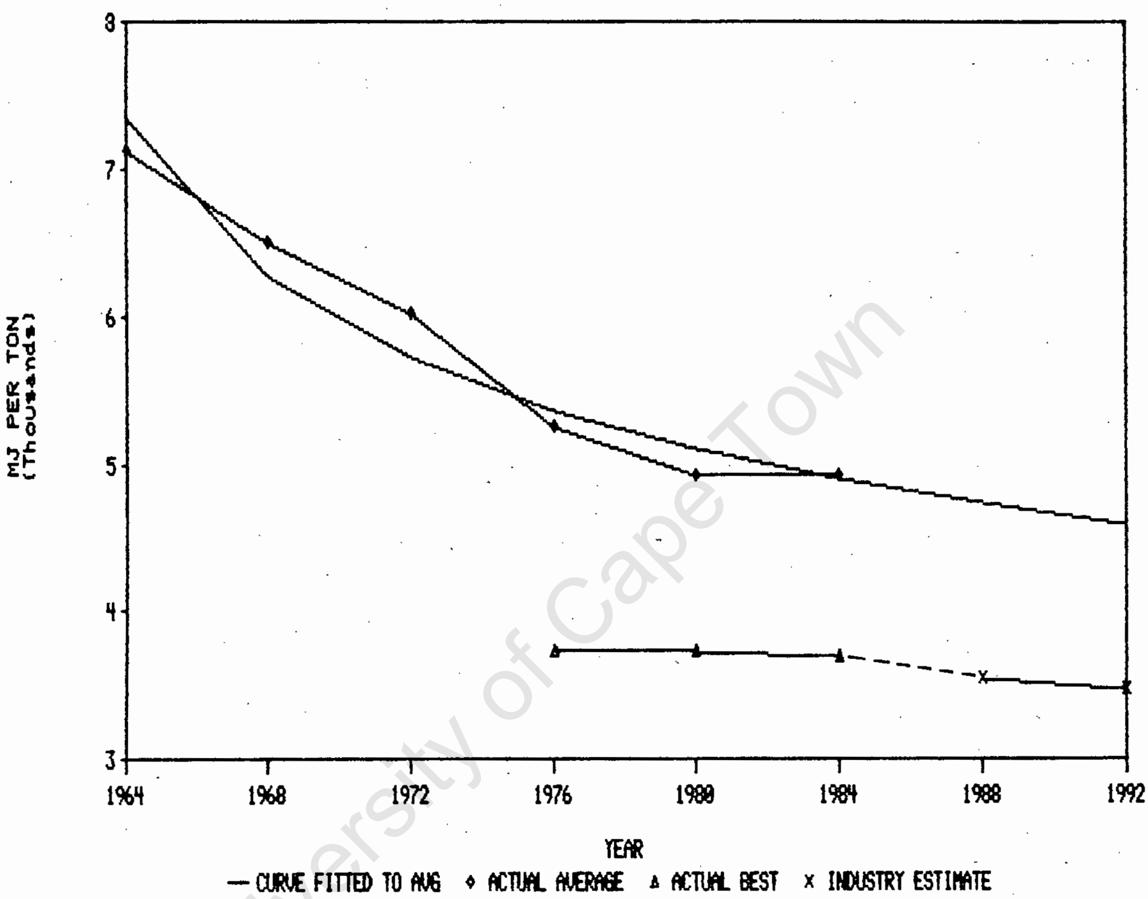


FIGURE 5.7

Coupling the projection of the curve fitted to the values of average specific energy consumption for clinker production with the estimates of production in Figure 5.6, and assuming electrical energy demand proportional to cement production at the present ratio, it is possible to make two estimates of the total energy requirements of the industry. These are shown in Figure 5.8.

ESTIMATE OF TOTAL ENERGY DEMAND IN THE CEMENT INDUSTRY

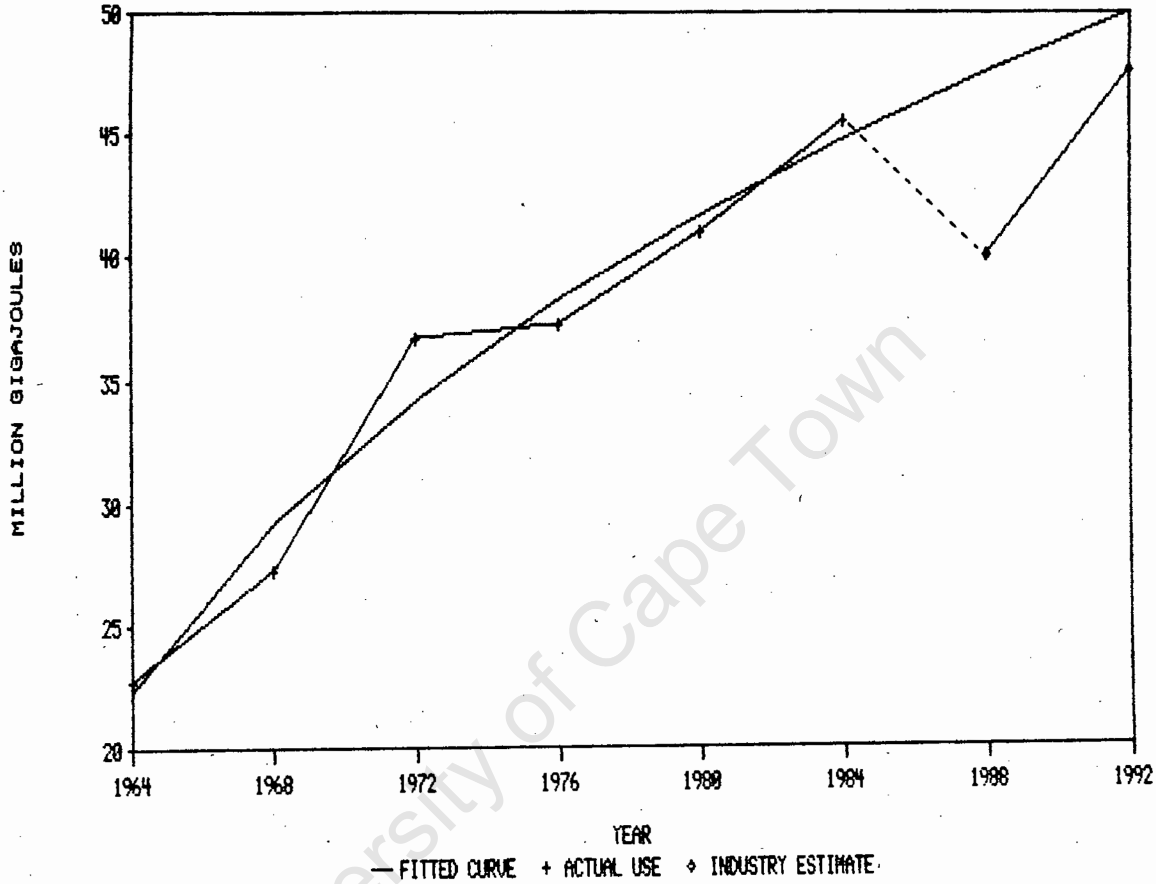


FIGURE 5.8

5.6 CONCLUSIONS

Cement clinker production is a highly energy intensive process, with an energy input of between approximately 6000 MJ and 4000 MJ per ton of cement clinker produced in South Africa, depending on the plant used.

The theoretical minimum energy input in clinker production is between 1758 MJ and 1842 MJ per ton. The lowest energy input reported in the literature is 3061 MJ per ton achieved in a dry process plant with a five stage preheater and a fluidised bed precalciner.

The transition of cement production in South Africa from wet process to dry process plant, especially more advanced plant with multi-stage preheaters, resulted in a marked decrease in the average specific energy consumption over the period 1964 to 1976. After that period, however, the value has remained fairly constant. With the decommissioning of the remaining wet process plant, the industry average specific energy consumption may be expected to drop by as much as 12%. This would result in a reduction in annual energy consumption of approximately 4,5 million GJ, or a cost saving of about R8,1 million, at a production level equal to that of 1984.

Due to the present recession, and the expected lag in the upturn, new plant is not expected to be commissioned for a number of years, and major plant renovations are unlikely. As a result energy savings in clinker production may be expected to be minimal and will probably result from improved production and kiln firing control. A 4% reduction in fuel consumption may be expected from such measures, representing a saving of about 1,56 million GJ, or R2,8 million per year.

A decrease in the average specific energy consumption in cement manufacture as a whole, may be expected to result from the increased production of blends of Portland cement and the pozzalan extenders, pulverised fuel ash and blast furnace slag. This, and the investigation of modified Portland cements, may be the most significant developments in terms of energy utilisation in the industry for the next few years. If the use of the blends already introduced increases to the extent where they account for 50% of production, an annual energy saving of about 4,3 million GJ will result, a cost saving of about R7,7 million, at the 1984 level of production.

Constant attention is paid to improving the efficiency of electricity use, due to its high cost relative to that of coal. Improved classification in the grinding system, reduction of pressure losses in ducting and developments in the control of electrostatic precipitators may be expected to reduce consumption of electricity by as much as 12%. This implies an electrical energy saving of about 215 GWh and a cost saving of about R7,5 million. Automatic control of power factor and maximum demand is common in the industry to optimise electricity use and reduce energy costs. Generation of electricity is possible using kiln exhaust gases, but is unlikely to be justifiable in the foreseeable future.

CHAPTER SIX

THE GLASS INDUSTRY IN SOUTH AFRICA

The glassmaking industry is classified under the Department of Statistics Standard Industrial Classification of All Economic Activities (SIC) as Manufacture of Sheet and Plate Glass, Glass Containers and Other Glassware not elsewhere classified, Subgroup 362000.

6.1 INTRODUCTION

6.1.1 THE GLASS MANUFACTURING PROCESS

Glass is a material that is made by cooling certain molten materials in such a manner that they do not crystallise, but remain in an amorphous state, with the viscosity increasing to such high values that, for practical purposes, a solid is formed. Commercial glass is generally made from silica with the addition of certain compounds that effect the properties of the final product.

The most common glass products are flatware, comprising window glass and plate glass, and containerware. The South African glass industry is not highly specialised, and much glassware for specialised purposes is imported.

Commercial glass manufacture begins with the mixing of the raw materials, mostly sand, limestone and soda ash, in batches. The raw materials are then introduced to the furnace, usually together with some broken scrap, which is called cullet. The materials must first be melted, and then held at a constant elevated temperature long enough to ensure the molten glass, which is called metal, is free of air bubbles.

Commercial glass furnaces are, in general, continuous except in cases where small quantities of glass are produced. Continuous furnaces may be considered to comprise three convection cells. The raw materials, and cullet if any, are charged into the first convection cell, which is the melting section. Here the feed is held until molten.

Once molten the "metal" moves into the second convection cell. These cells may be separated by a thin passage, but in modern kilns these two cells are formed in a single refractory vessel by controlled temperature differentials. The second cell is the refining section, where the molten glass remains until it is free of air bubbles.

From the second cell the glass passes into the working-head, or forehearth, where the glass is mixed to obtain uniform composition, and cooled to a specific, uniform temperature, critical for glass manufacture.

If a small batch lot is required, or a specialised glass is being made, batch-type furnaces are used, in which the glass is both melted and refined.

FORMING OPERATIONS

PRESSING

Products such as crockery and electrical insulators are produced by this method. A measured quantity of glass, called a gob, is transferred to a mould. a plunger then causes the glass to fill the mould. The glass is allowed to cool sufficiently to prevent distortion, and then removed and transported to an annealing station, or lehr.

BLOWING

Glass containerware and light bulbs are made using this technique. Unless very specialised glassware is being made, glass blowing is performed by automatic machines. In the automatic process a stream of glass flows from the forehearth and is cut into individual gobs by shears. A gob is fed into a blank mould where it is formed into a rough blank, called a parison, using either a plunger or compressed air. It is at this stage that the opening of the article gets its final shape. The blank mould then opens, and the parison is transported to the final mould, or blow mould, supported by the article opening. In the blow mould the article is blown to its final shape. It is then transported to a lehr for annealing.

DRAWING

Window glass is produced by drawing molten glass vertically from the forehearth in a wide sheet. This continuous sheet passes up through a lehr and then to the cutting room, where it is cut into suitable lengths for finishing. Alternatively the glass can be bent over a horizontal roller after the initial vertical draw. The surface finish is often good enough to make further finishing unnecessary. Glass tubing is manufactured by the same process.

ROLLING

Plate glass and patterned window glasses are produced by rolling. A continuous sheet of glass is issued between two cooled rollers at the end of the tank and then through a continuous lehr. The rollers imprint the pattern on the glass if required. The glass remains in a continuous sheet for grinding, and is then cut for polishing and further finishing, if necessary.

FLOAT GLASS

This process is a relatively recent development introduced nearly twenty five years ago, and is used to manufacture defect free glass necessary for such applications as glazing automobiles. Molten glass is poured directly onto molten metal, usually tin, where it cools sufficiently to produce a glass of exceptional quality. It is unnecessary to polish the surface of the glass that was in contact with the metal.

ANNEALING

After glass has been formed into products, it must be annealed to reduce the induced stresses in the material. Annealing involves a controlled heating and cooling process, from around 600 $^{\circ}$C to ambient temperature. This is accomplished in a lehr, which is a tunnel in which the required temperature profile can be achieved.

FINISHING OPERATIONS

After glass has been formed into a product and annealed, further operations often have to be performed before the product is complete. These operations include the grinding, polishing, bending or sagging of flatware and tempering of toughened glass.

6.1.2 THE INDUSTRY STRUCTURE IN SOUTH AFRICA

Glass is manufactured by three companies in South Africa. There are seven manufacturing plants, one in Natal, one in the Cape and the remainder in the Transvaal. The production capacity of the industry at present is 1985 tons of molten glass per day. Of this, approximately 65% is used to produce containerware, 25% to produce flatware and the remainder to produce speciality glassware, tableware and insulators.

6.1.3 SCOPE OF THE SURVEY OF THE GLASS INDUSTRY

This survey of the glass industry encompasses the production of glass in all seven plants of the three major companies in the industry. Data regarding the years prior to 1980 was not obtained from all plants, as, in some cases, energy monitoring was not comprehensive before that time, and two of the seven plants were commissioned after 1980.

6.1.4 ENERGY REQUIREMENTS OF THE GLASS INDUSTRY

Glass manufacturing is an energy intensive process, with between 8500 MJ and 20000 MJ required per ton of product sold in South Africa, depending on the type of ware. This energy input represents between 10% and 20% of the total cost of production.

The majority of energy is consumed in the glass making furnace, working head and lehrs. The average percentage of the total energy consumption accounted for by heating is 89%, with electrical power for compressors, materials handling, forming and decorating machinery accounting for 9.5%. Lighting, transport within the plant and offices and ancillaries consume the remaining 1.5%.

6.2 INFORMATION OBTAINED FROM THE SURVEY

The publication "Energy Utilisation in South Africa"[2] provides energy data regarding the glassmaking industry for the period 1970 to 1975. Where applicable this data is combined with the data obtained in this survey to investigate developments since that report. The data used to produce the graphs in this section is given in Appendix D.

Of particular interest will be the effect of the introduction of float glass on the specific energy requirements in flat glass production. Float glass manufacture was introduced in South Africa just prior to the completion of the above report. One plant in the United States reports having reduced energy consumption per unit output by more than 25% over an eight year period as a result of conversion to float glass manufacture[35].

6.2.1 PRODUCTION IN THE GLASS INDUSTRY

The total annual production of flatware, containerware and speciality glass, for the period 1980 to 1984, is given in Table 6.1. These amounts are the tonnage of glass produced in the factory, not the amounts sold, and thus include all waste produced in the plants.

The ratio of good glass to glass melted reported in this survey varied between 60% and 90% over the survey period, with an average value of approximately 80%. The percentage of cullet used varied between 20% and 40%. The production of flatware generally has the lower cullet ratio, as, to maintain quality, only cullet produced "in-house" is used. As a result, the lower the percentage of scrap, the lower the percentage of cullet used. A portion of the cullet for containerware is obtained from recycled product.

TOTAL PRODUCTION OF GLASS IN SOUTH AFRICA, 1980 TO 1984

	1980	1981	1982	1983	1984
TOTAL ANNUAL TONNAGE	525783	550766	536097	538225	550468
PERCENT FLATWARE	32%	29%	31%	26%	25%
PERCENT CONTAINERWARE	58%	63%	62%	67%	69%
SPECIALITIES AND INSULATORS	10%	8%	7%	7%	6%

TABLE 6.1

The production capacity for containerware increased in 1982 when Consol Glass (Pty) Ltd. started production in a new plant in Olifantsfontein, and again in 1983 when production started at the new Leondale plant of Metal Box Glass. This expansion in capacity has yet to be fully utilised

As flatware is used mainly in construction and automobiles, its demand is greatly affected by economic trends. The effect of the current recession is seen in the decreasing percentage of total production due to flatware since 1982, while the total tonnage has not fluctuated by more than 2%.

6.2.2 ENERGY CONSUMPTION IN THE GLASS INDUSTRY

The total annual energy input to glass manufacturing over the period 1980 to 1984 is given in Table 6.2.

TOTAL ENERGY INPUT TO GLASS MANUFACTURE, 1980 TO 1984
Million GigaJoules per year

	1980	1981	1982	1983	1984
ENERGY INPUT	6.34	6.32	6.29	6.64	6.66

TABLE 6.2

Four energy sources contribute almost the entire energy supply to the industry. They are electricity, coal, Sasol gas and heavy fuel oil. (Coal tar fuel oil is included in the heavy furnace oil category). Light furnace oil and LPG are used to a minor degree.

The percentages of the total energy supply contributed by the various sources are shown in Figure 6.1. Included in this graph are data obtained from "Energy Utilisation in South Africa" [(2)].

PERCENTAGE CONTRIBUTION TO TOTAL ENERGY INPUT BY TYPE

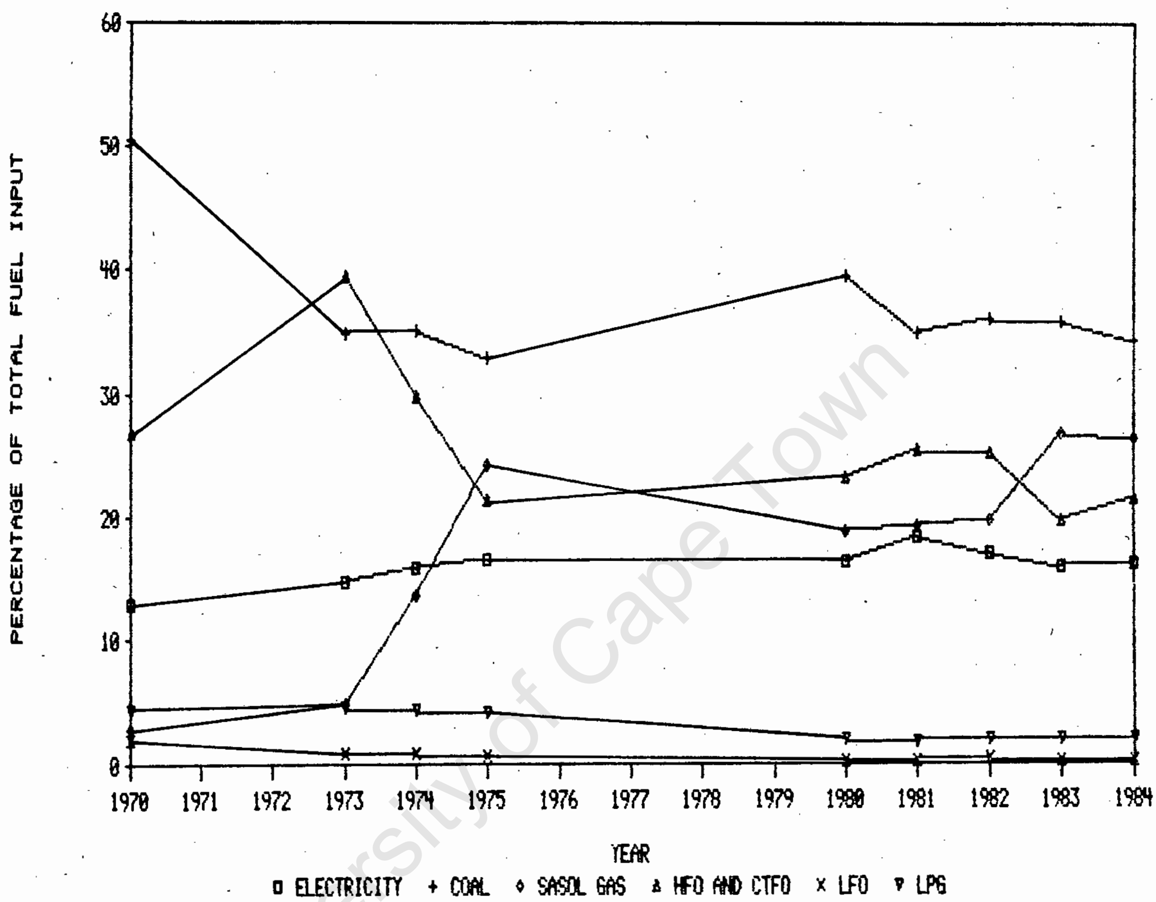


FIGURE 6.1

The use of coal is seen to be generally decreasing and that of Sasol gas increasing. These are the two major sources of energy to the industry, but a slight trend towards the increasing use of electricity is also apparent. If the cost of electricity approaches that of fossil fuels, as may be expected in the long term, its use should increase further due to the advantages of the electric furnace over fossil fuel furnaces. Some of these advantages are listed in Section 6.6. The substitution, in some cases, of heavy furnace oil with coal tar fuel oil has meant that this portion of the energy supply has not decreased as rapidly as might have been expected. The use of light furnace oil and LPG has, however, declined at a steady rate, which may be attributed to their high relative cost.

SPECIFIC ENERGY CONSUMPTION

Major factors influencing the gross energy requirement per ton of glass melted from raw materials are the amount of cullet used, the furnace type and the efficiency of furnace operation. When considering the energy use per ton of glass sold, however, the waste due to breakages and rejected ware is also important, and this figure is possibly of more interest to the industry itself. Specific energy consumption also varies with the type of ware produced.

SPECIFIC ENERGY USAGE IN GLASS MAKING, 1970 TO 1984

	AVERAGE MJ PER TON OF GLASS MELTED			AVERAGE MJ PER TON OF GLASS SOLD		
	TOTAL	FLAT	CONTAINER	TOTAL	FLAT	CONTAINER
1970	15100			19100		
1973	12900			16500		
1974	13200			17200		
1975	13800			18100		
1980	12060	11730	12210	14710	14600	14700
1981	11480	12730	10970	14080	15910	12900
1982	11730	12220	11510	14220	15270	13500
1983	12340	15560	11170	14950	19450	13180
1984	12100	16180	10760	14850	20260	12940

TABLE 6.3

ENERGY USE IN THE U.K. GLASS INDUSTRY COMPARED WITH SOUTH AFRICA

SPECIFIC ENERGY USE
GJ per ton of glass sold

YEAR	UNITED KINGDOM	SOUTH AFRICA
1970	20.15	19.1
1971	20.86	
1972	19.54	
1973	17.26	16.5
1974	18.30	17.2
1975	16.38	18.1
1976	16.66	
1977	16.46	
1978	15.20	
1979	15.66	
1980	14.66	14.71
1981	14.75	14.08
1982	14.46	14.22

TABLE 6.4

The average energy consumption per ton of glass melted in the USA in 1973 was 11.606 GJ per ton (36). This is 10% lower than the 12.9 GJ per ton reported for South Africa in that year, but as fluctuations of that magnitude have occurred from one year to the next, no conclusions can be made as to the relative energy efficiencies in the two countries.

6.4 TRENDS IN ENERGY CONSUMPTION IN THE GLASS INDUSTRY

It is obvious that the energy input per unit output in the industry is decreasing. Unfortunately, the available data does not cover a long enough period to enable adequate analysis, nor does it encompass each year of the period 1970 to 1984. In an effort to assess the decreasing trend in energy consumption per ton of glass manufactured and sold, though, curves were fitted to the available data and extrapolated. This rough assessment is shown in Figure 6.2.

ESTIMATE OF TRENDS IN SPECIFIC ENERGY CONSUMPTION IN GLASSMAKING IN SOUTH AFRICA

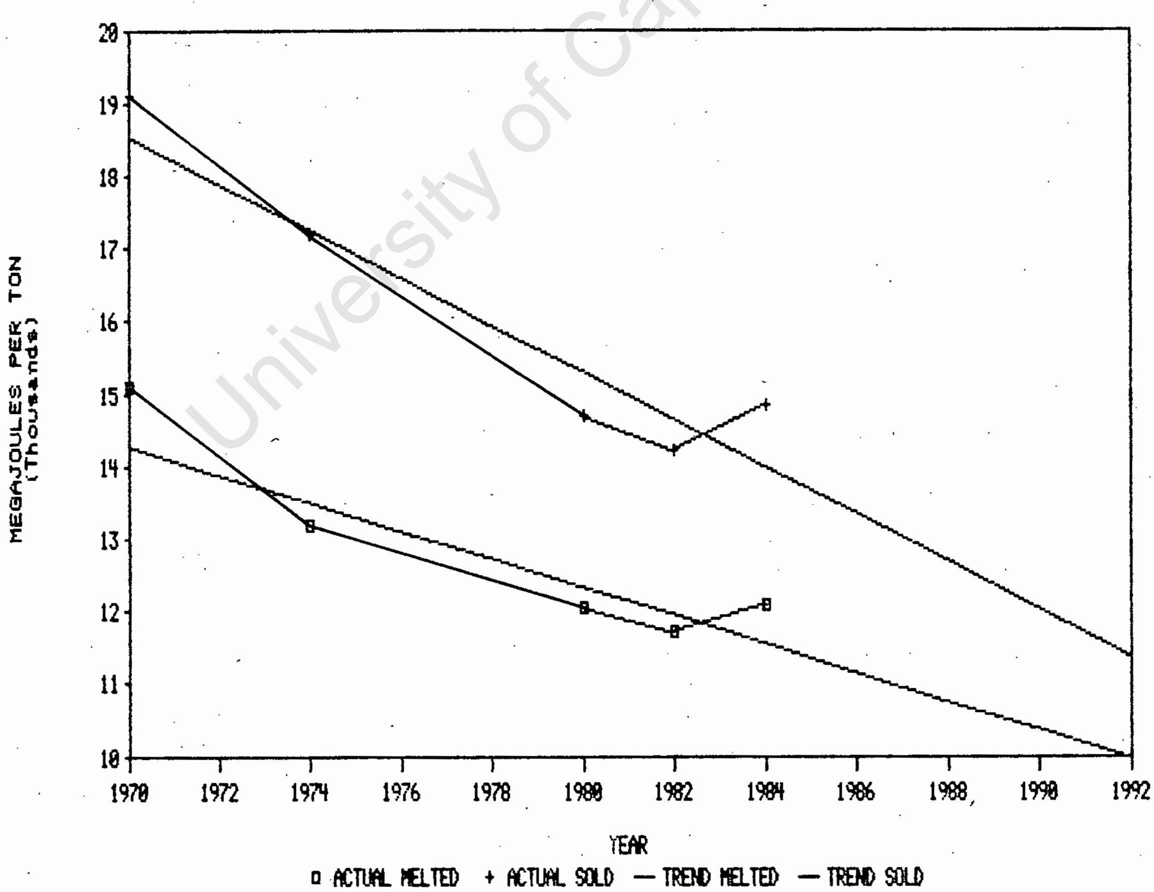


FIGURE 6.2

If development in energy utilisation continues in this manner, by 1992 the national average specific energy consumption in glass melting may be expected to be of the order of 10 GJ per ton, and that for glass sold, 11.4 GJ per ton.

A rough estimate of the total tonnage of flatware and containerware sold in 1992 is of the order of 610 000 tons. If this is considered in conjunction with the estimate of the energy consumption per ton of glass sold, the total annual energy consumption in that year may be expected to be about 7.4 million GJ.

6.5 ENERGY SAVING OPPORTUNITIES

GOOD HOUSEKEEPING

The potential for energy saving by improving "housekeeping" is not insubstantial. An estimated 5% reduction in specific energy consumption is considered possible in the glass industry in the UK, whose consumption is similar to that in South Africa [8]. One plant in the UK reported a saving of 2.5% for no capital investment [37].

Some examples of housekeeping measures are listed below.

Attention to compressed air systems, used widely in the glass industry, has great potential for savings. The system should have the correct number and sizes of compressors. Air leaks and dirty in-line filters are easily overlooked, and can decrease efficiency substantially. Ensuring delivery pressure is the minimum that is required by the system can result in large power reductions at the compressor. Air inlets should be kept clean and be situated in cool areas, as increased inlet temperature increases power consumption.

Heat loss from the furnace structure through the sight holes and through cracks which develop in the course of operation can be reduced by ensuring that the observation ports are closed and seal properly when not in use, and that cracks are sealed as soon as they occur.

If steam is produced, steam lines should be optimally insulated, and pipe work, filters and steam traps should be well maintained.

Control of lighting according to natural conditions using photocell control, and the use of more efficient lighting systems where possible, for example fluorescent instead of tungsten, can result in cost effective energy savings.

CULLET

An increase in the amount of cullet used in glass manufacture can result in a reasonable decrease in energy use, subject to available quantity and quality. Reductions of Ø.2% of energy consumption in melting per 1% increase in the cullet ratio have been quoted [37]. This would be partially offset by the energy and cost involved in collecting, crushing and cleaning the cullet. Increased incentive for the recycling of glassware could be expected to increase the amount of cullet used. Such incentive would be environmentally beneficial, as well as reducing the energy consumption of the glass industry.

COMBUSTION CONTROL

The industry is very conscious of the need for combustion control, not only from the point of view of optimising fuel use, but also to ensure the stability of furnace operation which is so important in maintaining quality and rejection rates at acceptable levels in the glass making process.

The installation of comprehensive combustion monitoring in the furnace, coupled with ever-improving microprocessor control could result in further energy savings for an expenditure that can be recouped within an acceptable period.

Fuel savings of 7% have been reported for a furnace using a continuous oxygen monitoring system [38]. The system measures oxygen levels without sampling, and is characterised by low maintenance, sensor life of more than six months, easy installation and compatibility with computer control systems.

A demonstration project in the UK hopes to achieve a 4% energy saving using continuous monitoring of oxygen levels to control excess oxygen [39]. The capital invested is expected to be amortised within eight months

INSULATION

The implications of attempting to improve insulation of glass making furnaces are well understood within the industry. Additional insulation incorrectly applied can cause damage to the furnace refractory material causing contamination of the glass and premature furnace refit. In view of the improved refractories that are becoming available, however, judicious additional application of insulation should enable reductions in furnace heat loss. The deciding factor will be financial feasibility.

ELECTRIC FURNACES

It is of interest to note the potential energy savings afforded by electrical glass furnaces. A cold top, all electric glass furnace, with a capacity of 140 tons per day is reported to use an average of 3121 MJ per ton of glass produced [40]. The glass quality was considered superior, and refractory erosion is low enough to allow 4 to 4,5 years between rebuilds, using thicknesses of 300 mm. The furnace, working head and lehrs are computer controlled to ensure consistency in all process loops, reducing scrap rates to below 10%. The low scrap rate, as well as the reduction of atmospheric pollution, and the lower capital cost and amortisation charges, seem to suggest that, depending on future electricity costs, a move to electric furnaces may be expected.

As in any of the other primary manufacturing industries, any move towards the use of electricity is dependent on its cost relative to that of other fuels. At present, it is unlikely that electricity will replace fossil fuels to any great extent, due to the relatively high cost of electricity and the capital expenditure that would be necessary for purchasing the plant.

In terms of total energy input, it must also be remembered that the efficiency of the electric furnace is offset, to a certain extent, by the losses resulting from electricity generation from fossil fuels.

IMPROVEMENT IN REGENERATORS

Considerable work on regenerators has been carried out, but it is still considered that there are opportunities for improving regenerator performance[41]. Improved design, operation and refractory materials are estimated to make fuel savings of about 5% possible.

A further possible improvement in regenerator performance could be achieved by the installation of secondary regenerators. With a single regenerator, the exhaust gases, when vented, are at about 500 ^{o}C. If a secondary regenerator is used, this can be reduced to about 250 ^{o}C, with a resultant energy saving. This would entail more capital expenditure than the modification of primary regenerators, though, and as a result may not be considered in South Africa for some time.

FOREHEARTHS

Improvements in forehearth design have resulted in a number of benefits. Improved insulation, automatic control of cooling air and redesigned structure have improved temperature stability and homogeneity, and substantial fuel savings [42].

LEHRS

The operational life of a lehr is generally long, and they are high cost items. As a result, replacement of an old unit with a newer more efficient lehr may be difficult to justify, despite the advantages of the high throughput, energy efficient and flexible modern recirculating lehrs.

In some cases, though, low cost design modifications to existing equipment, such as changing burner design, increasing insulation and improving control, are possible, and have resulted in significant improvements in performance [41].

BATCH PREHEATING

The preheating of raw materials by furnace exhaust gases is receiving attention in a number of circles. Analysis and laboratory tests have shown a fluidised-bed glass batch preheater to be a viable method of reducing energy costs and combustion emission, with capital investment expected to be amortised within two years [43].

BLAST FURNACE SLAG

The use of blast furnace slag in glassmaking has been shown to improve glass properties and the melting and refining processes [44]. Increased productivity and decreased energy consumption result. With increasing slag sales in this country, investigations of the possibilities for its use may be advantageous.

PRODUCT IMPROVEMENT

The reduction of wall thickness and product weight in the manufacture of containerware is a continuing process in the glass industry. These reductions enable more saleable articles to be produced for the same energy input.

6.6 CONCLUSIONS

The manufacture of glass requires an energy input of between 8500 MJ and 20 000 MJ for each ton of product sold, depending on a number of factors, including the product type. Approximately 90% of this energy is used in the glass melting furnace. The cost of the energy used represents between 10% and 20% of the total production costs.

In the glass industry in South Africa, the total tonnage of glass sold annually has been over 500 000 tons since 1980. This production requires about 6.5 million GJ.

The use of Sasol gas in the glass melting furnace is fast increasing, and it may soon be the major source of energy for the industry. The percentage of total energy requirements met by electricity also exhibits a tendency to increase. This trend should be expected to continue if the cost ratio of electricity to other fuels decreases, as the electric furnace has a number of advantages, including facility of quality control, automatic furnace control, and higher in-plant energy efficiency.

There is no doubt that newer technology tends to be increasingly energy efficient. The trend in specific energy consumption in South Africa indicates that it is decreasing with time, and, with the introduction of new technology, this can be expected to continue.

In comparing the industry in South Africa with that in the UK, it would appear that there are a number of opportunities for reduction of energy consumption in the industry. It is likely, however, that only those that entail minimal expenditure will be considered in the near future. These include improving the standards of energy monitoring and housekeeping, further reduction in the weight per unit of containerware, and uprating combustion control. Additional insulation and the use of blast furnace slag may also receive attention. These measures may be expected to result in as much as a 6% reduction in energy consumption, judging by performance in the industry in the U.K. This represents an annual energy saving of about 0,39 million GJ, or a cost saving of R650 000.

CHAPTER SEVEN

IRON AND STEEL BASIC INDUSTRIES IN SOUTH AFRICA

The manufacture of iron, steel and ferrous alloys is classified by the Department of Statistics Standard Industrial Classification of All Economic Activities (SIC) as Iron and Steel Basic Industries, group 37100.

7.1 INTRODUCTION

7.1.1 MANUFACTURING PROCESSES

STEELMAKING

REDUCTION

The first phase of steel manufacture is the reduction of iron ore to iron. Traditionally, this occurs in blast furnaces.

Iron production in blast furnaces requires the use of coke. Coke is produced, along with coke oven gas and other by-products, in coke ovens, from high quality coal. Coke performs three roles in the blast furnace. It is the fuel that raises the temperature in the furnace, the reducing agent that reduces the iron oxide to iron, and it provides the physical support for the burden, while being porous enough to allow hot gases to permeate to the top of the furnace.

The blast furnace is charged with iron ore, limestone and coke. Often the charge is in the form of sinter, which is an agglomeration of iron ore, limestone and coke breeze roasted together in the sinter plant to form a clinker which has lost a certain amount of unwanted volatile matter, and has good physical characteristics for the support of the burden.

In the blast furnace the iron ore is reduced to iron by the coke and the carbon monoxide produced as a result of coke combustion. The limestone combines with impurities in the iron ore to form a slag which floats on top of the molten iron and is removed separately. The blast furnace also produces a gas as a by-product, which is usually used in other departments of integrated steelworks.

The iron from the blast furnace is tapped off and either cast as "pig-iron", or flowed, molten, as "hot metal", directly to a steel making furnace.

A relatively recent alternative to the conventional blast furnace route to steelmaking is direct reduction. This produces a firm metallic iron "sponge" directly from the ore without the need for coke, using either gas or coal.

An increasing percentage of iron ore reduction is taking place in Direct Reduction plants, with world direct reduction capacity expected to increase by 150% in this decade [45]. There are a number of reasons for this growth. Tandem direct reduction/electric arc furnace plants enable small expansions of existing steelworks and development of small new steelworks to be economically possible. They can be planned and built faster, and are easier to operate than blast furnaces. Environmental considerations are simpler as no coking ovens are required.

Possibly most significant in the South African situation is that some direct reduction processes are specifically designed to use low grade coals. There are four categories of direct reduction plant currently in use; Static-bed retort, Shaft furnace, Rotary kiln or Hearth furnace and Fluidised-bed furnace. The shaft furnace and rotary kiln currently dominate the field.

The production of hot metal in direct reduction plant is a revolutionary development in direct reduction as an alternative to blast furnace production. By combining a direct reduction furnace with a melter-gasifier, liquid iron can be produced to be conventionally converted to steel. South Africa is in the forefront of this technology with the commissioning of a KR coal reduction plant at ISCOR's Pretoria works expected in early 1988.

CONVERSION

There are three major types of steel making furnace presently used world-wide. They are:

Basic Oxygen Steel Furnaces

Electric Arc Furnaces

Open Hearth Furnaces

THE BASIC OXYGEN STEEL FURNACE

At present, the majority of the world's steel is produced by Basic Oxygen Furnaces (BOF). The hot metal is contained in a basic lined converter and a high velocity jet of oxygen is blown onto the metal surface. As in all steel making processes the oxygen removes excess carbon to produce steel. This reaction is highly exothermic and scrap steel is usually placed in the furnace to absorb excess heat. Even with the introduction of scrap, the exhaust gas from the basic oxygen furnace has an energy content of roughly 500 MJ per ton of steel produced. In Japan, this gas is recovered and used elsewhere in the steelworks.

THE ELECTRIC ARC FURNACE

The electric arc furnace melts its charge by striking an electric arc between the charge and carbon electrodes. It can accommodate charges with compositions from 100% scrap and cast iron to 100% pig iron. In most practical cases between 5% and 10% of the feed is new iron, and the balance scrap. The new iron reduces the amount of added coke needed to maintain reducing conditions because of its carbon content, and helps correct the balance of alloying elements present in the scrap steel.

Electric arc furnaces allow good control of temperature and of metal composition and are thus widely used in the production of high quality and high alloy steels.

THE OPEN HEARTH FURNACE

The open hearth furnace is charged with roughly equal amounts of scrap and pig-iron, which is heated to melting point by a flame of hydrocarbon fuel. Regenerators are used to a large extent so that much of the waste heat is recovered for use before exhausting. However, energy consumption is higher than that of a Basic Oxygen Furnace. This used to be set-off by its greater capacity for scrap steel, but with the increasing use of the more flexible and energy efficient electric arc furnace, this is no longer justification for their high operating costs, and these furnaces are being phased out of operation throughout the world.

THE ROTOR FURNACE

The rotor furnace is a longitudinal refractory-lined cylinder, rotated at a slow speed. Oxygen is injected by two separate lances, high purity below the surface of the steel and low purity above the molten metal surface. This type of furnace was in use in South Africa but was decommissioned in 1982, due to high operational costs.

FERROALLOYS

The term ferroalloys refers to the alloys of manganese, chrome, vanadium, silicon and other metals with iron, and in some cases, the basic metals themselves. These are added in small quantities to the melt during steelmaking to impart specific qualities to the steel.

The base minerals are refined, and combined with iron where applicable, in electric arc furnaces, so that they are ready for immediate use in steelmaking.

7.1.2 THE INDUSTRY STRUCTURE IN SOUTH AFRICA

STEEL

There are six companies involved in steel production in South Africa, one of which produces stainless steel. Production takes place in ten plants around the country, the majority of which are in the Transvaal.

some plants the raising of steam for the generation of electricity, and other uses, may account for up to 25%. Minimal percentages are required for pumping, lighting, transport within the plant, offices and ancillaries.

Energy input costs in the ferroalloy industry amount to an average of 40% of the total production costs, with values as high as 48% being reported over the survey period. The average values for the survey sample, for the period 1978 to 1984, are shown in Table 7.1.

PERCENTAGE OF PRODUCTION COSTS DUE TO ENERGY IN THE FERROALLOY INDUSTRY

YEAR	1978	1979	1980	1981	1982	1983	1984
% OF TOTAL COSTS	30.9	30.2	29.5	32.1	37.2	38.2	42.0

TABLE 7.1

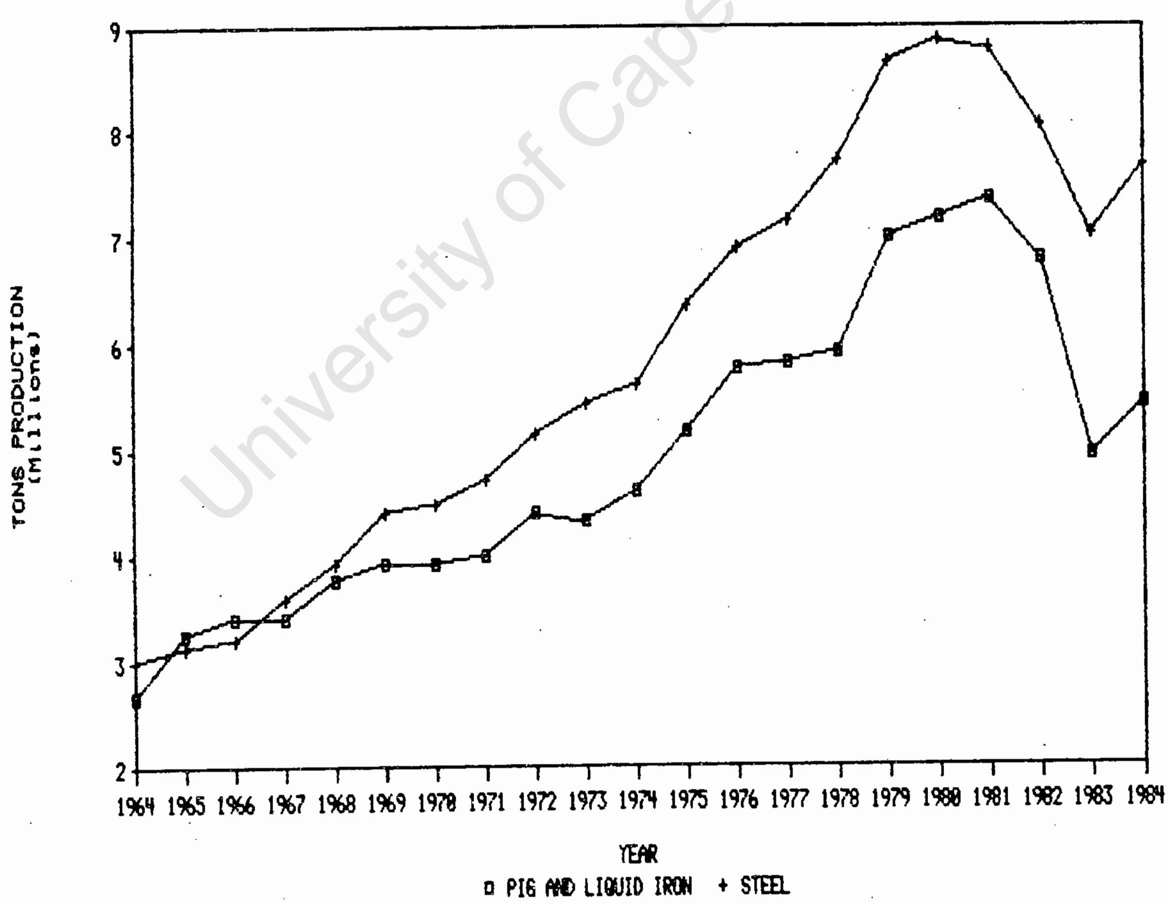
Approximately 45% of the total energy input in ferroalloy production is in the form of coke, used as the reducing agent in electric arc furnaces. Electric power for the furnaces accounts for about 50% of the total use. The majority of the remainder is consumed in supplementary firing. Pumping, lighting, transport and offices account for negligible portions.

7.2 INFORMATION OBTAINED FROM THE SURVEY

7.2.1 PRODUCTION IN THE IRON AND STEEL INDUSTRY

The total production of iron for steelmaking, and of finished steel in South Africa for the period 1964 to 1984 is given in Figure 7.1. Data used to produce graphs in this chapter is given in Appendix E.

IRON AND STEEL PRODUCTION IN SOUTH AFRICA, 1964 TO 1984



Source: Iron and Steel Producers' Association of South Africa

FIGURE 7.1

The steady growth of production in the steelmaking industry until 1980, and the subsequent decline in production in 1983 to a level lower than that seen in 1977, clearly indicate the effects of the recession on the industry.

A similar decline in production is seen in the ferroalloy industry output over the same period, shown in Figure 7.2. The factors effecting this sector's production are somewhat different to those effecting steelmaking, as the majority of the ferroalloy market is outside South Africa. The state of foreign economies, political situations and foreign exchange rates are, therefore, major factors influencing demand, and hence production.

The production of the major categories of ferroalloys is also shown in Figure 7.2. Manganese alloys include high, medium and low carbon ferro-manganese, silico-manganese and manganese metal. Silicon alloys, includes all grades of ferro-silicon and silicon metal, and the chrome includes ferro-chrome. The increase in total production due to the favourable Rand exchange rate for the foreign market is evident in Figure 7.2.

PRODUCTION OF FERROALLOYS IN SOUTH AFRICA, 1964 TO 1984

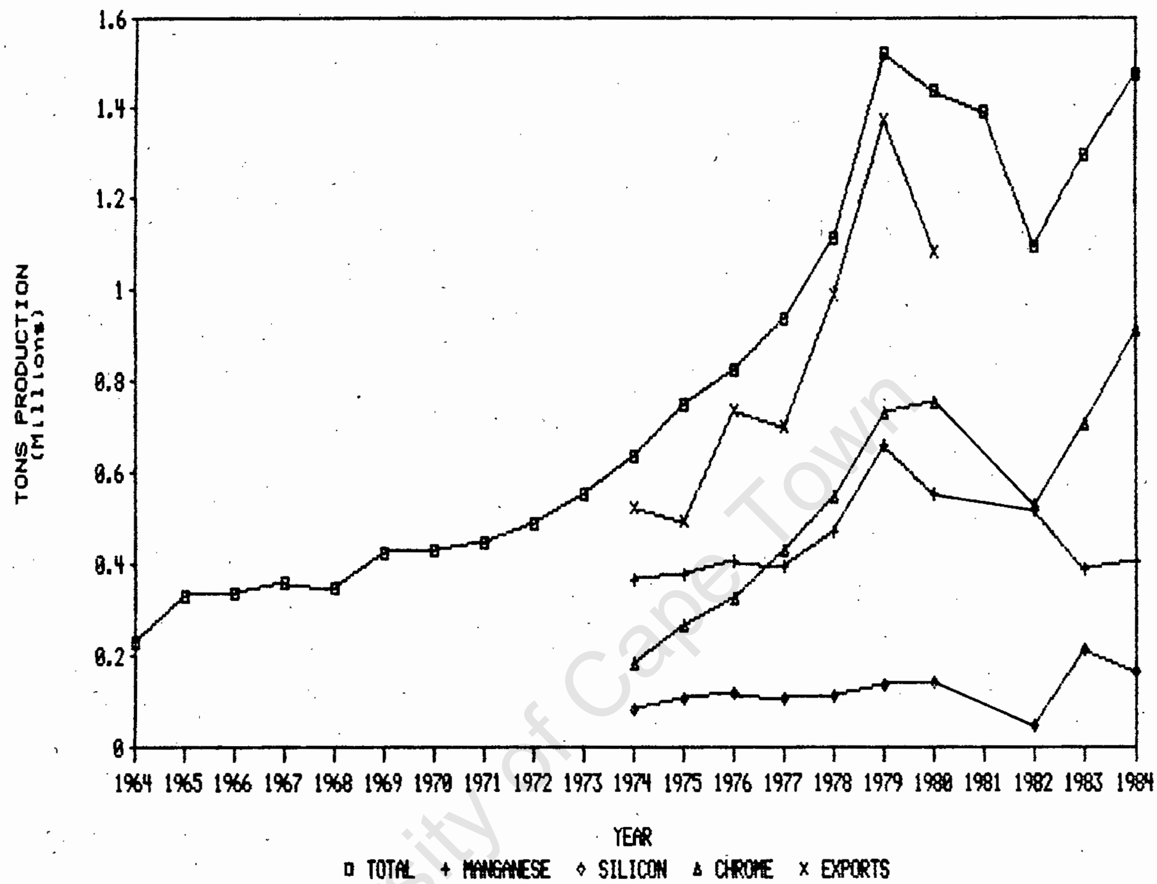


FIGURE 7.2

7.2.2 ENERGY CONSUMPTION IN THE IRON AND STEEL INDUSTRY

STEELMAKING

As can be expected, total energy consumption in the iron and steel industry follows the production trend fairly closely. Two estimates of the total consumption of energy in the industry are shown in Figure 7.3. The first was obtained by extrapolating the total energy consumption of ISCOR over the period 1977 to 1984 in proportion to that company's market share in each of those years. The second was obtained by multiplying the total production in each year by the mean energy consumption per ton of output reported by the survey sample over the period 1975 to 1984.

TOTAL CONSUMPTION OF ENERGY IN STEELMAKING, 1964 TO 1984

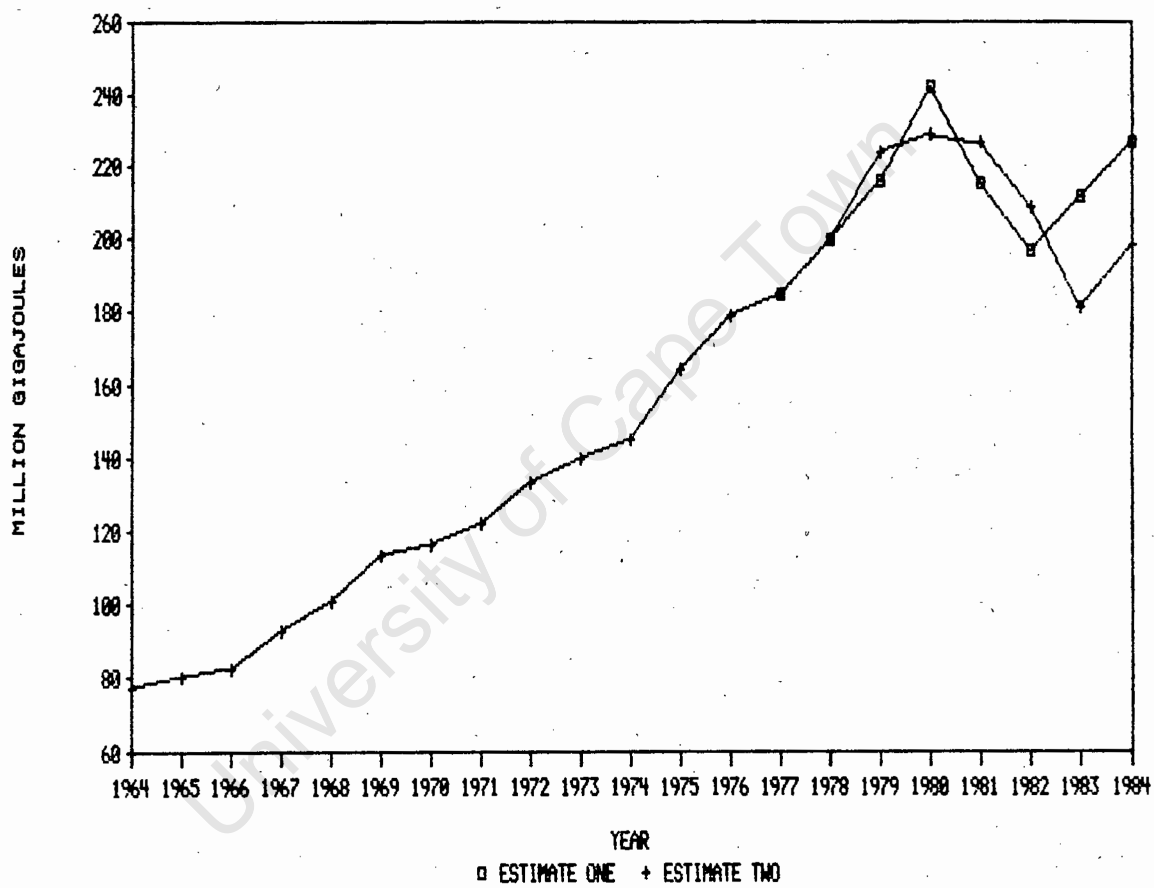


FIGURE 7.3

The breakdown of production by furnace type is of interest, as it reflects the increasing attention to energy conservation, and the amount of investment in the reduction of energy consumption. The percentage of total production contributed by electric, basic oxygen and open-hearth furnaces over the period 1979 to 1984 is given in Table 7.2.

STEEL PRODUCTION BY FURNACE TYPE

PERCENTAGE OF TOTAL PRODUCTION

YEAR	ELECTRIC	B.O.F	OPEN HEARTH
1979	24.5	66.5	9.0
1980	26.8	65.7	7.5
1981	25.3	69.5	5.2
1982	24.9	72.1	3.0
1983	32.7	67.3	0.004
1984	30.1	69.9	0.0

TABLE 7.2

The relative amounts of the energy sources used in steel production are shown in Figure 7.4. Considering the relatively large percentage of production taking place in electric furnaces, it is of interest to note the low percentage of electricity consumption. This would seem to suggest a comparatively high energy efficiency for this type of furnace. It must be remembered, though, that a portion of the energy used in steelmaking in electric furnaces is supplied by the coke used for refining, and that, in terms of overall energy consumption, the conversion losses in electricity production must be taken into account.

ENERGY USAGE IN SOUTH AFRICAN STEELMAKING BY SOURCE TYPE

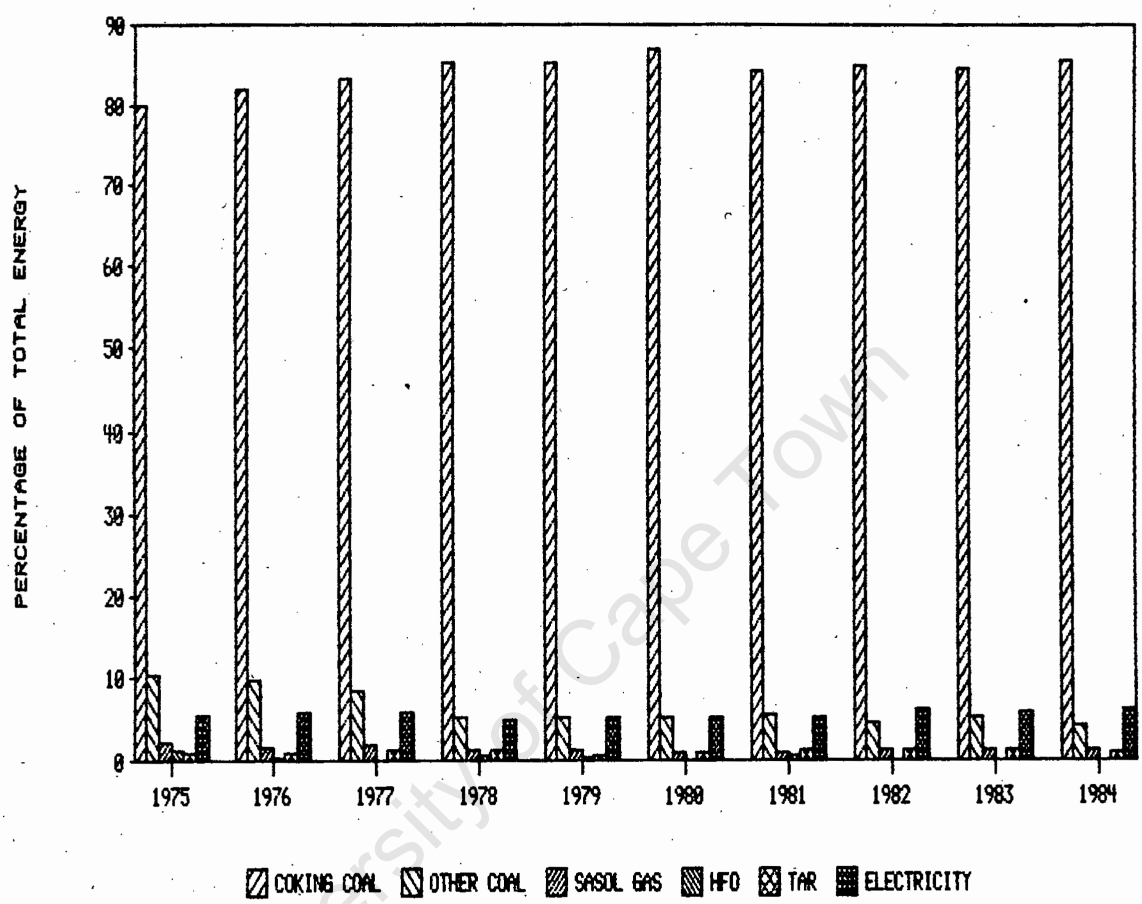


FIGURE 7.4

Specific energy consumption also varies with the different routes to finished output, so it is of interest to note the changing proportions of total production due to continuous casting and billets. Table 7.3 shows the increasing contribution to total production by the continuous casting process

PERCENTAGE OF TOTAL PRODUCTION OF STEEL BY CONTINUOUS CASTING

YEAR	1979	1980	1981	1982	1983	1984
PERCENTAGE	50	53	57	62	62	62

Source: Iron and Steel Producers' Association of South Africa

TABLE 7.3

This shift to the continuous casting process is evident world wide. South Africa's percentage of production compares favourably with that in other countries, such as West Germany, 62% in 1983 [46], and the UK, about 50% in 1980 [47].

As stated earlier, specific energy consumption data obtained in this study is worthy of attention. Figure 7.5 shows three plots of specific energy consumption over the period 1975 to 1984. The first line shows values of specific energy consumption per ton of liquid steel supplied by ISCOR for three of their plants [48]. The second shows the energy consumption per ton of finished steel, obtained from data supplied by the same three plants in this survey.

The difference between the two sets of data supplied, and the fact that the figures for liquid steel from the central source are, in general, higher than those for finished steel supplied from the individual plants, raise some doubt as to the value in considering the actual figures. As a result, it was decided to estimate the trend in specific energy consumption by interpolating between the two sets of data, thus producing the third plot in Figure 7.5. As can be seen from this line, the energy consumption per ton of steel has been steadily decreasing, until 1983, when a sharp increase occurs, followed by a slight decrease again in 1984. The industry output dropped off sharply in 1983 as shown in Figure 7.1, and recovered to a small extent in 1984. This would seem to suggest a strong correlation between plant capacity utilisation and efficiency of energy utilisation.

SPECIFIC ENERGY CONSUMPTION IN STEEL PRODUCTION IN SOUTH AFRICA

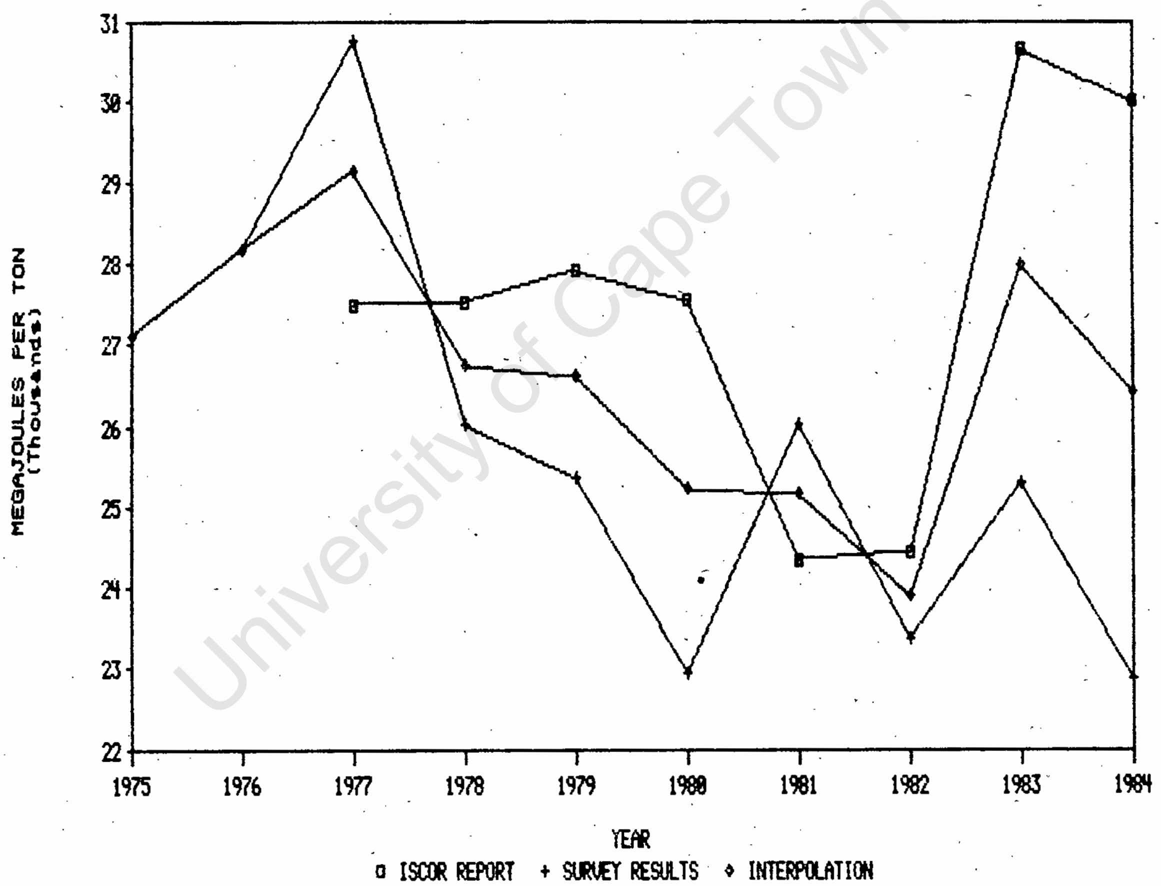
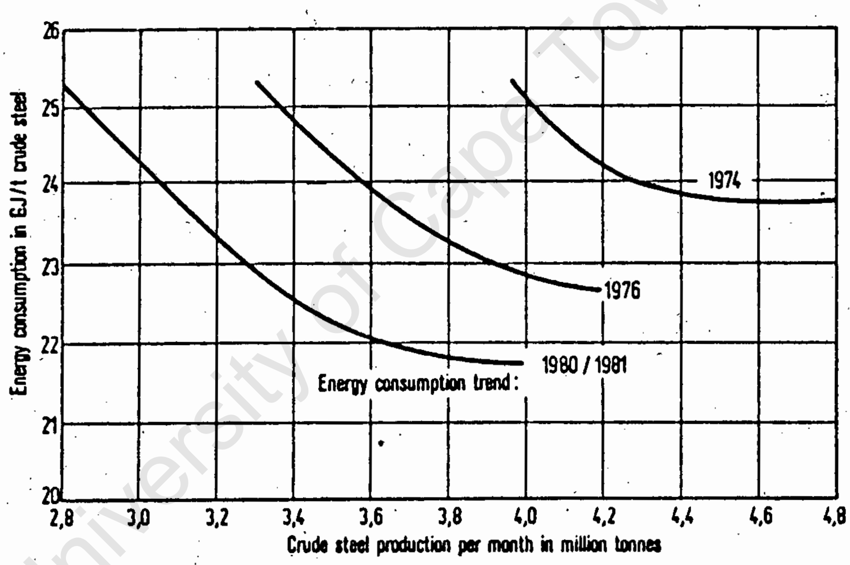


FIGURE 7.5

The dependence of specific energy consumption in steel production on the percentage utilisation of plant capacity is clearly seen in Figure 7.6, which shows the energy consumption per ton of crude steel as a function of the monthly production in the Federal Republic of Germany.

ENERGY CONSUMPTION AS A FUNCTION OF PRODUCTION CAPACITY IN THE FEDERAL REPUBLIC OF GERMANY



Source: Energy Conservation in the Iron and Steel Industry of the Federal Republic of Germany (46)

FIGURE 7.6

Figure 7.6 also shows the success of conservation efforts in the FRG. Specific energy consumption can be seen to decrease with time for the same monthly production. In addition, the transition to increased consumption as monthly production output decreases has occurred at lower production levels.

FERROALLOY PRODUCTION

From the data obtained in this survey, it is possible to make a rough estimate of the total energy consumption in the production of ferroalloys in South Africa. Two estimates are made based on data received, one of the total electricity consumption, and the other of the total energy consumption including the use of fossil fuel as the reduction medium, an amount estimated from survey data to be of the order of 45% of the total energy input. The two estimates are given in Figure 7.7.

TOTAL ENERGY CONSUMPTION IN FERROALLOY PRODUCTION

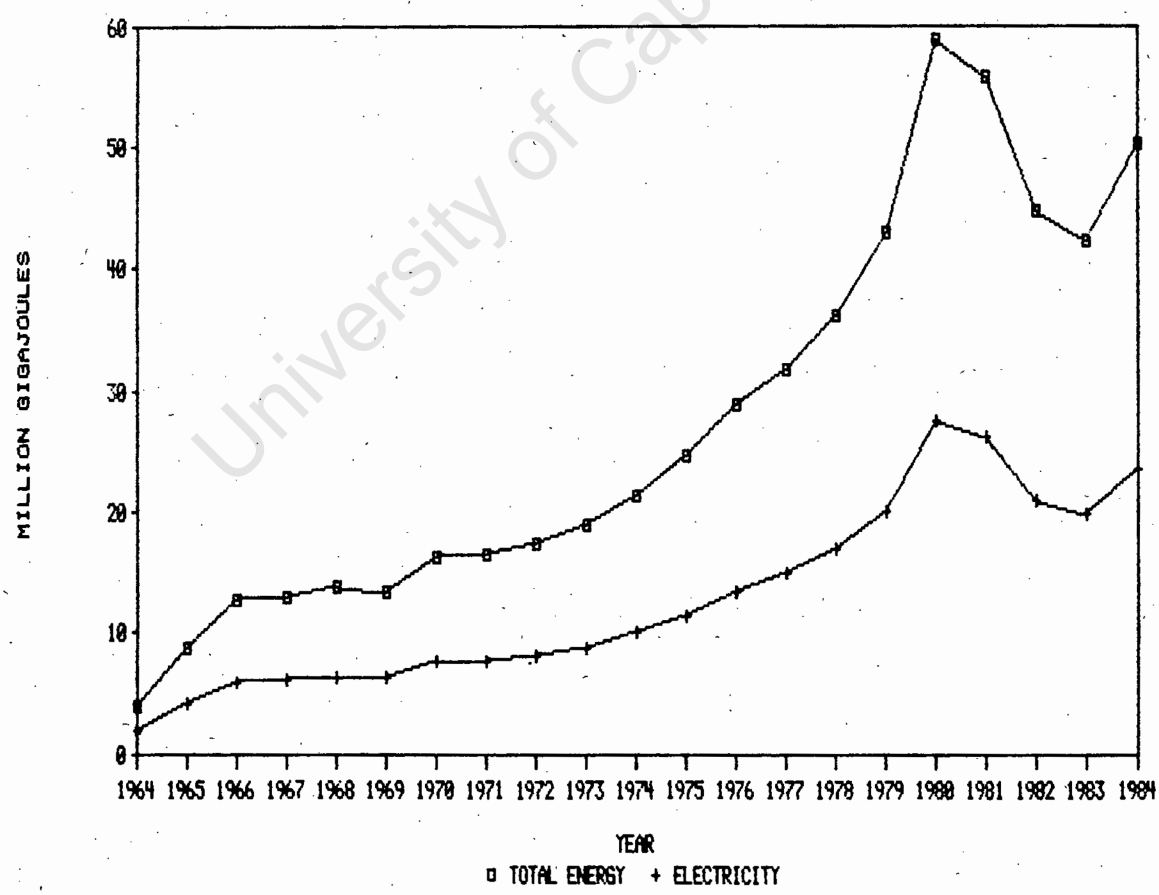


FIGURE 7.7

As this graph is produced by extrapolating incomplete data from a small percentage of the total sector, it should be used as a guide only.

7.2.3 ENERGY MANAGEMENT IN THE IRON AND STEEL INDUSTRY

Awareness of the need for effective energy management, and the inherent benefits of monitoring energy consumption for the purposes of highlighting poor performance, and areas of possible improvement, is prevalent in the industry. Unfortunately, economic considerations prevent a number of concerns from employing sufficient personnel specifically for the task of energy management.

ISCOR has a documented Corporate Energy Policy. A Corporate Energy Board exists to ensure that this policy is implemented and to make decisions regarding energy matters. This board is advised by the Corporate Energy Advisory Committee, with members representing each Works Centre, Mining Operation and Headquarters. This committee is also responsible for making recommendations to the Energy Board concerning policy, planning, procedures, technical aspects, energy utilisation standards, scheduling and energy saving projects. In addition, each Centre has a Centre Energy Committee to assist the Centre Manager in implementing the policy and standards at his Centre.

At some of the other plants visited in the course of this survey, energy management was included in the role of one of the plant personnel. The dual role of plant management and energy management is a difficult one, as productivity obviously has a higher priority in the short term. As a result, insufficient time may be available to adequately tackle energy problems.

In keeping with the high level of energy awareness, the majority of concerns hold discussions on energy utilisation, have active energy awareness schemes for all employees, and conduct energy audits to varying degrees. Of the plants visited, those that conducted no energy audits, nor appeared to have any formulated energy policy were producers of ferroalloys.

All the plants from which data was obtained reported having load shedding equipment for the reduction of maximum demand, and automatic power factor correction equipment. The average power factor reported was 0.96.

7.3 SPECIFIC ENERGY CONSUMPTION IN OTHER COUNTRIES

Table 7.4 shows the specific energy consumption for a number of countries reported by Jankowski [21]. As with all inter-country comparisons, there are some reservations as to the data compared. It cannot be certain that the data compared is all evaluated on the same basis, and that no inconsistencies exist.

A more comprehensive comparison of consumption in major steel producing countries up to 1976 is supplied by the Energy Audit series from the United Kingdom [47]. This is shown in Figure 7.8.

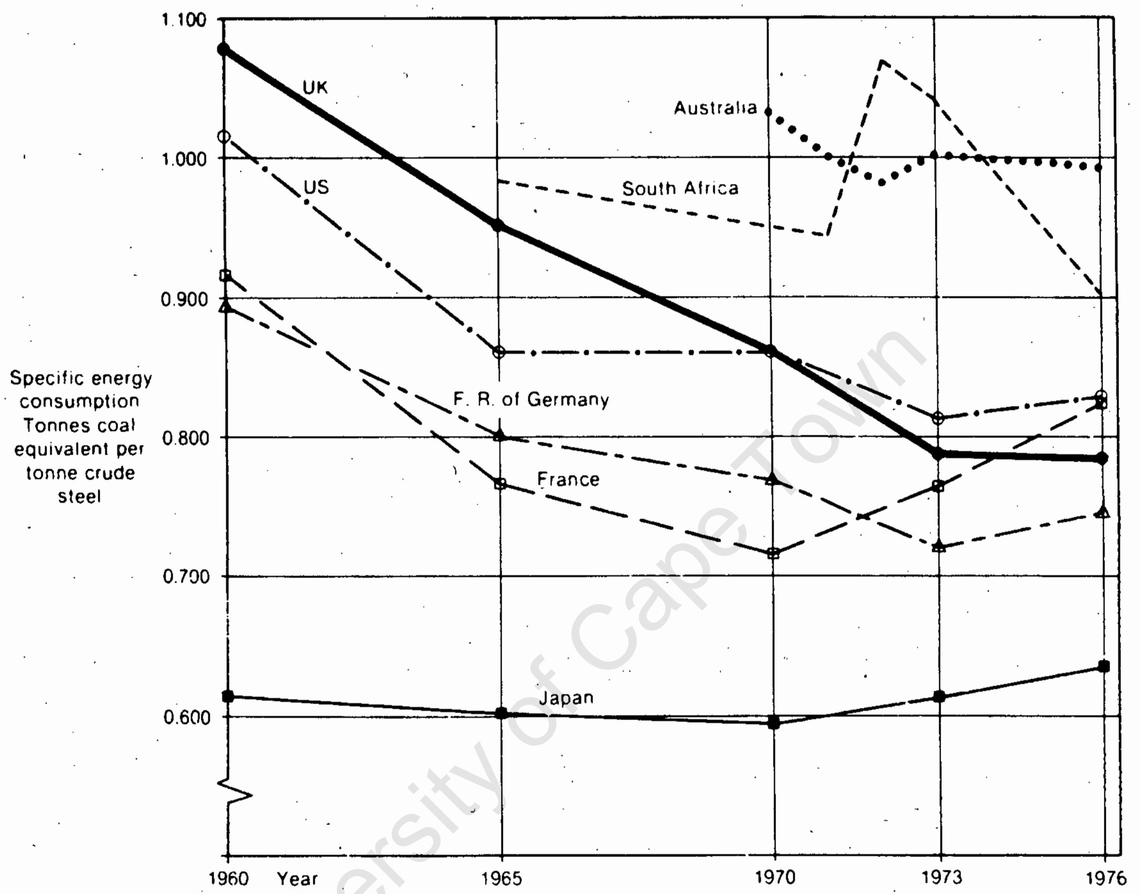
SPECIFIC ENERGY CONSUMPTION PER TON OF CRUDE STEEL

COUNTRY	GJ/TON
Italy (mid '70s)	14.0
Japan (1973)	18.0
UK (mid '70s)	20.0
W.Germany (1973)	22.5
USA (1976)	30.3
Belgium (1973)	22.9
Canada (mid '70s)	23.2
France (1973)	23.9
New Zealand (mid '70s)	31.0
Bangladesh (1973)	21.0
China P.R. (1978)	16.3 - 24.2
Egypt (1978)	35.9
Peru (1976)	23.8
Turkey (mid '70s)	20.9
Theoretical minimum	7.0

Source: Jankowski [21]

TABLE 7.4

ENERGY PER TON OF CRUDE STEEL



Source: The Iron and Steel Industry, Energy Audit Series No. 4.(47)

FIGURE 7.8

7.4 TRENDS IN IRON AND STEEL BASIC INDUSTRIES

In order to show the trends within the industry, curves were fitted to the data obtained in this survey. These curves were then extrapolated to produce rough estimates of short term future trends.

TREND IN PRODUCTION OF STEEL IN SOUTH AFRICA

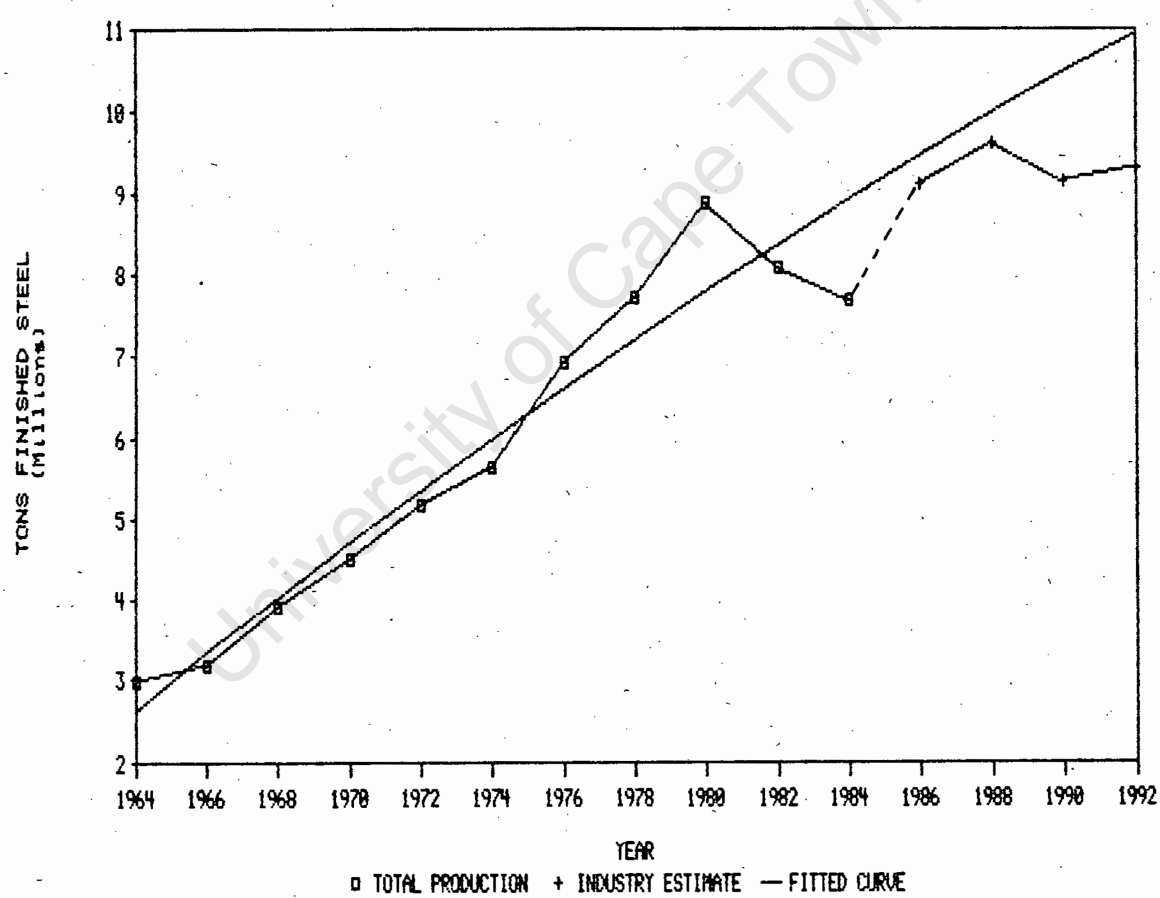


FIGURE 7.9

The total production of steel in South Africa from 1964 to 1984, as obtained from the Iron and Steel Producers Association is shown in Figure 7.9, along with an industry estimate of production up to 1992, and the curve that was fitted to the survey data. This curve is extrapolated to 1992. The industry estimate for the period after 1984 shows a recovery to a level close to the extrapolated trend which then levels off toward the end of the decade. Unfortunately, the method by which this estimate was made was not divulged, and, as a result, the reason for this plateau is unknown.

The total energy consumption in steelmaking was treated in the same way, and a graph developed giving historical data, an industry estimate and a curve fitted to the historical data, and extrapolated to 1992. This is shown in Figure 7.10.

TREND IN ENERGY CONSUMPTION IN STEELMAKING

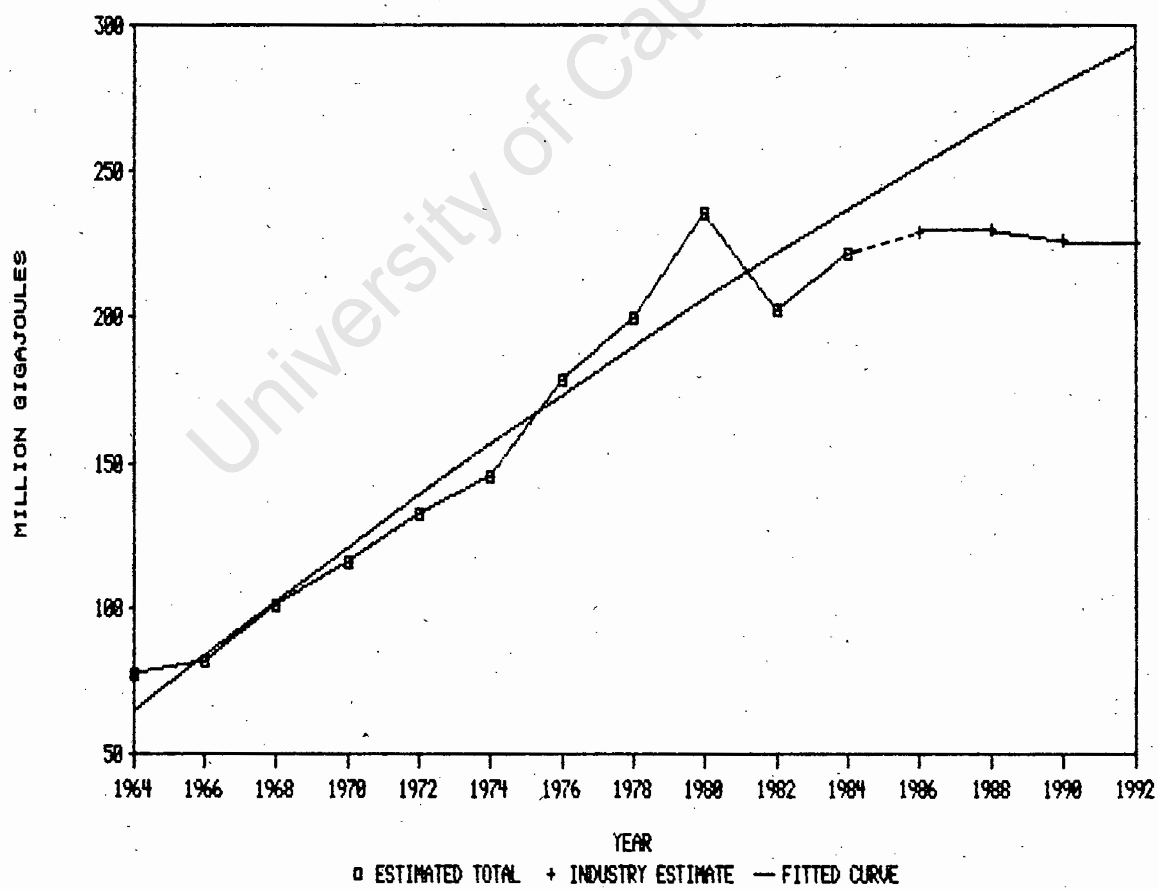


FIGURE 7.10

Of interest is the leveling out of the industry estimate of the total energy consumption after 1984. This is not only a function of the leveling out of production according to the industry estimate thereof, but also of the improvement in energy utilisation standards in this country and the introduction of the latest technological developments.

Unfortunately, the values of specific energy consumption obtained by this survey were too varied and encompassed too short a period to enable satisfactory curve fitting. In general, however, it can be seen from Figure 7.5 that the average energy consumption per ton of steel produced is decreasing with time, and that this trend may be expected to continue. To indicate this, the actual and planned specific energy consumption at the three major ISCOR plants is shown in Figure 7.11.

ENERGY CONSUMPTION PER TON OF LIQUID STEEL AT ISCOR

(PRETORIA, VANDERBIJLPARK, NEWCASTLE)

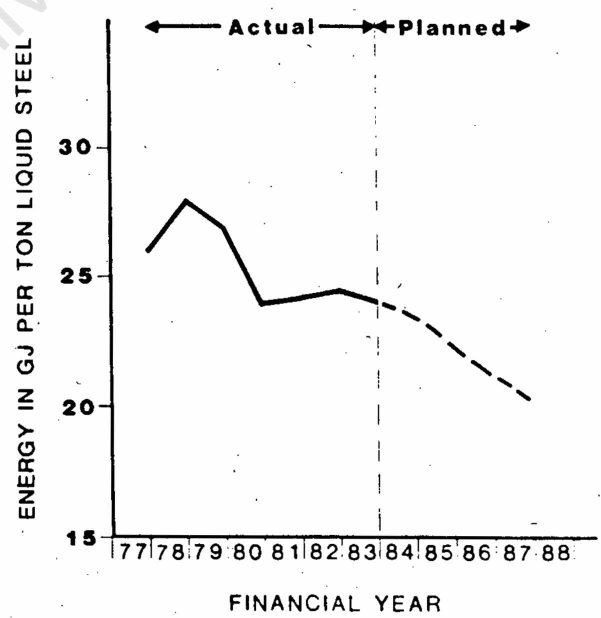


FIGURE 7.11

7.5 ENERGY SAVING OPPORTUNITIES

A number of energy saving techniques are commonplace in the industry. Among these are the reduction of the coke rate in the blast furnace, improved furnace control, increased hot charging of material, and increased use of refractory insulation and seals, those based on ceramic fibres being increasingly used. These, and the other measures listed below are amongst those receiving constant attention from the industry in its efforts to reduce energy consumption costs.

DRY COKE COOLING

Conventionally coke is quenched by water sprays, and the resultant steam, with a high concentration of coke particles, is released to the atmosphere. It is estimated that this heat loss amounts to over 700 MJ per ton of steel produced, or 2250 MJ per ton of coke produced. Dry cooling of coke offers the alternative of heat recovery, either for preheating the coking coal or for the raising of high grade steam for process or power generation. The feasibility of heat recovery for steam generation depends to a great extent on the works ability to absorb the steam. Dry coke cooling also offers significant environmental advantages.

MANUFACTURE OF FORM COKE

Form coke is made by compacting coking coal duff and lower quality coals with coal tar or pitch as a binder prior to coking. This "briquetted" coke may not necessarily conserve energy as such, but it extends the life of South Africa's coking coal deposits. ISCOR test results indicate that the quality of form coke is at least as good as that of the best coke produced by conventional methods.

INCREASED USE OF BLAST FURNACE GAS

The use of a radial turbine to recover the pressure energy in the top gases of a blast furnace is proving successful in Japan and France [47]. The turbine acts as an effective gas cleaning plant, and can be used either to drive an alternator or an axial air blower. A similar, but reportedly more sophisticated system is also used in the USSR and Japan.

COOLING OF FURNACES

The use of pressurised water systems for the cooling of furnaces enables the production of steam that may be used for generation of electricity, for process elsewhere in the plant, or sold if there is a market and supply can be guaranteed.

BOF GAS RECOVERY

Modern practice, particularly in Japan, involves keeping the space between the furnace vessel and the hood to a minimum, allowing only enough air to infiltrate to burn 10% of the gases. The remaining gas is collected and used as a cleaned fuel for use in the works or for power generation.

DIRECT REDUCTION AND COAL BASED TECHNOLOGY

The inherent advantages of direct reduction systems using low grade coals are obvious, considering the limited reserves of coking coal in South Africa. The latest developments in direct reduction enable the production of liquid iron, using a direct reduction furnace in conjunction with a melter gasifier. One of the available coal based systems, the KR process, developed in Austria, is being installed at ISCOR's Pretoria works.

Other systems are available, however, such as the Elred process, which includes electric power generation from the combustible flue gases with a surplus for other uses, the Inred process, the Plasmamelt process and Kawasaki's new ironmaking process [45]. The last two processes do make use of coke, although low grade. The Kawasaki process claims increased energy efficiency and reduced pollution.

The combination of the expected growth of electric arc furnace production, reduced in-house scrap due to continuous casting, and the increase in price and amount of tramp elements in purchased scrap, indicate the increasing demand for direct reduced iron. With research and development directed at the coal based processes, increased energy efficiency should be expected.

CONTINUOUS CASTING

The trend towards continuous casting is indicative of the cost savings it affords. By reducing the number of process steps, personnel and energy costs are reduced, and by increasing yield, material costs are reduced. The move to continuous casting can be expected to continue despite the high cost of the plant.

SCRAP PREHEATING

Reductions in power consumption per ton, tap to tap time, electrode consumption and refractory consumption, and an increase in productivity are reported for a 25 ton arc furnace with a scrap preheater using the furnace exhaust gas [49]. It was found that the heating efficiency increased with increased height of the scrap in the charge, decreased density of the scrap charge, and higher gas inlet temperature for a fixed energy input. The effect of the density of the scrap charge on arc furnace efficiency was confirmed by another, separate investigation [50]. The gases from the BOF can be used to preheat furnace feed in the same manner.

OXYGEN INJECTION

Oxygen may be injected into the arc furnace during refining to oxidise excess non-metallic elements, or during the melt, resulting in homogeneous melting, a reduction in the melting time, and hence in electricity consumption, and improved thermal efficiency. Disadvantages are accelerated electrode oxidation and iron loss. Economic studies for specific applications can show oxygen lancing to be viable [51].

The use of oxy-fuel burners to supplement electric power in the arc furnace increases the heat input to the furnace, reduces the consumption of electric power, electrodes, refractories, and reduces tap to tap time [51]. The resulting increased production can make this a cost effective option, although the cost of the fuel used is often higher than that of the electricity saved.

STEEL REHEAT FURNACES

A large consumer of energy in the steel mill is the reheat furnace. An inexpensive and commonly used way to reduce energy consumption in the reheat furnace is to charge it with hot billets as soon as possible. This is easier in plants with continuous casters.

One way to reduce fuel use is to increase the amount of coverage of watercooled pipe either by maintaining the insulation on water cooled pipe regularly, or using special shapes of pipe insulation [52]. The former method is by far the most effective.

Microprocessor control of the reheat furnace can be applied relatively inexpensively to optimise furnace efficiency and adjust the temperature profile of the furnace.

Preheating of combustion air results in substantial savings and the higher the air preheat, the higher the energy savings. The cost of recuperator systems increases with the air preheat temperature, though, and in general, 400°C appears to be the most cost effective temperature that can be attained.

The application of ceramic fibre to the hot face of the furnace walls can reduce heat loss through the furnace walls and decrease the heat up time by as much as 50%. The low thermal conductivity and heat storage properties of the ceramic fibre enhance the use of furnace control, as the furnace temperature profile can fluctuate more readily as required.

Heat recovery and the use of recuperators at the soaking pit and reheat furnaces is widely practiced in South Africa, and improvements in technology, particularly in the field of ceramics can be expected.

COLD TUNDISH AND LADLE LINERS

The lining of the tundish, the intermediate vessel between the ladle and the casting mould in continuous casting, previously required preheating prior to casting. Disposable linings that can be used with no adverse effects are now available and in wide use. Disposable refractory lining boards that require no preheating are now available for ladles, as well, and their increased use can be expected. As continuous casting practice increases, development of higher quality refractory products in this area must be expected.

7.7 CONCLUSIONS

The steel industry is the largest industrial energy consumer in South Africa [4]. In 1984 the industry consumed about 230 million GJ, slightly lower than the 1980 consumption of 245 million GJ. Over 80% of this energy is supplied by coking coal. This may be expected to drop as coal-based technology appears likely to replace the blast furnace to an increasing extent. The survey indicates that the specific energy consumption per ton of crude steel is approximately 23 GJ per ton. Other data collected, however, quoted conflicting values. This would appear to indicate that energy monitoring in the industry has scope for improvement. All the figures did show the trend that the specific energy consumption was decreasing with time.

The industry is aware of the need to conserve energy, and is prepared to implement the latest technological developments, as can be seen from the increasing amount of direct reduction plant in this country. In addition, energy management is being increasingly appreciated, and implemented in the industry.

Steelmaking using the open hearth process has been discontinued and replaced by BOF and electric arc furnaces. The major reasons for this are the high consumption of primary energy in the open hearth for low productivity, and the high cost of increasingly important environmental protection measures.

The increase in electric steel production may be expected to continue, depending on the future prices of electric power, the availability and price of scrap and sponge iron, and the quality requirements for steel.

The process that can be expected to be of increasing importance in South Africa is that of coal-based direct reduction, which avoids the use of coke generation, and produces pig iron that can be conventionally converted to steel. The linking of this type furnace with the electric arc furnace entails lower capital expenditure than the conventional steelmaking route, enabling economical small plant expansion

A number of energy saving measures are proving successful in this country, but there is potential for further savings using practices established in other countries. In these countries, the adoption of low cost energy saving measures, and the use of improved technology, resulted in an average reduction in specific energy consumption of about 16% between 1978 and 1984. The trend in South Africa's average specific energy consumption indicates that a similar trend occurred here. There has been an increase in the past two years, though. As a result, it is reasonable to expect future improvements to be similar to those expected in other steel producing countries, where reductions of up to 20% in specific energy consumption are expected by the end of the century. At present consumption levels this would mean an energy saving of about 52 million GJ at a current cost of about R110 million. This saving may be expected to result from continuing steady improvements, which, in the short terms will be largely as a result of low cost measures. The balance will involve extensive research and development, and considerable capital investment.

If the steel industry is to make full use of the opportunities available to it, steelworks should be expected to become net energy producers, largely through generation of electricity using waste heat. The current ESCOM policy makes this an uneconomical proposition for the steel industry, and this situation cannot be expected to change until there is a market for such power at a reasonable price.

Energy consumption by the ferroalloy industry in 1984 was estimated to be approximately 50 million GJ after a high of 60 million GJ in 1980. Electricity accounts for over 50 % of the supply, with coke, used for reduction constituting the majority of the remainder.

The level of energy efficiency in this industry offers scope for improvement through the introduction of established heat recovery technology. Energy management appeared to be at an early stage of development, and as its value is increasingly appreciated may be expected to be of greater importance in the industry. Current export incentive policy may be instrumental in delaying the introduction of energy conservation measures in some ferroalloy plants. Revision of this incentive may result in some plants seriously considering implementing measures previously shelved as unjustifiable. Comparison with the industry in the U.K. indicates that a reduction in consumption of as much as 10% may result. This would mean an energy saving of about 5 million GJ.

CHAPTER EIGHT

THE PULP AND PAPER INDUSTRY IN SOUTH AFRICA

The manufacture of pulp and paper is classified under the Department of Statistics Standard Industrial Classification of All Economic Activities as Manufacture of Pulp, Paper and Paperboard, subgroup 34110.

8.1 INTRODUCTION

8.1.1 MANUFACTURE OF PULP AND PAPER

The primary raw material used in the paper industry is cellulose fibre. Wood is the chief source of cellulose fibres for papermaking, but bagasse (sugar cane waste) and waste paper are other important sources.

Papermaking may be considered to commence with the reduction of raw materials, and depending on the final product required, comprises a number of different processes. Brief descriptions of various processes follow.

WOODCHIPPING

If pulp is to be produced chemically or semi-chemically and the raw material is timber (as in the majority of cases), logs are first debarked and then chipped by a rotating flywheel with bars acting as cutting blades. The chips are screened and sent to a pulping digester. The bark and fines from chipping may be used in a boiler unit as fuel.

GROUNDWOOD PULPING

This involves grinding debarked logs into fibre or fibre bundles using large rotating grinders. The pulp produced in this way is called groundwood pulp. The yield of pulp from wood may be as high as 95%. The pulp produced , however, has a low strength and contains a high level of impurities.

THERMOMECHANICAL PULPING

Conventional thermomechanical pulp is made by pre-steaming wood chips at high pressure before reducing them to pulp in pressurised refiners

CHEMI-THERMOMECHANICAL PULPING

In this process the woodchips are chemically treated before pulp production in pressurised refiners.

KRAFT PULPING

The kraft process is a chemical pulping process in which woodchips are cooked with a strong alkaline solution of sodium hydroxide, sodium carbonate and sodium sulphide to remove most of the lignin binding the fibres together.

NEUTRAL SULPHITE SEMI-CHEMICAL PULPING (NSSC)

In this chemical pulping process, woodchips are cooked with a liquor containing sodium carbonate and sodium sulphite. This removes some of the lignin binding the fibres together. The yield from this process is higher than that of the kraft process, but the pulp quality is lower.

SODA PULPING

The soda process uses a strong aqueous solution of sodium hydroxide as the pulping agent.

BLACK LIQUOR ENERGY RECOVERY

The spent cooking liquors (black liquors) from the chemical pulping processes are concentrated in evaporators to 55-65 percent solids. This concentrated black liquor is high in organic content and is burned in boiler furnaces to recover energy.

WHITE LIQUOR RECOVERY SYSTEM

The molten inorganic salts remaining after burning the black liquor are dissolved in water and chemically treated to enable their return to the digester.

Processes to recover such chemicals as ethyl alcohol, acetic acid and dimethyl sulphoxide are also possible in chemical pulping operations.

BLEACHING

For some applications it may be necessary to bleach the pulp before paper is manufactured. Chlorine or oxygen processes are used.

REFINING

Pulp suspensions of around 5% solids are refined by mechanical action to make the fibres more flexible and to fray them to increase their surface area. This is achieved by passing the pulp between rotating and stationary bars of a refining device, of which there are several types. After refining the suspension is called stock. Papers made from highly beaten stocks are dense, hard and strong, while papers made from lightly beaten stocks are of low density, soft and porous.

STOCK PREPARATION

Additive materials are introduced to the pulp after refining. These include sizes to reduce the porosity and absorbability of the paper, fillers to reduce transparency and improve the surface for printing, dyestuffs for colour control, and others such as wet-strength agents, deflocculant agents and defoamers as required.

SCREENING

In the final process before papermaking, the stock is screened to remove all contaminants and the dilute fibre-water suspension is pumped to the papermaking machine.

RECYCLED PAPER

If paper is to be made from waste paper, the stock is prepared in a slusher heated by steam, which has devices to remove large articles of refuse. More cleaning is needed than for pulp, and if high quality products are to be manufactured it is usually necessary to de-ink the waste. A pitch dispersal plant may be needed to remove contamination due to plastics.

PAPER MANUFACTURE

The tendency of cellulose fibres to bond together when dried from suspension in water provides the essence of papermaking technology.

SHEET FORMATION AND DRYING

A continuous paper machine converts a very dilute aqueous suspension of fibres and other constituents into a long dry sheet of paper. The suspension is deposited from a head box as a jet of uniform thickness onto a continuous moving screen or belt, or a rotating cylindrical filter, depending on the paper machine type. Water drains through the screen or roll due to suction boxes or presses. The sheet is removed from the moving screen at the couch roll at a consistency of about 80% water, and transferred to a supporting woolen felt. In a cylinder-type machine the sheet is removed from the top of the cylinder and may be joined to other wet sheets from adjacent cylinders to form a thicker sheet or a board.

Once the wet paper sheet has been formed, the process does not differ greatly from machine to machine. The sheet passes through a series of press rolls which reduce the water content to approximately 65%. The sheet then passes over a series of steam heated cylindrical driers which reduce the water content to between 5% and 10%.

CONVERTING OPERATIONS

Many grades of paper receive some further treatment after drying to enhance certain characteristics. Calendering involves passing the sheet through a series of heavy rollers to impart a gloss to the paper for printing or writing purposes. More complex operations, to produce such things as corrugated board for packaging, or multiwall sacks for packaging granular materials occur subsequent to the papermaking process and are called off-machine processes.

8.1.2 STRUCTURE OF THE INDUSTRY IN SOUTH AFRICA

The pulp and paper industry in South Africa comprises four manufacturing groups, one small independent paper manufacturer, and one pulp manufacturing company. In 1984 the industry accounted for a total paper and board production of 1 397 503 tons [53]. For the same period the apparent consumption of paper and board in South Africa was 1 427 369 tons. By the end of 1985 the installed paper and board making capacity was expected to be 2 023 000 tons. In 1983 South Africa was ranked the 14th largest pulp manufacturer and the 20th largest paper and board manufacturer in the world.

8.1.3 SCOPE OF SURVEY OF PULP AND PAPER INDUSTRY

This survey covers a sample of the pulp and papermaking industry in South Africa responsible for 80% of the total paper and paperboard produced in 1984, and an average of 66% of the industry paper and board output over the period 1975 to 1984. In addition, the total pulp output from the sample represents 74% of the total industry capacity in 1984 and an average of 64% of the industry pulp capacity for the period 1975 to 1984.

8.1.4 ENERGY REQUIREMENTS OF THE PULP AND PAPER INDUSTRY

The pulp and paper industry is a very energy intensive industrial sector, on a par with steel production, using an average of about 26,6 GJ per ton of product. In many countries, it is either the largest or one of the largest single consumers of energy [54].

Steam raising accounts for the majority of the energy consumption in the industry. The average percentage of total energy requirements used for steam raising reported by the respondents to this survey was 71% for integrated pulp and paper mills and 63% for non-integrated paper mills. This steam is used for paper drying, and for steaming, digesting and washing pulp in pulp mills.

Electricity for driving pumps, papermaking machinery and other electrical equipment accounts for an average of 20% of the total consumption in integrated pulp and paper mills and 27% in paper mills. The remainder is due to transport within the plant (56% of the remainder), lighting (28%) and offices and ancillaries (16%).

The percentage of electricity consumption due to pulping in integrated mills differs greatly according to the pulping process used. The survey shows the percentage to be of the order of 20%-40% for pulping in chemical pulp mills and 50%-60% for mechanical and TMP mills.

Steam can be raised for process or electricity generation in boilers fired with wood waste, and recovered black liquor, depending on the plant type.

The average percentage of total production costs due to energy has grown from 9.3% in 1975 to 17.1% in 1984 for the survey sample. The average for that period was 14.3%.

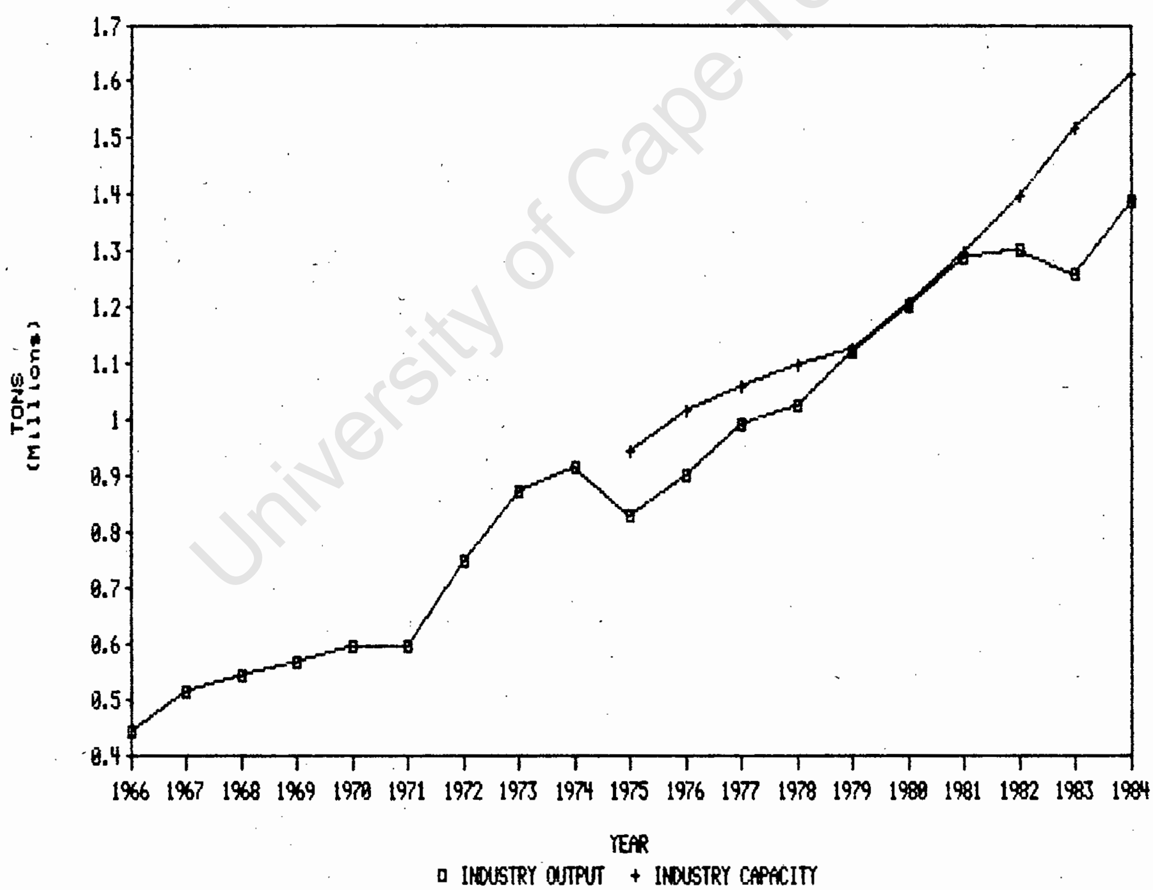
8.2 INFORMATION OBTAINED FROM THE SURVEY AND DISCUSSION OF RESULTS

Where possible, data obtained from this survey is presented with data supplied in the work "Energy Utilisation in South Africa". published in 1978 [2]. Appendix F gives the data used to generate the graphs in this chapter.

8.2.1 PRODUCTION IN THE PULP AND PAPER INDUSTRY

The pulp production and capacity of SAICCOR is not accounted for in this section as the data given here was obtained from the Association of Pulp, Paper and Board Manufacturers of South Africa[55], and SAICCOR does not contribute information to the Association.

PRODUCTION AND CAPACITY FIGURES FOR THE PULP AND PAPER INDUSTRY IN SOUTH AFRICA, 1966 TO 1984



Source: The Association of Pulp, Paper and Board Manufacturers of South Africa

FIGURE 8.1

The production of paper in South Africa for the period 1966 to 1984, in conjunction with the industry's capacity for paper manufacture and pulp production for the period 1975 to 1984, is shown in Figure 8.1.

Growth in production can be seen to be approximately linear over the period shown, with an average increase of 64 000 tons per year. The industry capacity shows a distinctly linear trend from 1975 to 1984. The differences between capacity and production can be partly explained by the commissioning of new plant in those periods, which did not achieve near-capacity production immediately.

No figures were obtained for the industry's total pulp production for all years, but information from the Association of Pulp Paper and Board Manufacturers [53] shows South Africa to be a net importer of both hardwood and softwood pulps for paper production. It must be remembered, though, that the pulp production of SAICCOR is not accounted for, and this is largely exported.

8.2.2 ENERGY CONSUMPTION IN THE PULP AND PAPER INDUSTRY

The total energy consumption reported by the plants participating in this survey, and the division between electrical energy and that from fuels, was extrapolated in proportion to the percentage of the total paper production represented in each year to produce an estimate of the total energy consumption in the industry for the survey period. This estimated energy consumption is shown in Figure 8.2.

ESTIMATED ENERGY CONSUMPTION IN THE PULP AND PAPER INDUSTRY, 1975 TO 1979

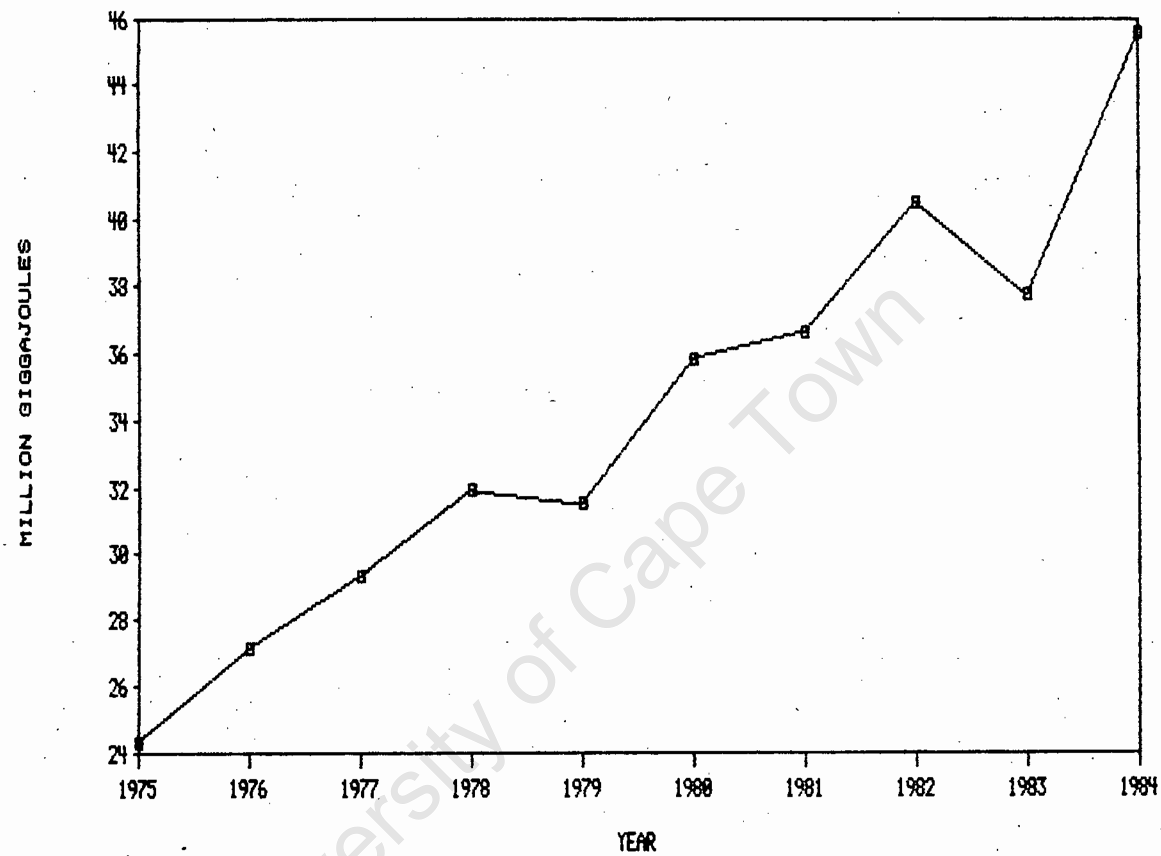


FIGURE 8.2

As expected, the growth in energy consumption in the paper industry follows the general linear trend evident in the production figures. The sharp drop in consumption in 1983 coincides with the drop in production in that year.

The percentage of the total energy input supplied by purchased fuels and electricity, and by "waste" fuels, such as bark and black liquor, and self-generated electricity in the survey sample, over the survey period is given in Figure 8.3.

PERCENTAGE OF TOTAL ENERGY INPUT PURCHASED COMPARED WITH WASTE OR SELF-GENERATED ENERGY INPUT

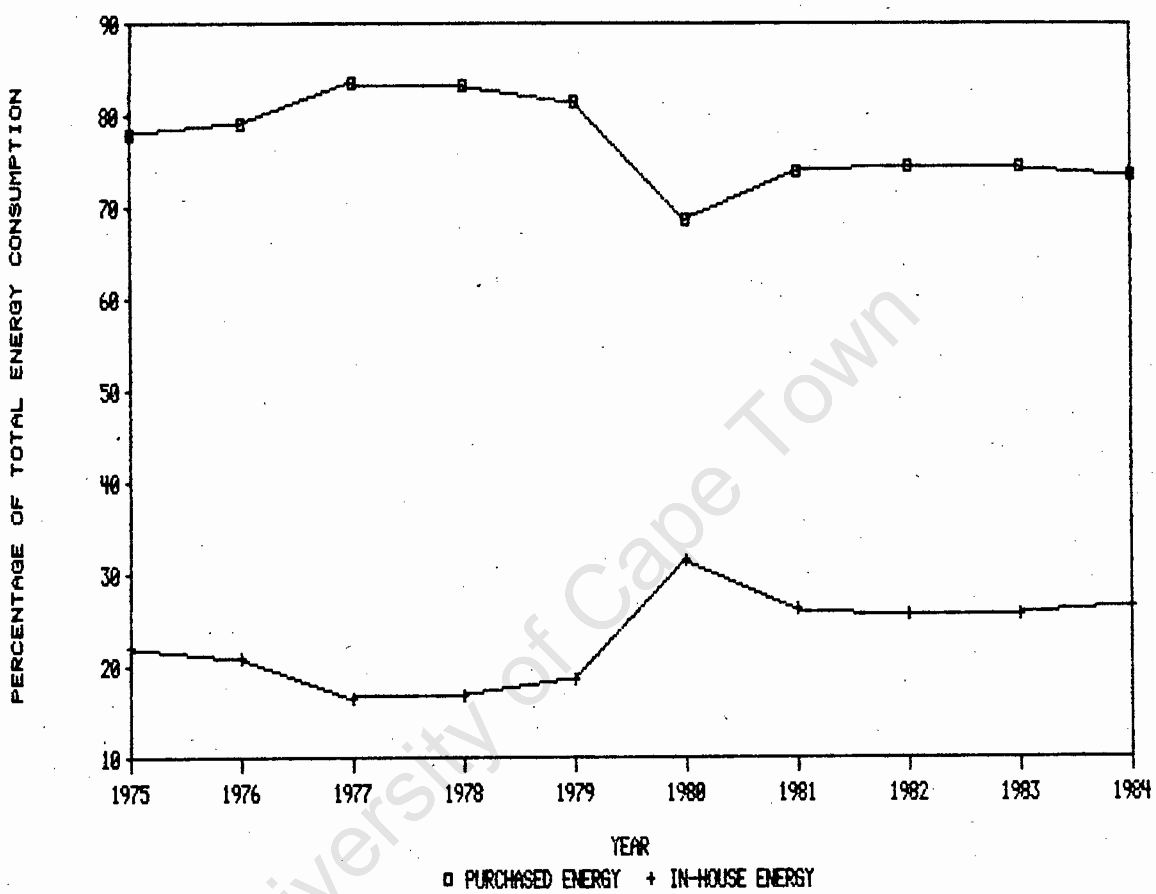


FIGURE 8.3

The percentage of "in-house" energy supply can be seen to have increased over the past ten years from approximately 20% to approximately 25% of the total energy consumption in the sample covered by this survey. In this regard, it would appear that there is substantial room for development. The pulp and paper industry in the USA increased its use of residual fuel and self generated electricity from 40.4% of total consumption in 1972 to 55% in 1983, representing a decrease in the use of oil fuels of 57% (56). In the same time span, the consumption of oil fuels in Sweden was cut by over 70% due to increased use of in-house energy (57).

The energy input of the various types of purchased fuels used by the plants participating in the survey is given, as a percentage of the total energy input due to purchased fuels, in Table 8.1.

ENERGY INPUT BY FUEL TYPE.

(Expressed as a percentage of the total purchased fuel energy input in the survey sample)

	1975	1979	1984
FUEL	%	%	%
Sasol Gas	0.7	1.4	1.0
Fuel Oil	25.4	28.3	6.9
Coal	73.7	70.0	91.9
LPG	0.0	0.1	0.02
Diesel/Petrol	0.2	0.4	0.2

TABLE 8.1

A distinct change from fuel oil to coal can be seen between 1979 and 1984. The trend to coal from oil is seen clearly if the whole period 1975 to 1984 is considered, as in Figure 8.4. As the other fuel types comprise only a minor portion of the total consumption, only the percentages of Sasol gas, fuel oil and coal are shown.

PERCENTAGE OF TOTAL PURCHASED FUELS BY TYPE, 1975 TO 1984

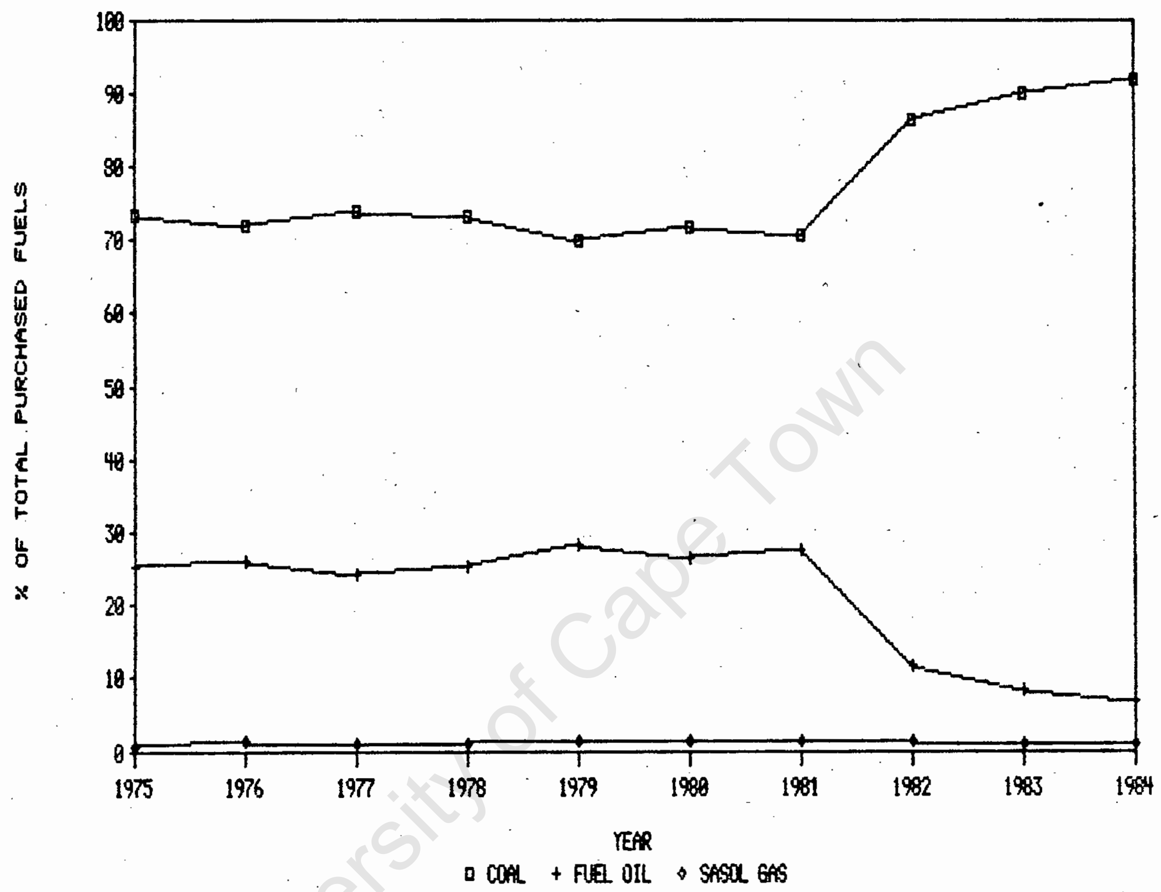


FIGURE 8.4

Having already considered the percentage of total energy input due to residual fuels and self generated electricity, it is of interest to see how much of the total fuel input is due to purchased fuels, how much electricity is self generated, and how the percentages have changed with time. The use of waste fuels, such as bark, and recovered fuels, is compared with the use of purchased fuels in Figure 8.5. The comparative usage is given as a percentage of the total fuel input in the survey sample for each year.

CONSUMPTION OF PURCHASED AND WASTE/RECOVERED FUELS 1975 TO 1984

(Energy input expressed as percentages of total fuel energy input to sample)

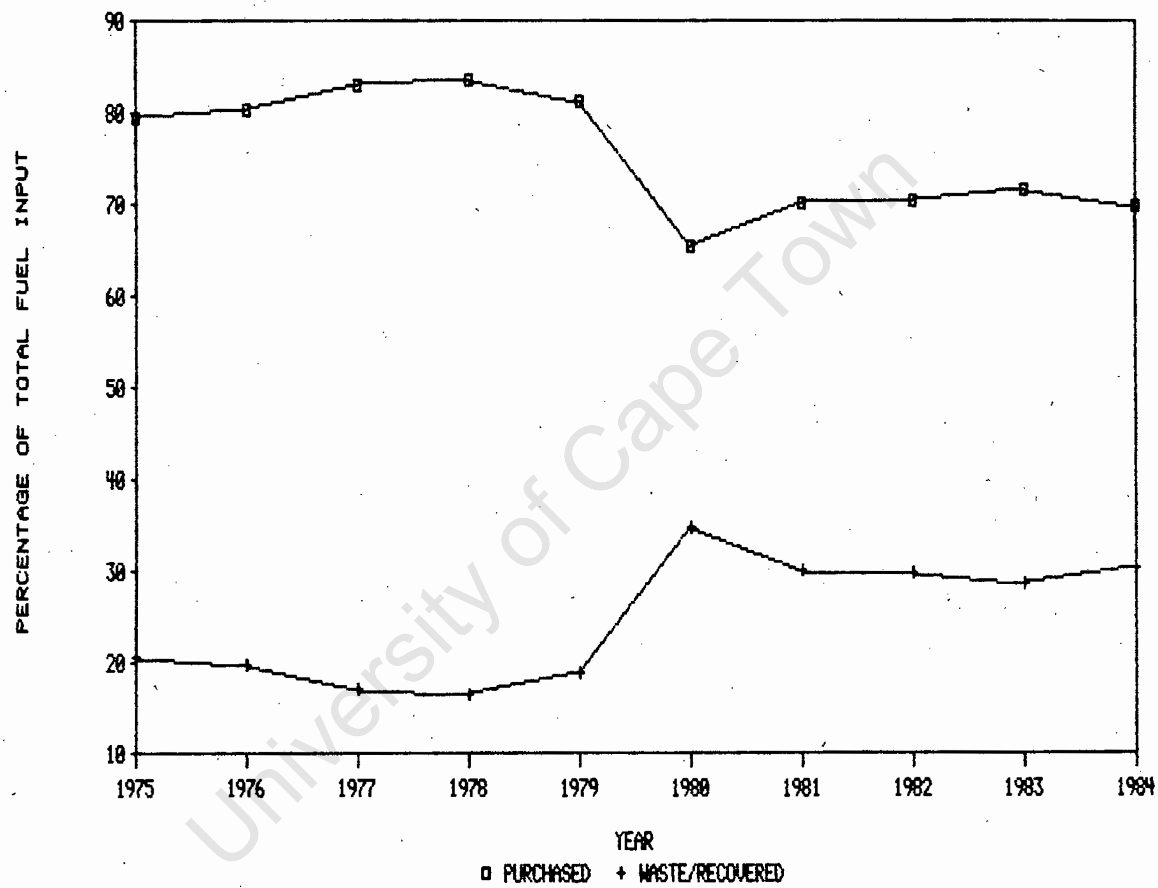


FIGURE 8.5

It can be seen in Figure 8.5 that the use of in-house fuels has increased from approximately 20% to approximately 30% over the last decade. As the percentage of total in-house energy increased from 20% to 25%, the percentage of total electricity used generated by the industry must have decreased.

The total electricity consumption by the survey sample, and the breakdown of the supply into self-generated and grid-supplied electricity over the survey period, are shown in Figure 8.6. The percentage of total consumption represented by self-generated electricity is also shown.

ELECTRICITY USE AND GENERATION
IN THE PULP AND PAPER INDUSTRY, 1975 to 1984

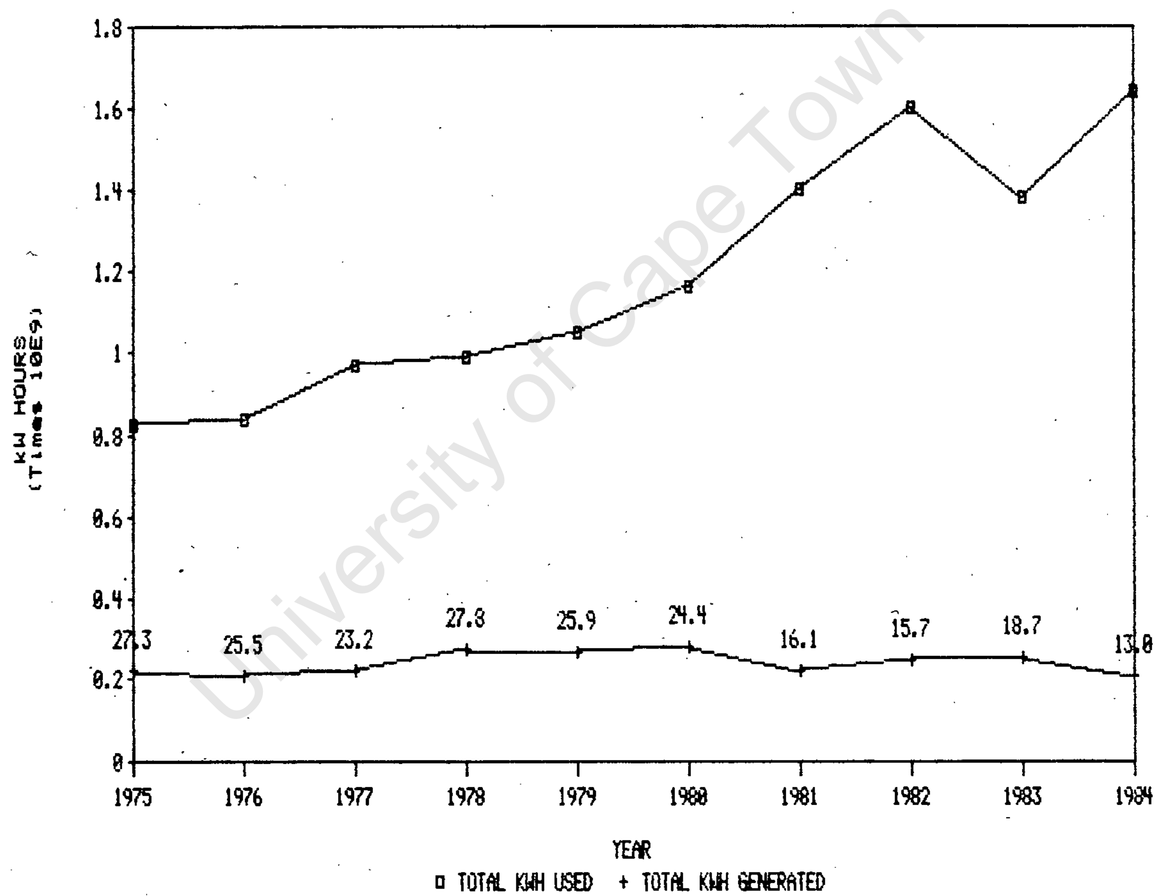


FIGURE 8.6

It can be seen that the total amount of self-generated electricity has remained relatively constant over the past ten years, while the total consumption has increased steadily.

This trend can be expected to change as electricity prices increase and self-generation becomes more justifiable economically.

SPECIFIC ENERGY CONSUMPTION

Consideration of specific energy consumption in the pulp and paper industry is complicated by the variation in energy consumption per ton of output according to plant, process and product. Energy consumption in pulp manufacture depends on the pulping process used, the amount of energy recovered and waste energy used. The energy requirements for the production of different papers and boards also differ.

In addition, when attempting to assess specific energy consumption in integrated pulp and paper mills from overall plant statistics such as those gathered in this survey, it is not possible to ascertain how much energy was used in pulpmaking and how much in papermaking. If it is decided to assess the energy input for the process overall, from raw materials to paper, it must be remembered that not all the pulp produced is necessarily used for paper or board manufacture in the same plant. An amount may be sold for export or for use in another non-integrated mill.

Another problem arises in the calculation of the specific energy consumption in the industry. Values may be based on either purchased energy or total energy input. The former may be derived with reasonable accuracy. However, if total energy consumption is considered, figures may not be totally accurate as it cannot be assured that all "in-house" energy inputs are accurately recorded.

As a result, an overall specific energy requirement for the industry obtained from the data gathered cannot be used as an absolute value for inter-country comparisons. Nor, indeed, can it serve as an indication of trends in the energy efficiency of the industry with any reliability as the internal structure of the industry and the product mix may change. Despite this, values of energy consumption per ton of paper produced by the survey sample are given in Table 8.2.

OVERALL SPECIFIC ENERGY REQUIREMENT IN PAPERMAKING IN SOUTH AFRICA

YEAR	TOTAL ENERGY PER TON OF PAPER GJ/ton	PURCHASED ENERGY PER TON OF PAPER GJ/ton
1975	29.406	22.915
1976	30.097	23.821
1977	26.863	21.980
1978	27.994	22.768
1979	25.751	20.524
1980	28.520	19.132
1981	27.406	19.961
1982	29.931	21.954
1983	28.735	21.007
1984	31.873	23.153

TABLE 8.2

The changes in overall specific energy consumption, seen in Table 8.2, cannot be assumed to indicate changes in the efficiency of energy utilisation, for the reasons given previously. It is perhaps more relevant to consider some values of specific energy consumption for representative plants, given in Table 8.3.

SPECIFIC ENERGY REQUIREMENTS FOR TYPICAL PLANT IN THE PULP AND PAPER INDUSTRY

PLANT TYPE	PRODUCT	ENERGY INPUT GJ/TON
Paper Mill	Tissue	8.85
Paper Mill	Paperboard	11.69
Integrated Mill	Kraft Paper (Kraft and NSSC pulp)	26.11

TABLE 8.3

8.2.3 ENERGY MANAGEMENT IN THE PULP AND PAPER INDUSTRY

The pulp and paper industry, as a result of the energy intensity of its products, is very conscious of all aspects of energy conservation. In general, either one of the management personnel of the plants surveyed is responsible for energy management, or energy related matters are handled by a group energy engineer.

Only one of the plants surveyed stated that no energy audit of any kind was carried out at the plant, but plans have been made for an audit system to be instituted. While 70% of the plants conduct discussions with employees on energy management topics, 90% do not conduct any energy awareness scheme, using such means as posters or noticeboards. Awareness drives are planned at a further 30% of the plants, though.

Companies and individual plants within the industry also send operating staff on commercial boiler management courses, or have their own training programmes.

Of the plants surveyed, 60% have installed automatic load shedding equipment for the reduction of maximum electrical demand. Those plants that do not have such equipment stated that there were no plans for its installation at present.

All plants reported having automatic power factor correction equipment, and the average power factor of all the plants is 0.94.

Additional energy conservation measures currently practiced include improving levels of general "housekeeping" such as repairing steam leaks and lagging steam and condensate pipes, recovery of flash steam and condensate, control of boiler combustion and heat recovery from the furnace.

Due to the high cost of fuel oil compared with coal per unit energy input, the change from fuel oil to coal for steam raising has been a general feature in the industry over the survey period, as has the trend towards using lower grade coals. The shift away from oil based fuels has extended even to the use of electricity instead of diesel for transport within plants. The burning of coal is also supplemented, where possible, by other fuel sources such as wood bark.

8.3 ENERGY USE IN THE PAPER INDUSTRY IN OTHER COUNTRIES

The overall specific energy consumption in the paper industries of other countries are given in Tables 8.4 and 8.5.

SPECIFIC ENERGY CONSUMPTION IN THE UK AND JAPANESE PULP AND PAPER INDUSTRIES

YEAR	AVERAGE SPECIFIC ENERGY CONSUMPTION IN U.K.* GJ per ton	SPECIFIC PURCHASED ENERGY IN JAPAN** GJ per ton
1965	26.3	
1970	24.3	
1974	22.3	
1975	25.9	27.72
1976	26.0	26.16
1977	24.7	
1978	25.1	24.87
1979	23.9	
1980	24.4	21.74
1981	21.9	
1982	21.8	19.29
1983		18.29

* Source: BPBIF Report on Energy Consumption and Cost for 1982 (58)

** Source: Kalish J. (57)

TABLE 8.4

PURCHASED ENERGY CONSUMPTION PER TON OF PAPER
IN SELECTED OECD COUNTRIES IN 1981

COUNTRY	PURCHASED ENERGY PER TON OF PAPER GJ/TON
CANADA	12.07
USA	15.27
JAPAN	13.49
FINLAND	19.53
FRANCE	12.78
ITALY	12.07
SWEDEN	29.11
UK	19.88

Source: Energy Efficiency in the Pulp and Paper Industry with Emphasis on Developing Countries. Ewing [59]

TABLE 8.5

As can be seen from the previous two tables, comparisons of this nature must be viewed with caution. Firstly, there may be inconsistencies in reporting, as would appear to be the case regarding the data for Japan, as just the two sources above appear to conflict, and for Sweden. Jankowski [21] quotes a total energy consumption per ton of paper for Sweden in 1973 of 31.65 GJ per ton. Since 1973, consumption of oil in the Swedish industry has decreased by 11% and in 1981 spent liquors and bark corresponded to 66% of the total energy consumption [54]. Simple arithmetic will show that the figure quoted by Ewing is inconsistent.

Secondly, those countries that import a large proportion of the pulp used in papermaking, such as Italy, will show a much lower specific energy consumption than a country that exports a large percentage of its pulp, such as Sweden. In addition, countries producing a large proportion of mechanical pulp will show a higher unit energy consumption.

8.4 TRENDS IN ENERGY CONSUMPTION IN THE PAPER INDUSTRY

TREND IN PRODUCTION OF PAPER IN SOUTH AFRICA

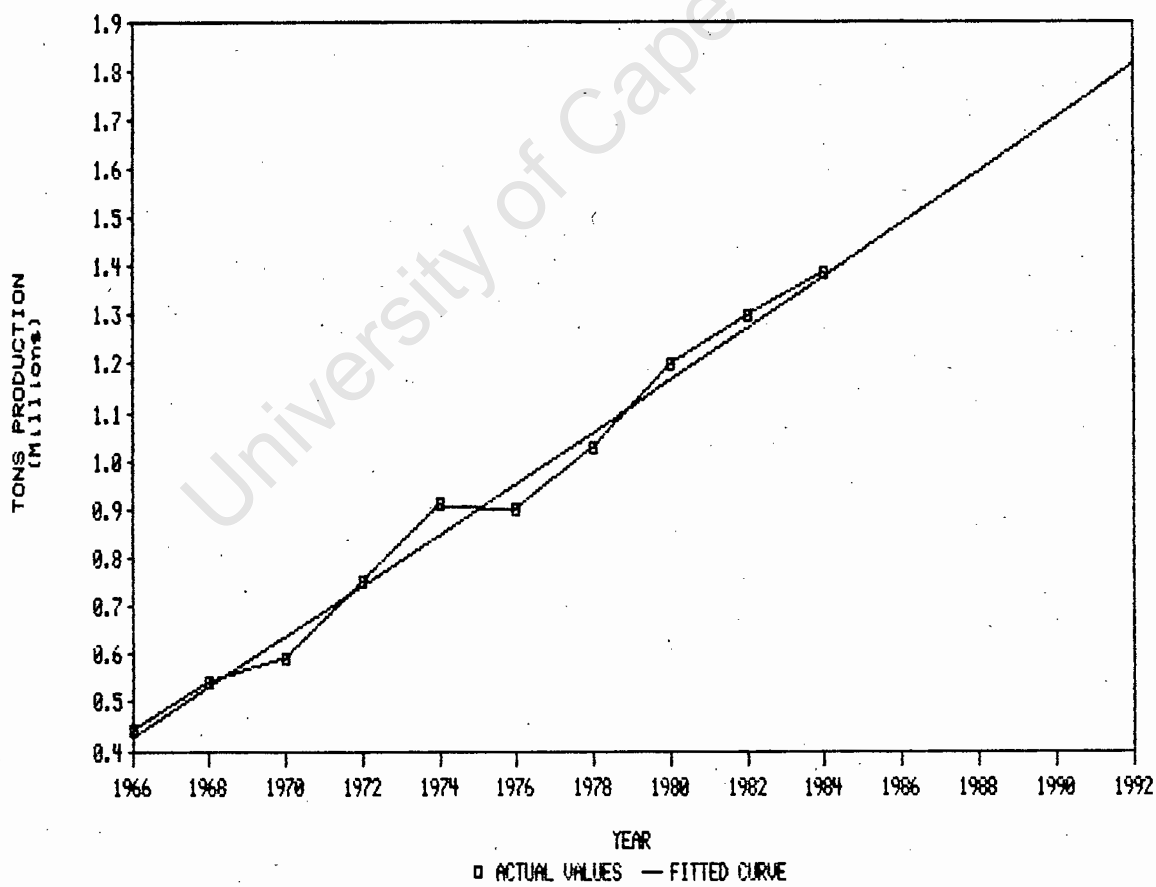


FIGURE 8.7

The trend in production of paper in the industry in South Africa is shown in Figure 8.7. This, and following graphs were developed by fitting curves to available data and extrapolating the curves for six years. As can be seen the growth of the industry has been constant over the past two decades, and with some installed capacity still not utilised, this growth may be expected to continue.

The trend in energy consumption is shown in Figure 8.8. This shows the total energy consumption increasing steadily, corresponding with production. However the amount of purchased energy is seen to be increasing at a lower rate, indicating the increasing self-sufficiency of the industry.

TREND IN ENERGY CONSUMPTION IN PAPERMAKING IN SOUTH AFRICA

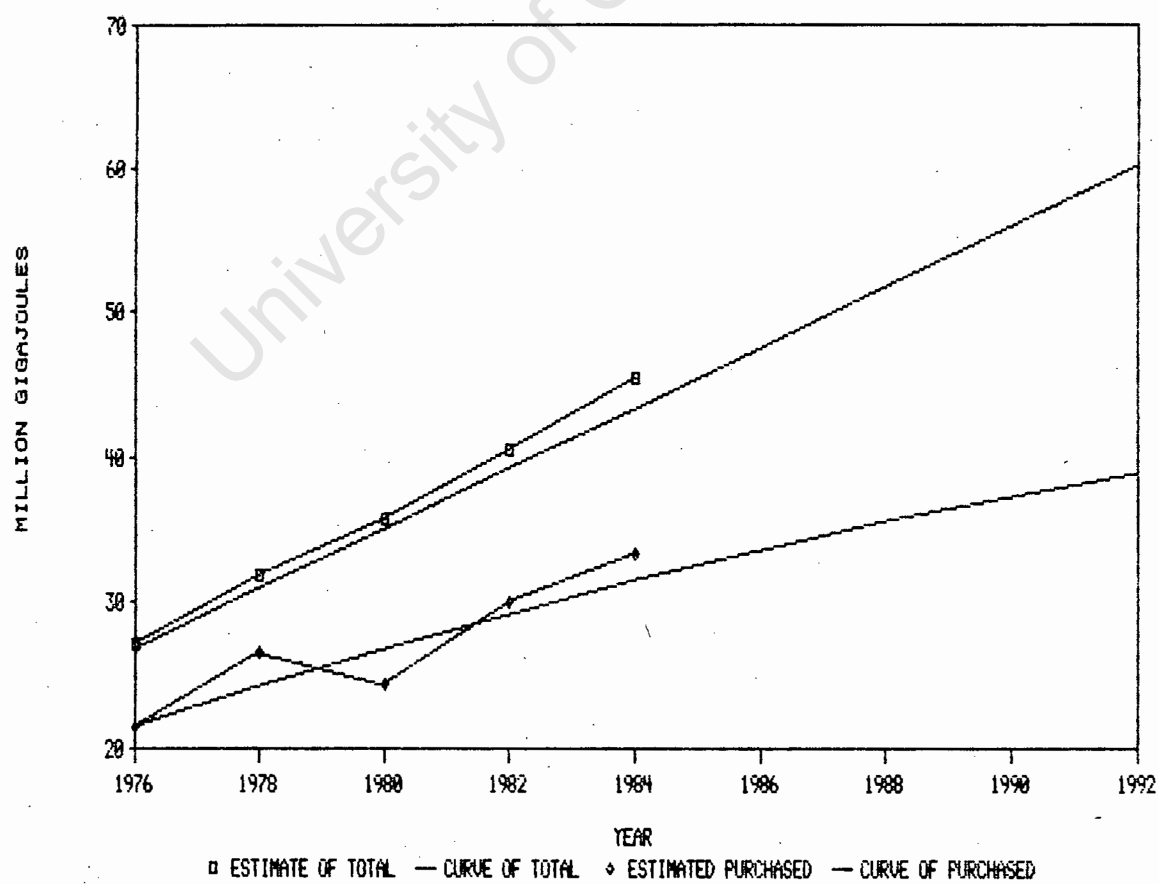


FIGURE 8.8

An assessment of the trend in specific energy consumption is presented with the reservations noted earlier. Data obtained in the survey showed great variation, and as a result the coefficient of correlation between curve and data was not high. The graph obtained is presented in Figure 8.9. The major point of value in this graph is the fact that the consumption of purchased fuels per ton of output is clearly decreasing. The fact that the overall specific energy consumption appears to be increasing is worthy of further investigation, as data supplied in this survey may have been incomplete.

TREND IN SPECIFIC ENERGY CONSUMPTION IN PAPERMAKING

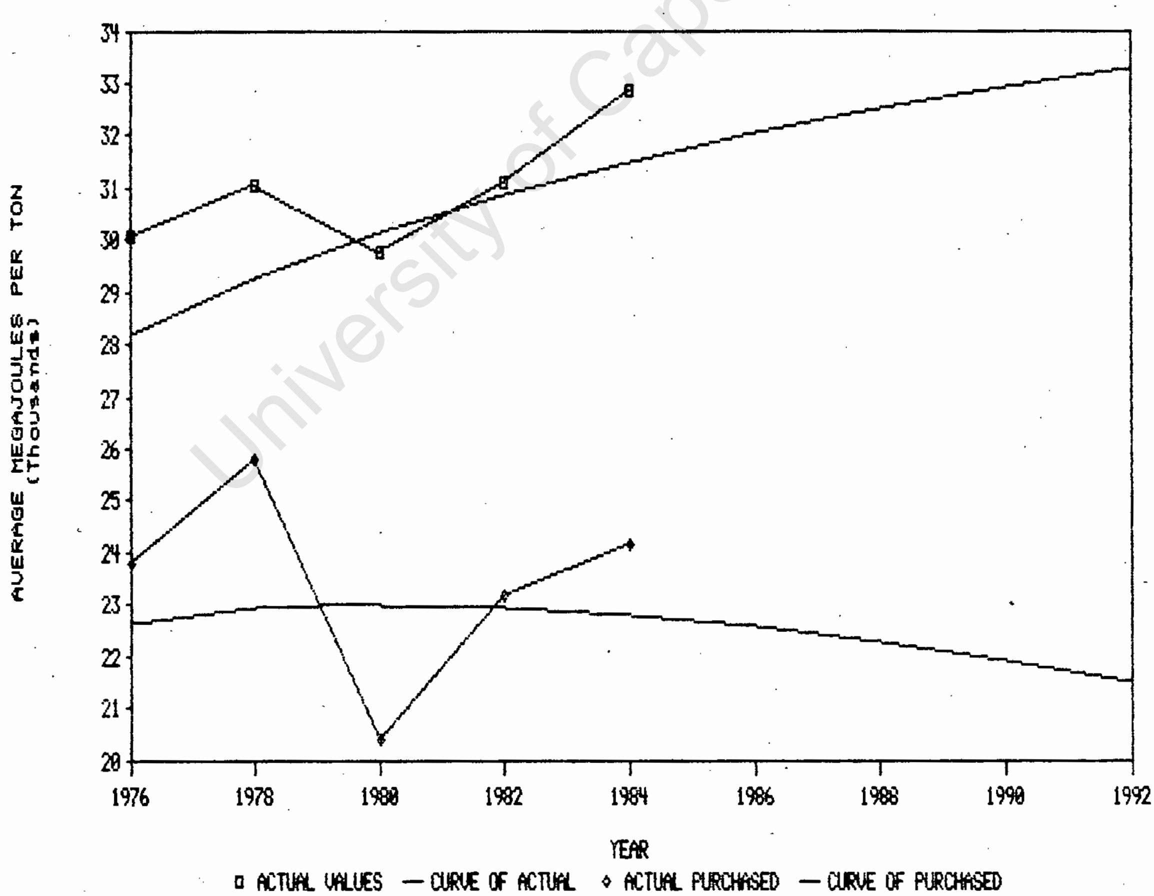


FIGURE 8.9

8.5 ENERGY SAVING OPPORTUNITIES

There are a number of possibilities for reducing energy requirements in the pulp and paper industry. Some involve the use of systems which are most easily incorporated in the design of new plant, but many can be added to plant already established. A number of energy saving measures are listed below.

ENERGY MANAGEMENT AND GOOD HOUSEKEEPING

It is felt that measures such as operation of boilers to design specifications, correct maintenance of steam traps, and maintenance and improvement of insulation, involving minimal capital expenditure, provide one of the most cost effective means to achieving energy savings in the paper industry at present. Estimated potential savings on purchased fuels without installation of additional capital equipment may be as high as 20%[60].

WOOD HANDLING

Improvements that may be possible in the area of wood handling include, whole log chipping, mechanical barking instead of hydraulic barking, and belt conveying instead of pneumatic conveying. An obvious measure, that is beyond control for existing plants, is the optimising of the distance of the plant from material sources to reduce transport costs.

PULPING

In the chemical pulping processes, higher pulp yields will have the effect of reducing the specific energy consumption in digesters and evaporators. Data available from other countries indicates the possibility of achieving this[61].

Increased liquor strength may also be expected to decrease energy demand. Although washing does not consume a significant amount of energy, the amount of dilution of spent liquor which occurs is important in evaporator operation. The higher the consistency of the washed pulp, the lower the amount of water to be evaporated to produce liquor suitable for firing directly in the recovery furnaces.

In comparison with overseas data, energy savings of up to 25% may be possible in the evaporator system by the introduction of newer, more efficient evaporators with greater numbers of effects [61].

BLEACHING

The use of hot effluent or digester blow heat to preheat incoming water in the bleachery, or anywhere where process water is required, can result in significant energy savings.

PULP DRYING AND PAPERMAKING

Successive developments in press equipment result in more efficient mechanical water removal in the presses. As the removal of moisture by mechanical means requires less energy than removal by heat or vacuum, energy consumption in papermaking and pulp drying can be considerably reduced.

In comparison with figures applying to plants overseas, it would appear that it is possible to reduce moisture content of the pulp from dryers by as much as 30%. Overseas mills report moisture contents from the press section similar to those found locally, but as much as 30% more water evaporated after the dryer [61], in specific cases.

The minimisation of water use, by using closed circulating water systems, which recycle and re-use effluent streams, yields both energy and environmental benefits and has already shown its worth in South African plants.

HEAT RECOVERY

Heat recovery systems can be, and are, used on digesters, bleach plants, chemical recovery plant, TMP plant, pulp dryers and papermachines to decrease heat losses. The scope for the heat pump in some of these applications is considerable. Heat pumps can be applied in existing mills without any process modifications being necessary, and pay-back periods are estimated to be between one and two years.

The investigation of the use of heat pumps, one at the black liquor evaporator to produce live steam, and another to recover heat from the saturated air leaving the dryer, at one Swedish paper mill, indicated good prospects for improving the energy efficiency of both evaporation and drying [62]. The possibility of advantageous application in the digester plant is also reported.

Heat recovery on the paper machine hood exhaust can result in a paper machine being independent of make-up steam for air handling [63]. Varying levels of heat recovery potential are offered by indirect air-to-air, direct air-to-water or indirect air-to-liquid heat recovery systems, and by the use of flash steam from the paper machine condensate. These techniques can be combined to maximise the use of available heat in the air handling system, which is typically the most neglected equipment in the paper mill [64].

The potential for increased use of solid wastes for steam raising in South Africa is considerable [61]. Many mills buy in white wood, and consequently do not have bark to use as a fuel. It is possible that, at present, the transport costs do not warrant debarking at the mill in these cases. However, even where debarking does occur in-plant, very little of the bark and other solid wastes are used to raise steam. There is also potential for buying in wood waste as a fuel. In Canada, purchased wastes from other wood based industries are a significant part of the total energy consumption. In both cases the financial justification should be periodically reassessed.

A properly designed electrical system in the plant with correctly sized, efficient motors, pumps, fans and agitators will reduce electrical consumption. This is generally the aim in the design of new plant, but analysis of existing plant can result in savings. In addition, improvement of power factor and control of maximum demand play a significant role in reducing electricity costs.

In other countries, the implementation of such measures as listed above has resulted in energy savings of between 20% of purchased fuels, reported for Sweden, and 35% reported for the United States [59].

Sources within the industry feel that there is scope for improving the energy performance of pulp and papermaking in South Africa, by making use of the experiences of plants in other countries, and adapting advanced technologies and techniques to the conditions here. This is supported by a comparison of energy demand in a number of countries with that in the South African industry, which indicates that total energy demand in Sweden is 67% of that in South Africa, while that in Canada is 85 % [61].

This scope is confirmed by work by other sources. A study of 46 boilers in the industry by the National Timber Research Institute estimates that possible savings of R40 000 per individual boiler per year may be achieved by improved boiler control alone [65]. Another study by the NTRI revealed that, in a poll of 19 paper machines, less than 10% of the mills could report on steam distribution, and in 40% of the cases steam flow was unknown [66]. The same report found that 53% of the respondents rated the need for an energy audit of the paper machine as "high". A third work from the same source noted that before the implementation of any energy conservation programme, an energy audit is essential [67]. From conversation with personnel in the industry, it is clear that energy monitoring is practiced on a wide scale, but that a conclusive in-depth audit is not possible at all plants. Such an audit, effectively conducted, would be welcome in those cases.

It is considered, however, that no attempts at improving energy use will be effective without the commitment and full cooperation of top management.

8.6 CONCLUSIONS

The pulp and paper industry in South Africa is one of the largest industrial consumers of energy. In 1984 total energy consumption amounted to almost 46 million GJ. Of this, approximately 70% was purchased. The percentage of purchased energy for pulp and paper production appears to be decreasing, however.

Coal provides the majority of the purchased energy used, and its use is increasing. Electricity consumption is increasing proportionally with production, but the percentage of electricity requirements that is generated in-house is decreasing. This may be expected to reverse as electricity prices make cogeneration more financially attractive.

Consideration of average specific energy consumption for paper manufacture holds a number of inherent complications and comparison of absolute values is not necessarily conclusive. The survey results show that the average consumption of purchased energy per ton of paper produced in South Africa was between 20 GJ and 26 GJ per ton, while the total energy input was over 30 GJ per ton for the period covered.

The industry has a high level of energy awareness, and energy conservation is a major consideration in operations. It is generally accepted that there is potential for increased efficiency. There are a number of measures whereby energy consumption can be reduced, some of which are particularly applicable to the South African situation. These include increasing energy efficiency at the point of use, for example, improving combustion control of boilers and the efficiency of steam distribution systems, the improved use of waste and residue as fuels, and the increased cogeneration of electricity. The first has received a large amount of attention, and, with the availability of reasonably priced micro-processor combustion control, can be expected to result in an increase in boiler efficiency of 5% in the short term. This would result in energy savings of about 1,1 million GJ or a cost saving around R2 million. Measures requiring large capital expenditure are not expected to be implemented in the near future unless pay back periods are minimal. With currently available technology, the overall potential energy saving may be as high as 6,44 million GJ, at present levels of consumption, or 20% of the total purchased energy supply. At current prices this would mean a cost saving of about R25,5 million.

In some cases, energy monitoring is not as comprehensive as desired by some in the industry, and in these cases there appears to be a need for in-depth plant audits on which to base energy saving programmes specific to individual plants.

As in all industries, the success of any energy saving policy or programme depends on the support of top management, and to this end the introduction of a national policy to encourage improved energy utilisation should be considered.

CHAPTER NINE

CONCLUSIONS AND RECOMMENDATIONS

The industries covered in this survey were responsible for the consumption of an estimated 400 million gigajoules of energy in 1984. Energy costs represented between 12% and 48% of the total production costs of the companies concerned.

At present, the need for energy conservation is not necessarily immediately obvious to all, as energy prices, in general, though increasing, are not yet excessive, and awareness that sources of fossil fuels are dwindling is limited. The majority of companies approached in this survey are aware of the potential cost saving to be obtained through energy conservation measures, though, and are active, to some extent, in this field. Despite this, energy management appears to be an under utilised practice in this country in comparison to accepted practice in industrialised countries.

Although it is contrary to the ideology of the free enterprise system to offer subsidies or impose penalties in order to encourage certain practices, this may be the only way to encourage the widespread implementation of energy conservation measures, and energy management principles in this country.

Proposals of energy conservation measures in industry may not be receiving the support from upper management that they deserve, as the financial benefits afforded by the implementation of such measures may not meet the present management criteria governing capital expenditure. If, for example, such expenditure were tax deductable, it may be more justifiable. Obviously with any scheme of this nature, evidence would have to be provided to prove that the expenditure resulted in improved energy utilisation.

The alternative of imposing penalties for inefficient energy use, would be impossible to implement at present, as the information necessary to identify a plant operating inefficiently is not available and is unlikely to be for some time. It is also unlikely that a company would willingly submit records that would result in financial penalties.

The practice of energy management, which is proving beneficial in other countries, is in its infancy in this country. In general, it would appear that in industry in South Africa, the responsibility for energy management is inherent in the role of one or more of the production personnel. In such multi-role cases, energy management must be of lower priority than production management, and must suffer as a result. Indeed, the standard of energy use monitoring, the first step in effective energy management, is generally lower than that in the same industries in the major industrialised countries, where analysis of energy usage is carried out on a weekly basis at the minimum.

The appointment of a specific person, or persons, whose sole reponsibility is energy utilisation and expenditure, while ensuring each department share this responsibility, is a major move towards increased energy efficiency and resultant cost reduction. The cost of employing personnel whose sole responsibility is energy conservation, is often not obviously justifiable, as the potential benefits of energy management are not always immediately evident. For example, some possibilities for energy conservation may only be highlighted through increased levels of energy monitoring, and such levels may only be attained if there is someone whose entire time is devoted to the task. It is likely that energy conservation programmes will continue to be of low priority while energy prices remain fairly reasonable.

To accelerate the institution of energy management, it is essential to demonstrate the cost savings possible. This can be achieved by running government funded energy audits of specific plants. These should be detailed investigations of energy use within the plant, with the intention of not only identifying specific possible energy saving measures, but also assessing the financial implications of such measures. This would provide the private sector with concrete examples of the application of energy management principles in South Africa, which would encourage their adoption of such principles.

Small companies, which may appreciate the benefits of energy audits and effective energy management, in many cases could not afford the personnel and equipment costs arising from such practices. In such cases, qualified outside consultants could provide a much needed and valuable service. A scheme along the lines of the Energy Bus scheme, run by the National Industrial Fuel Efficiency Service Limited in the United Kingdom, may be considered in this regard. Scepticism of the capabilities of such consultants, which appears to be commonplace in the industrial sector at present, would be a major factor to overcome before the widespread acceptance of such a service.

The energy problem does not stop at the factory gate, however. The future national energy policy rests with the government, and its proper formulation requires in-depth knowledge of the amounts of energy used, and the patterns of its use, in all economic sectors. The lack of detailed energy consumption information in South Africa renders the task of the energy analyst, forecaster and planner far more difficult. To obtain the data required for this purpose by survey would be most difficult and would possibly suffer from poor response. It may be possible to obtain the information without great expense to any party, or inconvenience to the energy user, by introducing legislation requiring all companies to submit energy consumption figures for the year. This could perhaps be included as a section of the company report, or some compulsory document such as a tax return. In such a way, detailed energy statistics could be gathered with the minimum inconvenience.

Energy awareness is increasing in South Africa as energy prices increase and traditional practices are gradually being replaced by more efficient ones. However, government action can accelerate this process, and thereby ease its own task of national energy policy formulation.

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APPENDIX A

ENERGY CONSUMPTION PER CAPITA AND UNIT GROSS DOMESTIC PRODUCT PER CAPITA FOR TEN COUNTRIES IN 1979

	ENERGY PER CAPITA (TONS COAL EQUIVALENT PER CAPITA	GROSS DOMESTIC PRODUCT PER CAPITA (THOUSAND 1979 US $ PER CAPITA)
AUSTRALIA	5.9948	8.2993
BRAZIL	0.7879	1.2674
COSTA RICA	0.5650	1.8404
JAPAN	3.7915	7.8712
MEXICO	1.5805	1.9953
NEW ZEALAND	3.1716	6.6697
SOUTH AFRICA	3.0068	2.0229
SWEDEN	5.7662	13.3241
CANADA	10.6800	9.6200
USA	11.1200	9.5900

APPENDIX B 1

PERCENTAGE OF TOTAL ENERGY CONSUMPTION IN REFRACTORY MANUFACTURE SUPPLIED BY DIFFERENT FUEL TYPES 1975 TO 1984

PERCENTAGE OF TOTAL FUEL SUPPLY

YEAR	ELECTRICITY	SASOL	COAL	OIL	DIESEL	CTFO
1975	5.72	43.73	47.91	0.71	1.93	0.00
1976	6.40	49.50	41.80	0.62	1.68	0.00
1977	5.52	47.27	44.75	0.67	1.80	0.00
1978	6.31	45.05	46.10	0.69	1.86	0.00
1979	5.82	46.15	45.53	0.66	1.83	0.00
1980	6.61	47.90	42.64	1.14	1.71	0.00
1981	8.26	52.83	36.65	0.38	1.88	0.00
1982	10.30	53.71	34.24	1.37	0.00	0.39
1983	11.41	55.96	30.85	0.61	0.00	1.17
1984	13.76	52.93	32.36	0.64	0.00	0.31

APPENDIX C 1

TOTAL PRODUCTION OF CEMENT AND CLINKER 1964 TO 1984

MILLION TONS

YEAR	CLINKER	CEMENT	CEMENT CAPACITY
1964	3.028	3.179	
1965	3.491	3.688	
1966	3.714	3.924	
1967	3.772	3.982	
1968	3.971	4.194	
1969	4.552	4.787	
1970	5.145	5.421	
1971	5.598	5.903	
1972	5.690	5.999	
1973	6.029	6.362	
1974	6.791	7.160	7.478
1975	6.806	7.176	7.809
1976	6.683	7.046	7.988
1977	6.234	6.573	8.564
1978	6.471	6.823	8.846
1979	6.085	6.416	8.844
1980	7.242	7.636	8.681
1981	7.700	8.119	8.869
1982	7.597	8.010	9.445
1983	7.466	7.872	9.198
1984	7.766	8.188	9.515

APPENDIX C 2

ENERGY CONSUMPTION IN THE CEMENT INDUSTRY

MILLION GIGAJOULES

YEAR	COAL	ELECTRICITY	OTHER FUELS	TOTAL
1964	21.600	1.157		22.757
1965	23.949	1.254		25.203
1966	24.786	1.297		26.083
1967	25.164	1.362		26.526
1968	25.866	1.434		27.300
1969	26.352	1.635		27.987
1970	30.348	1.976		32.324
1971	33.021	2.102		35.123
1972	34.371	2.235		36.606
1973	35.370	2.614		37.984
1974	36.179	3.015		39.194
1975	35.563	3.246	0.013	38.822
1976	33.920	3.328	0.013	37.261
1977	28.964	3.123	0.013	32.101
1978	33.059	3.438	0.022	36.519
1979	29.421	3.124	0.017	32.563
1980	35.017	5.875	0.021	40.913
1981	38.924	6.203	0.020	45.147
1982	38.018	6.420	0.020	44.458
1983	34.448	6.032	0.026	40.506
1984	38.961	6.479	0.041	45.481

APPENDIX C 3

SPECIFIC ENERGY CONSUMPTION IN CEMENT MANUFACTURE

MJ PER TON CEMENT

YEAR	INDUSTRY AVERAGE	REPORTED BEST
1964	7130	
1965	6860	
1966	6670	
1967	6670	
1968	6510	
1969	5790	
1970	5900	
1971	5900	
1972	6040	
1973	5870	
1974	5800	
1975	5727	3838
1976	5254	3734
1977	4971	3676
1978	5187	3856
1979	5006	3607
1980	4933	3733
1981	5227	3800
1982	4964	3773
1983	4856	3799
1984	4936	3704

APPENDIX C 4

IMPROVEMENT IN SPECIFIC ENERGY CONSUMPTION WITH ADVANCES IN TECHNOLOGY

YEAR	AVERAGE SPECIFIC ENERGY CONSUMPTION MJ PER TON	KILN TYPE	PREHEATER TYPE
1949	8655	WET	NONE
1949	8655	WET	NONE
1949	6573	WET	NONE
1949	6564	WET	NONE
1954	8655	WET	NONE
1957	6530	WET	NONE
1959	4779	DRY LONG	NONE
1966	5623	DRY LONG	NONE
1968	4518	DRY LONG	1 STAGE SUSPENSION
1968	4176	DRY SHORT	4 STAGE SUSPENSION
1970	6514	WET	NONE
1972	4742	DRY SHORT	2 STAGE SUSPENSION
1972	4138	DRY SHORT	4 STAGE SUSPENSION
1974	3996	DRY SHORT	4 STAGE SUSPENSION
1977	3876	DRY SHORT	4 STAGE SUSPENSION
1980	3958	DRY SHORT	4 STAGE SUSPENSION
1981	3927	DRY SHORT	4 STAGE SUSPENSION
1983	3704	DRY SHORT	4 STAGE SUSPENSION
1984	3700	DRY SHORT	4 STAGE SUSPENSION
1985	N/A		PRECALCINER ADDED

APPENDIX C 5

PERCENTAGE OF PRODUCTION CAPACITY BY KILN TYPE

YEAR	WET	DRY	SEMI-DRY
	%	%	%
1964	66.3	18.3	15.4
1965	66.3	18.4	15.3
1966	63.0	22.7	14.3
1967	53.4	34.4	12.2
1968	45.4	46.8	7.8
1969	44.8	47.5	7.7
1970	45.7	47.0	7.3
1971	41.9	51.4	6.7
1972	33.8	61.0	5.2
1973	32.0	62.7	5.3
1974	28.1	67.7	4.2
1975	26.7	69.1	4.2
1976	27.4	68.5	4.1
1977	22.0	74.1	3.9
1978	20.8	75.5	3.7
1979	19.7	76.6	3.7
1980	18.8	77.4	3.8
1981	16.2	80.1	3.7
1982	16.0	84.0	0.0
1983	13.0	87.0	0.0
1984	12.6	87.4	0.0

APPENDIX D 1

PERCENTAGE OF TOTAL ENERGY INPUT TO GLASSMAKING
BY ENERGY SOURCE TYPE

YEAR	ELECTRICITY %	COAL %	SASOL %	HFO %	LFO %	LPG %
1970	13.0	50.6	2.8	27.0	1.9	4.4
1971						
1972						
1973	14.8	34.9	4.9	39.5	0.9	4.6
1974	15.9	35.1	13.7	29.7	0.8	4.5
1975	16.6	32.8	24.2	21.3	0.7	4.1
1976						
1977						
1978						
1979						
1980	16.4	39.4	18.8	23.1	0.3	2.0
1981	18.4	34.9	19.3	25.4	0.3	1.7
1982	17.0	35.9	19.6	25.1	0.4	1.9
1983	15.9	35.7	26.6	19.7	0.3	1.9
1984	16.0	34.2	26.3	21.3	0.2	2.0

APPENDIX D 2

TRENDS IN SPECIFIC ENERGY CONSUMPTION IN GLASS MAKING

YEAR	AVERAGE MJ PER TON OF GLASS MELTED	AVERAGE MJ PER TON OF GLASS SOLD	TREND IN MJ PER TON OF GLASS MELTED (FITTED CURVE)	TREND IN MJ PER TON OF GLASS SOLD (FITTED CURVE)
1970	15100	19100	14300	18550
1972			13910	17910
1974	13200	17200	13530	17270
1976			13140	16620
1978			12750	15970
1980	12060	14710	12360	15320
1982	11730	14220	11970	14670
1984	12100	14850	11570	14020
1986			11180	13370
1988			10790	12710
1990			10390	12050
1992			10000	11400

APPENDIX E 1

PRODUCTION OF IRON AND STEEL IN SOUTH AFRICA

TONS

YEAR	LIQUID AND PIG IRON	STEEL
1944	463600	
1949	695300	
1954	1171000	1376800
1959	1703100	1838100
1964	2656400	3001800
1965	3271200	3129600
1966	3421900	3198100
1967	3420200	3602200
1968	3775100	3931900
1969	3930700	4416900
1970	3929500	4508700
1971	4009700	4735800
1972	4409100	5160000
1973	4329500	5440600
1974	4620500	5625800
1975	5179900	6367300
1976	5795200	6926100
1977	5831200	7179500
1978	5927500	7735000
1979	7030637	8667529
1980	7209757	8870640
1981	7368545	8788427
1982	6803623	8075484
1983	4970073	7034873
1984	5454892	7677365
INDUSTRY ESTIMATE TO 1992		
1986		9111043
1988		9620245

1990	9162577
1992	9306748

APPENDIX E 2

TOTAL FERROALLOY PRODUCTION

TONS

YEAR	TOTAL	MANGANESE	SILICON	CHROME	EXPORTS
1944	8200				
1949	13200				
1954	25900				
1959	104400				
1964	230300				
1965	331700				
1966	336000				
1967	358300				
1968	349500				
1969	424000				
1970	429200				
1971	447800				
1972	490200				
1973	555800				
1974	636200	364780	79670	183670	525120
1975	747600	378790	106830	262780	496310
1976	823100	406330	119330	321080	732830
1977	934200	396550	105940	430420	702450
1978	1111100	471370	112530	548740	990860
1979	1523000	660420	134110	728430	1374820
1980	1443600	550090	138660	754870	1083820
1981	1391900				
1982	1094400	519250	47460	527700	
1983	1302600	385850	209990	706810	
1984	1475600	403950	162690	908910	

APPENDIX E 3

ENERGY CONSUMPTION IN STEELMAKING

ESTIMATE ONE IS ISCOR'S TOTAL ENERGY EXTRAPOLATED IN PROPORTION TO ITS MARKET SHARE.

ESTIMATE TWO IS THE COUNTRY'S TOTAL PRODUCTION MULTIPLIED BY THE AVERAGE SPECIFIC ENERGY CONSUMPTION FOR THE SURVEY PERIOD.

MILLION GIGAJOULES

YEAR	ESTIMATE ONE	ESTIMATE TWO
1964		77.5
1965		80.8
1966		82.5
1967		93.0
1968		101.5
1969		114.0
1970		116.4
1971		122.2
1972		133.2
1973		140.4
1974		145.2
1975		164.3
1976		178.8
1977	185.4	185.3
1978	199.5	199.6
1979	215.6	223.7
1980	242.0	229.0
1981	215.1	226.8
1982	196.5	208.4
1983	211.2	198.3
1984	227.0	216.4

APPENDIX E 4

ESTIMATE OF ENERGY CONSUMPTION IN FERROALLOY INDUSTRY

MILLION GIGAJOULES

YEAR	TOTAL ENERGY	ELECTRICAL ENERGY
1964	4.04	1.89
1965	8.91	4.17
1966	12.8	6.01
1967	13.0	6.08
1968	13.9	6.49
1969	13.5	6.33
1970	16.4	7.68
1971	16.6	7.77
1972	17.3	8.11
1973	19.0	8.88
1974	21.5	10.1
1975	24.6	11.5
1976	28.9	13.6
1977	31.9	14.9
1978	36.2	16.9
1979	43.0	20.1
1980	58.9	27.6
1981	55.7	26.2
1982	44.8	21.0
1983	42.4	19.8
1984	50.4	23.6

APPENDIX E 5

ENERGY BY TYPE IN STEEL MAKING

PERCENTAGE OF TOTAL ENERGY CONSUMPTION

	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
COKING COAL	80.0	82.1	83.2	85.4	85.5	87.1	84.5	85.0	84.7	85.6
OTHER COAL	10.6	9.9	8.5	5.3	5.4	5.3	5.7	4.7	5.2	4.4
LPG	0.08	0.09	0.09	0.12	0.13	0.12	0.11	0.11	0.11	0.09
SASOL GAS	2.2	1.6	2.0	1.3	1.3	1.1	1.1	1.5	1.5	1.4
HFO	1.4	0.3	0.1	0.6	0.3	0.1	0.5	0.0	0.0	0.0
TAR	1.0	1.2	1.2	1.3	0.8	1.0	1.5	1.5	1.4	1.0
ELECTRICITY	5.7	6.0	6.0	5.1	5.4	5.4	5.3	6.2	6.0	6.4

APPENDIX F 1

PRODUCTION OF PAPER IN SOUTH AFRICA

TONS PER ANNUM

YEAR	TOTAL OUTPUT OF INDUSTRY	TOTAL CAPACITY OF INDUSTRY
1966	445362	
1967	512433	
1968	545490	
1969	566681	
1970	595744	
1971	596800	
1972	750878	
1973	872913	
1974	915615	
1975	828155	943000
1976	903366	1015000
1977	991141	1058000
1978	1026674	1100000
1979	1121952	1125000
1980	1200561	1210000
1981	1288063	1298000
1982	1301047	1401000
1983	1261009	1520000
1984	1387503	1615000

APPENDIX F 2

ESTIMATED TOTAL ENERGY CONSUMPTION IN PAPERMAKING

YEAR	MILLION GIGAJOULES
1975	24.4
1976	27.2
1977	29.3
1978	31.9
1979	31.6
1980	35.8
1981	36.6
1982	40.5
1983	37.8
1984	45.6

APPENDIX F 3

PERCENTAGE OF TOTAL ENERGY PRODUCED IN-HOUSE

YEAR	%
1975	22.1
1976	20.9
1977	16.5
1978	16.8
1979	18.6
1980	31.5
1981	26.2
1982	25.6
1983	25.6
1984	26.5

APPENDIX F 4

PERCENTAGE OF TOTAL FUEL INPUT DUE TO WASTE OR RECOVERED FUELS

YEAR	%
1975	20.73
1976	19.64
1977	16.93
1978	16.42
1979	18.84
1980	34.73
1981	29.98
1982	29.78
1983	28.57
1984	30.23

APPENDIX F 5

AVERAGE SPECIFIC ENERGY CONSUMPTION IN PAPERMAKING

YEAR	TOTAL ENERGY PER TON OF PAPER MJ/TON	PURCHASED ENERGY PER TON OF PAPER MJ/TON
1976	30097	23807
1978	31059	25841
1980	29793	20408
1982	31139	23167
1984	32856	24149

ENERGY QUESTIONNAIRE FOR THE BRICK INDUSTRY

YOUR COOPERATION IN COMPLETING THIS QUESTIONNAIRE AS FULLY AS POSSIBLE WOULD BE GREATLY APPRECIATED. YOU ARE ASSURED THAT THE INFORMATION SUPPLIED WILL BE TREATED AS CONFIDENTIAL AND WILL NOT BE PUBLISHED IN ANY MANNER THAT WOULD MAKE THE IDENTIFICATION OF INDIVIDUAL COMPANIES POSSIBLE.

IF IT IS NOT POSSIBLE TO COMPLETE ANY SECTION OF THIS QUESTIONNAIRE PLEASE STATE WHY, AND SUPPLY ANY AVAILABLE DATA THAT APPLIES TO THE SECTION CONCERNED.

ANY ADDITIONAL INFORMATION THAT YOU CONSIDER OF VALUE, AND ANY COMMENTS THAT YOU WISH TO MAKE, WILL BE APPRECIATED.

PLEASE NOTE THAT THIS QUESTIONNAIRE RELATES TO A SINGLE PLANT ONLY AND NOT THE COMPANY AS A WHOLE.

SECTION 1

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a. NAME AND ADDRESS OF COMPANY:

....

....

b. NAME AND ADDRESS OF PLANT TO WHICH THIS QUESTIONNAIRE RELATES:

....

....

c. GENERAL DESCRIPTION OF PRODUCTS:

....

d. NAME, ADDRESS AND APPOINTMENT OF OFFICIAL OF YOUR COMPANY RESPONSIBLE FOR ENERGY POLICY AND USE, IF ANY:

....

....

e. NAME, ADDRESS AND APPOINTMENT OF RESPONDENT, IF DIFFERENT TO d:

....

....

SECTION 2

GENERAL ENERGY USAGE

PLEASE GIVE THE PERCENTAGES OF TOTAL ENERGY, ON AN ENERGY CONTENT BASIS USED FOR EACH OF THE FOLLOWING. IF THE DATA IS NOT READILY AVAILABLE, ESTIMATES WILL SUFFICE.

DIRECT HEATING: ....

INDIRECT HEATING (eg Steam Raising): ....

POWER: ....

LIGHTING: ....

TRANSPORT WITHIN THE PLANT: ....

OFFICES AND OTHERS: ....

PLEASE GIVE THE NUMBER OF EMPLOYEES ON THE PLANT:

	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
NUMBER OF EMPLOYEES										

PLEASE GIVE THE PERCENTAGE OF TOTAL PRODUCTION COSTS ACCOUNTED FOR BY ENERGY COSTS. IF DATA IS UNAVAILABLE, ESTIMATES WILL SUFFICE.

	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
% OF PROD-UCTION										

SECTION 3

BRICKFIELD PRODUCTION FIGURES

	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
a. BRICKS (MILLIONS PER ANNUM)										
COMMON, STOCK OR BACKING	......	......	......	......	......	......	......	......	......	......
FACING	......	......	......	......	......	......	......	......	......	......
ENGINEERING	......	......	......	......	......	......	......	......	......	......
OTHER	......	......	......	......	......	......	......	......	......	......
b. CLAY TILES (MILLIONS PER ANNUM)	......	......	......	......	......	......	......	......	......	......
c. PIPEWARE (TONNES PER ANNUM	......	......	......	......	......	......	......	......	......	......

STATE APPROXIMATELY HOW MANY BRICKS/TILES TO ONE TONNE

	COMMON	FACING	ENGINEERING	CLAY TILES
UNITS PER TONNE:	....	....	....	....

G3

SECTION 4

KILN PARTICULARS

IN THIS SECTION, A FULL ACCOUNT OF THE KILNS AT THE PLANT IS REQUIRED IF POSSIBLE. THIS INCLUDES:

1. THE NUMBER OF KILNS OF EACH TYPE.
2. IF ANY KILNS WERE COMMISSIONED OR DECOMMISSIONED DURING THE SURVEY PERIOD, AND WHEN.
3. A FULL DESCRIPTION OF THE KILNS OF EACH TYPE, eg FIVE ROUND DOWN-DRAUGHT KILNS INTERCONNECTED, OR SIDE FIRED CAR-TUNNEL KILN.
4. THE FUEL USED FOR FIRING.
5. WHAT THE EXHAUST GASES ARE USED FOR, eg EXHAUSTED TO ATMOSPHERE, OR USED FOR DRYING.

IF HEAT BALANCES ARE CARRIED OUT, PLEASE GIVE THE TOTAL HEAT LOSSES FOR THE KILN TYPE.

IF THERE IS INSUFFICIENT SPACE ON THIS PAGE, PLEASE ATTACH FURTHER PAGES.

	KILN TYPE 1	KILN TYPE 2	KILN TYPE 3	KILN TYPE 4
KILN TYPE: (FULL DESCRIPTION)	....	....	....	....
TOTAL INSTALLED PRODUCTION CAPACITY (PLEASE STATE UNITS USED)	....	....	....	....
ESTIMATED TOTAL KILN HEAT LOSSES: (kJ/sq m)	....	....	....	....

SECTION 5

DRYER PARTICULARS

IN THIS SECTION A FULL ACCOUNT OF THE DRYERS AT THE PLANT IS REQUIRED IF POSSIBLE. THIS INCLUDES:

1. THE NUMBER OF DRYERS OF EACH TYPE.
2. IF ANY DRYERS WERE COMMISSIONED OR DECOMMISSIONED DURING THE SURVEY PERIOD, AND WHEN.
3. A FULL DESCRIPTION OF THE DRYERS OF EACH TYPE, eg TUNNEL DRYER WITH BAFFLE PLATES FOR RECIRCULATION.
4. THE FUEL USED FOR DRYING eg EXHAUST FROM KILN
5. IF FURTHER USE IS MADE OF THE DRYER EXHAUST GASES.

IF HEAT BALANCES ARE CARRIED OUT, PLEASE GIVE THE TOTAL HEAT LOSSES FOR THE DRYER TYPE.

IF THERE IS INSUFFICIENT SPACE ON THIS PAGE, PLEASE ATTACH FURTHER PAGES.

	DRYER TYPE 1	DRYER TYPE 2	DRYER TYPE 3	DRYER TYPE 4
DRYER TYPE: (FULL DESCRIPTION)				
TOTAL INSTALLED PRODUCTION CAPACITY (PLEASE STATE UNITS USED)				
ESTIMATED TOTAL DRYER HEAT LOSSES: (kJ/sq m)				

SECTION 6

BRICKMAKING

PLEASE GIVE THE PERCENTAGE OF THE TOTAL PRODUCTION OF BRICKS MADE BY EACH BRICK-FORMING PROCESS, eg SEMI-DRY EXTRUSION etc.

PERCENTAGE OF TOTAL OUTPUT

	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
PROCESS 1	......	......	......	......	......	......	......	......	......	......
PROCESS 2	......	......	......	......	......	......	......	......	......	......
PROCESS 3	......	......	......	......	......	......	......	......	......	......
PROCESS 4	......	......	......	......	......	......	......	......	......	......
PROCESS 5	......	......	......	......	......	......	......	......	......	......

SECTION 7

BRICK DRYING

PLEASE STATE THE PERCENTAGE OF TOTAL BRICK PRODUCTION DRIED BY EACH TYPE OF DRYER FOR EACH YEAR, IF POSSIBLE.

PERCENTAGE OF PRODUCTION

DRYING METHOD	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
1....................	......	......	......	......	......	......	......	......	......	......
2....................	......	......	......	......	......	......	......	......	......	......
3....................	......	......	......	......	......	......	......	......	......	......
4....................	......	......	......	......	......	......	......	......	......	......

SECTION 8

ENERGY CONSUMPTION

PLEASE GIVE THE APPROXIMATE PERCENTAGES OF ENERGY COSTS ACCOUNTED FOR BY THE FOLLOWING. IF DATA IS NOT AVAILABLE, ESTIMATES WILL SUFFICE.

	PERCENTAGE CONSUMPTION
CLAY WINNING	....
CLAY TRANSPORTATION	....
CLAY PREPARATION	....
BRICKMAKING	....
BRICK TRANSPORTATION	....

ELECTRICITY CONSUMPTION (kWH)

IN THIS SECTION PLEASE INDICATE IF ANY MAJOR ELECTRICAL EQUIPMENT WAS COMMISSIONED OR DECOMMISSIONED, AND SHOW IN WHICH YEAR THIS OCCURRED.

	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
TOTAL AMOUNT USED	......	......	......	......	......	......	......	......	......	......
AMOUNT GENERATED ON SITE	......	......	......	......	......	......	......	......	......	......
AMOUNT PURCHASED	......	......	......	......	......	......	......	......	......	......
AMOUNT SOLD (IF ANY)	......	......	......	......	......	......	......	......	......	......

IF NO ELECTRICITY IS GENERATED ON SITE, COMPLETE ONLY THE TOP LINE.

CONSUMPTION OF OTHER FUELS

NOTE THAT COAL USED FOR THE PRODUCTION OF PRODUCER GAS IS CONSIDERED SEPARATELY TO COAL USED FOR ANY OTHER PURPOSE.

WHERE THE QUESTIONNAIRE STATES FUEL TYPE 'n', PLEASE STATE THE TYPES OF FUELS, OTHER THAN THOSE ALREADY MENTIONED, THAT HAVE BEEN USED OVER THE SURVEY PERIOD.

PLEASE STATE THE UNITS USED FOR EACH FUEL TYPE.

AMOUNT USED	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
COAL FOR PRODUCER GAS (UNIT)..........	......	......	......	......	......	......	......	......	......	......
COAL FOR OTHER USES (UNIT)..........	......	......	......	......	......	......	......	......	......	......
PRODUCER GAS (UNIT)..........	......	......	......	......	......	......	......	......	......	......
OIL (UNIT)..........	......	......	......	......	......	......	......	......	......	......
SASOL GAS (UNIT)..........	......	......	......	......	......	......	......	......	......	......
FUEL TYPE ONE .... (UNIT)..........	......	......	......	......	......	......	......	......	......	......
FUEL TYPE TWO .... (UNIT)..........	......	......	......	......	......	......	......	......	......	......

PLEASE STATE THE AVERAGE CALORIFIC VALUES OF THE FUELS USED. WHERE OTHER APPEARS, PLEASE LIST NOTE THOSE FUELS NOT SPECIFIED. IF ANY OF THE VALUES HAVE CHANGED SIGNIFICANTLY OVER THE SURVEY PERIOD FOR ANY REASON, FOR EXAMPLE, CHANGING THE GRADE OF COAL, PLEASE STATE THE CHANGE/S, WHEN THEY OCCURRED AND FOR WHAT REASON.

CALORIFIC VALUES OF:
(PLEASE STATE UNIT USED)

COAL ....

FUEL OIL ....

LP GAS ....

SASOL GAS ....

PRODUCER GAS ....

OTHER ....

OTHER ....

OTHER ....

ENERGY QUESTIONNAIRE FOR THE CEMENT INDUSTRY

YOUR COOPERATION IN COMPLETING THIS QUESTIONNAIRE AS FULLY AS POSSIBLE WOULD BE GREATLY APPRECIATED. YOU ARE ASSURED THAT THE INFORMATION SUPPLIED WILL BE TREATED AS CONFIDENTIAL AND WILL NOT BE PUBLISHED IN ANY MANNER THAT WOULD MAKE THE IDENTIFICATION OF INDIVIDUAL COMPANIES POSSIBLE.

EXPLANATORY NOTES

1. PLEASE NOTE THAT THIS QUESTIONNAIRE RELATES TO A SINGLE PLANT ONLY AND NOT THE COMPANY AS A WHOLE.

2. THE QUESTIONNAIRE APPLIES TO THE CEMENT MANUFACTURING PROCESS FROM THE RAW MATERIAL STOCKPILES TO THE DESPATCH OF THE FINAL PRODUCT. SECTION 5 IS INTENDED TO TAKE INTO ACCOUNT THE ENERGY INPUT TO THE RAW FEED AT THE QUARRY.

SECTION 1

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....

....

b. NAME AND ADDRESS OF PLANT TO WHICH THIS QUESTIONNAIRE RELATES:

....

....

c. GENERAL DESCRIPTION OF PRODUCTS:

....

d. NAME, ADDRESS AND APPOINTMENT OF OFFICIAL OF YOUR COMPANY RESPONSIBLE FOR ENERGY POLICY AND USE, IF ANY:

....

....

e. NAME, ADDRESS AND APPOINTMENT OF RESPONDENT, IF DIFFERENT TO d:

....

....

SECTION 2

GENERAL ENERGY USAGE

PLEASE GIVE THE APPROXIMATE PERCENTAGES OF TOTAL ENERGY, ON AN ENERGY CONTENT BASIS USED FOR EACH OF THE FOLLOWING. IF DATA IS NOT READILY AVAILABLE, ESTIMATES WILL SUFFICE.

DIRECT HEATING: ....

INDIRECT HEATING (e.g. STEAM RAISING): ....

POWER: ....

LIGHTING: ....

TRANSPORT WITHIN THE PLANT: ....

OFFICE AND OTHERS: ....

PLEASE GIVE THE NUMBER OF EMPLOYEES ON THE PLANT:

	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
NUMBER OF EMPLOYEES:										

PLEASE GIVE THE PERCENTAGE OF TOTAL PRODUCTION COSTS ACCOUNTED FOR BY ENERGY COSTS. IF DATA IS UNAVAILABLE, ESTIMATES WILL SUFFICE.

	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
% OF PRODUCTION: COSTS										

SECTION 3

INSTALLED MACHINERY (kW)

TOTAL KILN DRIVE MOTOR POWER: ....

TOTAL FAN POWER: ....

TOTAL RAW FEED MILL POWER: ....

TOTAL CEMENT MILL POWER: ....

TOTAL COAL MILL POWER: ....

POWER OF ANY OTHER SIGNIFICANT MACHINERY (e.g.AIR COMPRESSORS):

MACHINERY TYPE:.................. ....

SECTION 4

KILN PARTICULARS

	KILN 1	KILN 2	KILN 3	KILN 4	KILN 5	KILN 6
KILN TYPE: (PLEASE DESCRIBE WITH RELEVANT DIMENSIONS)						
RATED CAPACITY (TONS PER ANNUM):						
YEAR COMMISSIONED:						
TYPE OF PROCESS:						
PREHEATER TYPE (PLEASE DESCRIBE):						
NO. OF PREHEATER STAGES:						
ESTIMATED KILN HEAT LOSSES (kJ/m^2)						
AVERAGE REFRACTORY LINING REPLACEMENT PERIOD:						
COAL MILL TYPE:						
RAW FEED MILL TYPE:						
CEMENT MILL TYPE:						
COOLER TYPE:						
ESTIMATED COOLER HEAT LOSSES (kJ/m^2)						

SECTION 5

RAW MATERIALS

TOTAL ANNUAL RAW MATERIAL CONSUMPTION (TONS PER ANNUM)	LIMESTONE (ALL GRADES)	GYPSUM	OTHERS (e.g. IRON ORE, SLAG, SHALE ETC) PLEASE SPECIFY		
			....	....	....
1975					
1980					
1984					
ESTIMATED AVERAGE ENERGY INPUT AT QUARRY (MJ/TON) 1975					
1980					
1984					

SECTION 7

PRODUCTION FIGURES

CLINKER PRODUCTION (TONS PER ANNUM)	KILN 1	KILN 2	KILN 3	KILN 4	KILN 5	KILN 6
1975						
1976						
1977						
1978						
1979						
1980						
1981						
1982						
1983						
1984						

SECTION 7 (CONTINUED)

CEMENT PRODUCTION (TONS PER ANNUM)	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
ORDINARY PORTLAND										
LOW ALKALINE										
RAPID HARDENING										
SULPHATE RESISTING										
P.B.F.C.										

WHAT AVERAGE PERCENTAGES OF THE FOLLOWING ARE ADDED TO CLINKER FOR YOUR CEMENTS?

	GYPSUM	LIMESTONE	FLY-ASH	B.F.SLAG	OTHER (PLEASE SPECIFY ....
OPC					
P.B.F.C.					
LOW ALKALINE					
SULPHATE RESISTING					
RAPID HARDENING					

ENERGY QUESTIONNAIRE FOR THE GLASS INDUSTRY

YOUR COOPERATION IN COMPLETING THIS QUESTIONNAIRE AS FULLY AS POSSIBLE WOULD BE GREATLY APPRECIATED. YOU ARE ASSURED THAT THE INFORMATION SUPPLIED WILL BE TREATED AS CONFIDENTIAL AND WILL NOT BE PUBLISHED IN ANY MANNER THAT WOULD MAKE THE IDENTIFICATION OF INDIVIDUAL COMPANIES POSSIBLE.

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b. NAME AND ADDRESS OF PLANT TO WHICH THIS QUESTIONNAIRE RELATES:

....

....

c. GENERAL DESCRIPTION OF PRODUCTS:

....

d. NAME, ADDRESS AND APPOINTMENT OF OFFICIAL OF YOUR COMPANY RESPONSIBLE FOR ENERGY POLICY AND USE, IF ANY:

....

....

e. NAME, ADDRESS AND APPOINTMENT OF RESPONDENT, IF DIFFERENT TO d:

....

....

SECTION 2

GENERAL ENERGY USAGE

PLEASE GIVE THE PERCENTAGES OF TOTAL ENERGY, ON AN ENERGY CONTENT BASIS USED FOR EACH OF THE FOLLOWING. IF THE DATA IS NOT READILY AVAILABLE, ESTIMATES WILL SUFFICE.

DIRECT HEATING: ....

INDIRECT HEATING (eg Steam Raising): ....

POWER: ....

LIGHTING: ....

TRANSPORT WITHIN THE PLANT: ....

OFFICES AND OTHERS: ....

PLEASE GIVE THE NUMBER OF EMPLOYEES ON THE PLANT:

	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
NUMBER OF EMPLOYEES										

PLEASE GIVE THE PERCENTAGE OF TOTAL PRODUCTION COSTS ACCOUNTED FOR BY ENERGY COSTS. IF DATA IS UNAVAILABLE, ESTIMATES WILL SUFFICE.

	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
% OF PROD-UCTION										

SECTION 3

INSTALLED MACHINERY

PLEASE STATE THE INSTALLED POWER OF THE PLANT NORMALLY IN OPERATION (IGNORE STANDBY PLANT).

	INSTALLED POWER (kW)		
	1975	1980	1984
AIR COMPRESSORS	....	....	....
COOLING FANS	....	....	....
MATERIAL FEED EQUIPMENT (PUMPS, CONVEYORS, ETC)	....	....	....
LEHRS	....	....	....
DECORATION EQUIPMENT	....	....	....
OTHER (PLEASE DESCRIBE)	....	....	....
OTHER (PLEASE DESCRIBE)	....	....	....

SECTION 4

GLASS PRODUCTION (Tonnes per annum)

IN THIS SECTION PLEASE GIVE THE TOTAL ANNUAL FURNACE OUTPUT AS THE AMOUNT OF GLASS MANUFACTURED.

	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
AMOUNT OF GLASS MANUFACTURED	......	......	......	......	......	......	......	......	......	......
AMOUNT OF GLASS SOLD	......	......	......	......	......	......	......	......	......	......
CULLET USED	......	......	......	......	......	......	......	......	......	......

G20

SECTION 5

ENERGY CONSUMPTION

IN THIS SECTION PLEASE INDICATE IF ANY MAJOR EQUIPMENT WAS COMMISSIONED OR DECOMMISSIONED, WHETHER ELECTRICAL OR OTHERWISE, AND SHOW IN WHICH YEAR THIS OCCURRED.

ELECTRICITY CONSUMPTION (kWH)	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
TOTAL AMOUNT USED	......	......	......	......	......	......	......	......	......	......
AMOUNT GENERATED ON SITE	......	......	......	......	......	......	......	......	......	......
AMOUNT PURCHASED	......	......	......	......	......	......	......	......	......	......
AMOUNT SOLD (IF ANY)	......	......	......	......	......	......	......	......	......	......

IF YOU DO NOT GENERATE ELECTRICITY ON SITE, COMPLETE ONLY THE TOP LINE

CONSUMPTION OF OTHER FUELS

NOTE THAT COAL USED FOR THE PRODUCTION OF PRODUCER GAS IS CONSIDERED SEPARATELY TO COAL USED FOR ANY OTHER PURPOSE.

WHERE THE QUESTIONNAIRE STATES FUEL TYPE 'n', PLEASE STATE THE TYPES OF FUELS, OTHER THAN THOSE ALREADY MENTIONED, THAT HAVE BEEN USED OVER THE SURVEY PERIOD.

PLEASE STATE THE UNITS USED FOR EACH FUEL TYPE.

AMOUNT USED	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
COAL FOR PRODUCER GAS (UNIT)..........	......	......	......	......	......	......	......	......	......	......
COAL FOR OTHER USES (UNIT)..........	......	......	......	......	......	......	......	......	......	......
PRODUCER GAS (UNIT)..........	......	......	......	......	......	......	......	......	......	......
SASOL GAS (UNIT)..........	......	......	......	......	......	......	......	......	......	......
LP GAS (UNIT)..........	......	......	......	......	......	......	......	......	......	......
FUEL OIL (UNIT)..........	......	......	......	......	......	......	......	......	......	......
FUEL TYPE ONE .... (UNIT)..........	......	......	......	......	......	......	......	......	......	......
FUEL TYPE TWO .... (UNIT)..........	......	......	......	......	......	......	......	......	......	......

PLEASE STATE THE AVERAGE CALORIFIC VALUES OF THE FUELS USED. WHERE OTHER APPEARS, PLEASE LIST NOTE THOSE FUELS NOT SPECIFIED. IF ANY OF THE VALUES HAVE CHANGED SIGNIFICANTLY OVER THE SURVEY PERIOD FOR ANY REASON, FOR EXAMPLE, CHANGING THE GRADE OF COAL, PLEASE STATE THE CHANGE/S, WHEN THEY OCCURRED AND FOR WHAT REASON.

CALORIFIC VALUES OF:
(PLEASE STATE UNIT USED)

COAL ....

FUEL OIL ....

LP GAS ....

SASOL GAS ....

PRODUCER GAS ....

OTHER ....

OTHER ....

OTHER ....

SECTION 6

PLEASE SUPPLY THE FOLLOWING INFORMATION ABOUT EACH OF YOUR FURNACES.

	FURNACE 1	FURNACE 2	FURNACE 3
FURNACE TYPE	....	....	....
CAPACITY (TONNES PER DAY)	....	....	....
FUEL TYPE(S) USED	....	....	....
SPECIFIC ENERGY USAGE (GJ/TONNE)	....	....	....
HEAT LOSSES (kJ/sq m)	....	....	....

IS ANY ENERGY USED AT YOUR WORKINGHEAD/S?
IF SO, WHAT IS THE SPECIFIC ENERGY USAGE (GJ/TON)? ....

PLEASE SUPPLY THE FOLLOWING INFORMATION ABOUT EACH OF YOUR LEHRS.

	LEHR 1	LEHR 2	LEHR 3
LEHR TYPE	....	....	....
CAPACITY (TONNES PER DAY)	....	....	....
FUEL TYPE(S) USED	....	....	....
SPECIFIC ENERGY USAGE (GJ/TONNE)	....	....	....
HEAT LOSSES (kJ/sq m)	....	....	....

ENERGY QUESTIONNAIRE

FOR THE IRON, STEEL AND FERROUS ALLOY INDUSTRY

YOUR COOPERATION IN COMPLETING THIS QUESTIONNAIRE AS FULLY AS POSSIBLE WOULD BE GREATLY APPRECIATED. YOU ARE ASSURED THAT THE INFORMATION SUPPLIED WILL BE TREATED AS CONFIDENTIAL AND WILL NOT BE PUBLISHED IN ANY MANNER THAT WOULD MAKE THE IDENTIFICATION OF INDIVIDUAL COMPANIES POSSIBLE.

IF IT IS NOT POSSIBLE TO COMPLETE ANY SECTION OF THIS QUESTIONNAIRE PLEASE STATE WHY, AND SUPPLY ANY AVAILABLE DATA THAT APPLIES TO THE SECTION CONCERNED.

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b. NAME AND ADDRESS OF PLANT TO WHICH THIS QUESTIONNAIRE RELATES:

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c. GENERAL DESCRIPTION OF PRODUCTS:

....

d. NAME, ADDRESS AND APPOINTMENT OF OFFICIAL OF YOUR COMPANY RESPONSIBLE FOR ENERGY POLICY AND USE, IF ANY:

....

....

e. NAME, ADDRESS AND APPOINTMENT OF RESPONDENT, IF DIFFERENT TO d:

....

....

SECTION 2

GENERAL ENERGY USAGE

PLEASE GIVE THE PERCENTAGES OF TOTAL ENERGY, ON AN ENERGY CONTENT BASIS, USED FOR EACH OF THE FOLLOWING. IF THE DATA IS NOT READILY AVAILABLE, ESTIMATES WILL SUFFICE.

DIRECT HEATING: ....

INDIRECT HEATING (eg Steam Raising): ....

POWER ....

LIGHTING: ....

TRANSPORT WITHIN THE PLANT: ....

PUMPING: ....

OFFICES AND OTHERS: ....

PLEASE GIVE THE NUMBER OF EMPLOYEES ON THE PLANT:

	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
NUMBER OF EMPLOYEES										

PLEASE GIVE THE PERCENTAGE OF TOTAL PRODUCTION COSTS ACCOUNTED FOR BY ENERGY COSTS. IF DATA IS UNAVAILABLE, ESTIMATES WILL SUFFICE.

	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
% OF PROD-UCTION										

SECTION 3

PLEASE SUPPLY THIS INFORMATION AS FAR AS POSSIBLE, IF ANY OF THE DATA IS UNAVAILABLE, PLEASE STATE WHY.

PRODUCTION FIGURES (kTONNES PER ANNUM)

	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
HOT METAL	......	......	......	......	......	......	......	......	......	......
RAW STEEL	......	......	......	......	......	......	......	......	......	......
FINISHED STEEL	......	......	......	......	......	......	......	......	......	......
OTHER	......	......	......	......	......	......	......	......	......	......
OTHER	......	......	......	......	......	......	......	......	......	......
OTHER	......	......	......	......	......	......	......	......	......	......

SALES FIGURES

	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
PIG IRON	......	......	......	......	......	......	......	......	......	......
SEMIS	......	......	......	......	......	......	......	......	......	......
FINISHED STEEL	......	......	......	......	......	......	......	......	......	......
OTHER	......	......	......	......	......	......	......	......	......	......
OTHER	......	......	......	......	......	......	......	......	......	......
OTHER	......	......	......	......	......	......	......	......	......	......

ORE REDUCTION

PLEASE STATE THE AMOUNT OF ORE REDUCED BY EACH METHOD IN THOUSANDS OF TONNES.

	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
BLAST FURNACE	......	......	......	......	......	......	......	......	......	......
DIRECT REDUCTION	......	......	......	......	......	......	......	......	......	......
ARC FURNACE	......	......	......	......	......	......	......	......	......	......

SECTION 4

ENERGY CONSUMPTION

IN THIS SECTION PLEASE INDICATE IF ANY MAJOR EQUIPMENT WAS COMMISSIONED OR DECOMMISSIONED, WHETHER ELECTRICAL OR OTHERWISE, AND SHOW IN WHICH YEAR THIS OCCURRED.

ELECTRICITY CONSUMPTION

(KWH)	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
TOTAL AMOUNT USED	......	......	......	......	......	......	......	......	......	......
AMOUNT GENERATED ON SITE	......	......	......	......	......	......	......	......	......	......
AMOUNT PURCHASED	......	......	......	......	......	......	......	......	......	......
AMOUNT SOLD (IF ANY)	......	......	......	......	......	......	......	......	......	......

PLEASE STATE THE PERCENTAGE OF TOTAL ELECTRICITY CONSUMPTION ACCOUNTED FOR BY EACH OF THE FOLLOWING AREAS

	% OF TOTAL CONSUMPTION
FURNACES	....
OTHER	....
OTHER	....
OTHER	....
OTHER	....

CONSUMPTION OF OTHER FUELS

NOTE THAT COAL USED FOR THE PRODUCTION OF COKE IS CONSIDERED SEPARATELY TO COAL USED FOR ANY OTHER PURPOSE.

IF COAL OR COKE IS USED ONLY FOR REDUCTION, THE QUANTITIES USED SHOULD BE STATED, AS THIS IS CONSUMPTION OF ENERGY.

WHERE THE QUESTIONNAIRE STATES FUEL TYPE 'n', PLEASE STATE THE TYPES OF FUELS, OTHER THAN THOSE ALREADY MENTIONED, THAT HAVE BEEN USED OVER THE SURVEY PERIOD.

PLEASE STATE THE UNITS USED FOR EACH FUEL TYPE.

AMOUNT USED	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
COAL FOR COKE (UNIT)..........	......	......	......	......	......	......	......	......	......	......
COAL FOR PRODUCER GAS (UNIT)..........	......	......	......	......	......	......	......	......	......	......
COAL FOR ELECTRICITY (UNIT)..........	......	......	......	......	......	......	......	......	......	......
COAL FOR OTHER USES (UNIT)..........	......	......	......	......	......	......	......	......	......	......
COKE AND BREEZE (UNIT)..........	......	......	......	......	......	......	......	......	......	......
COKE OVEN GAS (UNIT)..........	......	......	......	......	......	......	......	......	......	......
PRODUCER GAS (UNIT)..........	......	......	......	......	......	......	......	......	......	......
BLAST FURNACE GAS (UNIT)..........	......	......	......	......	......	......	......	......	......	...... cont...

CONSUMPTION OF OTHER FUELS

cont.... AMOUNT USED	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
FUEL OIL (UNIT)..........	....	....	....	....	....	....	....	....	....	....
L.P.G. (UNIT)..........	....	....	....	....	....	....	....	....	....	....
SASOL GAS (UNIT)..........	....	....	....	....	....	....	....	....	....	....
FUEL TYPE ONE .... (UNIT)..........	....	....	....	....	....	....	....	....	....	....
FUEL TYPE TWO .... (UNIT)..........	....	....	....	....	....	....	....	....	....	....

PLEASE STATE THE AVERAGE CALORIFIC VALUES OF THE FUELS USED. WHERE OTHER APPEARS, PLEASE LIST NOTE THOSE FUELS NOT SPECIFIED. IF ANY OF THE VALUES HAVE CHANGED SIGNIFICANTLY OVER THE SURVEY PERIOD FOR ANY REASON, FOR EXAMPLE, CHANGING THE GRADE OF COAL, PLEASE STATE THE CHANGE/S, WHEN THEY OCCURED AND FOR WHAT REASON.

CALORIFIC VALUES OF:
(PLEASE STATE UNIT USED)

COKING COAL ....

BLEND COAL ....

COKE AND BREEZE ....

COKE OVEN GAS ....

PRODUCER GAS ....

BLAST FURNACE GAS..

FUEL OIL ....

LP GAS ....

SASOL GAS ....

OTHER ....

OTHER ....

ENERGY QUESTIONNAIRE FOR THE PULP AND PAPER INDUSTRY

YOUR COOPERATION IN COMPLETING THIS QUESTIONNAIRE AS FULLY AS POSSIBLE WOULD BE GREATLY APPRECIATED. YOU ARE ASSURED THAT THE INFORMATION SUPPLIED WILL BE TREATED AS CONFIDENTIAL AND WILL NOT BE PUBLISHED IN ANY MANNER THAT WOULD MAKE THE IDENTIFICATION OF INDIVIDUAL COMPANIES POSSIBLE.

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b. NAME AND ADDRESS OF PLANT TO WHICH THIS QUESTIONNAIRE RELATES:

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c. GENERAL DESCRIPTION OF PRODUCTS:

....

d. NAME, ADDRESS AND APPOINTMENT OF OFFICIAL OF YOUR COMPANY RESPONSIBLE FOR ENERGY POLICY AND USE, IF ANY:

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e. NAME, ADDRESS AND APPOINTMENT OF RESPONDENT, IF DIFFERENT TO d:

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SECTION 2

GENERAL ENERGY USAGE

PLEASE GIVE THE PERCENTAGES OF TOTAL ENERGY, ON AN ENERGY CONTENT BASIS, USED FOR EACH OF THE FOLLOWING. IF THE DATA IS NOT READILY AVAILABLE, ESTIMATES WILL SUFFICE.

DIRECT HEATING: ....

INDIRECT HEATING (eg Steam Raising): ....

POWER ....

LIGHTING: ....

TRANSPORT WITHIN THE PLANT: ....

PUMPING: ....

OFFICES AND OTHERS: ....

PLEASE GIVE THE NUMBER OF EMPLOYEES ON THE PLANT:

	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
NUMBER OF EMPLOYEES										

PLEASE GIVE THE PERCENTAGE OF TOTAL PRODUCTION COSTS ACCOUNTED FOR BY ENERGY COSTS. IF DATA IS UNAVAILABLE, ESTIMATES WILL SUFFICE.

	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
% OF PROD-UCTION										

SECTION 4

ENERGY CONSUMPTION

IN THIS SECTION PLEASE INDICATE IF ANY MAJOR EQUIPMENT WAS COMMISSIONED OR DECOMMISSIONED, WHETHER ELECTRICAL OR OTHERWISE, AND SHOW IN WHICH YEAR THIS OCCURRED.

ELECTRICITY CONSUMPTION

(KWH)	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
TOTAL AMOUNT USED	......	......	......	......	......	......	......	......	......	......
AMOUNT GENERATED ON SITE	......	......	......	......	......	......	......	......	......	......
AMOUNT PURCHASED	......	......	......	......	......	......	......	......	......	......
AMOUNT SOLD (IF ANY)	......	......	......	......	......	......	......	......	......	......

PLEASE STATE THE PERCENTAGE OF TOTAL ELECTRICITY CONSUMPTION ACCOUNTED FOR BY EACH OF THE FOLLOWING AREAS.

	% OF TOTAL CONSUMPTION		
	1975	1980	1984
CHEMICAL PULP MILLS	......	......	......
MECHANICAL PULP MILLS	......	......	......
PAPER MILLS	......	......	......

CONSUMPTION OF OTHER FUELS

(NOTE THAT FOR SPENT LIQUOR, BARK AND WOOD WASTE, THE UNITS ARE BONE DRY TONNES. PLEASE STATE THE UNITS USED FOR THE OTHER FUELS)

	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
COAL AMOUNT USED (UNIT)..........	......	......	......	......	......	......	......	......	......	......
FUEL OIL AMOUNT USED (UNIT)..........	......	......	......	......	......	......	......	......	......	......
LP GAS AMOUNT USED (UNIT)..........	......	......	......	......	......	......	......	......	......	......
SASOL GAS AMOUNT USED (UNIT)..........	......	......	......	......	......	......	......	......	......	......
SPENT LIQUOR AMOUNT USED (UNIT)..........	......	......	......	......	......	......	......	......	......	......
WOOD WASTE AMOUNT USED (UNIT)..........	......	......	......	......	......	......	......	......	......	......
BARK AMOUNT USED (UNIT)..........	......	......	......	......	......	......	......	......	......	......
OTHER FUEL AMOUNT USED (UNIT)..........	......	......	......	......	......	......	......	......	......	......

PLEASE STATE THE AVERAGE CALORIFIC VALUES OF THE FUELS USED. IF ANY OF THE VALUES HAVE CHANGED SIGNIFICANTLY OVER THE SURVEY PERIOD FOR ANY REASON, FOR EXAMPLE, CHANGING THE GRADE OF COAL, PLEASE STATE THE CHANGE/S, WHEN THEY OCCURRED AND FOR WHAT REASON.

CALORIFIC VALUES OF:
(PLEASE STATE UNIT USED)

COAL ....

FUEL OIL ....

LP GAS ....

SASOL GAS ....

SPENT LIQUOR ....

WOOD WASTE ....

BARK ....

OTHER ....

DO YOU SELL ANY ESCESS BARK, WOOD WASTE OF SPENT LIQUOR? YES NO

IF YES, WHAT AMOUNTS?

	AMOUNT SOLD IN BONE DRY TONNES		
	1975	1980	1984
BARK	....	....	....
WOOD WASTE	....	....	....
SPENT LIQUOR	....	....	....

The following three sections were common to all questionnaires.

SECTION A

ENERGY MANAGEMENT

PLEASE MARK YOUR ANSWER WITH A CROSS.

a. DOES YOUR COMPANY HAVE A FULLTIME/PART-TIME ENERGY MANAGER? FULLTIME___ PART-TIME___ NO___

b. ARE DISCUSSION HELD WITH EMPLOYEES ON ENERGY MANAGEMENT? YES____ NO____

c. ARE YOU CONDUCTING AN ENERGY AWARENESS DRIVE? (POSTERS ETC) YES____ NO____

d. DO YOU CONDUCT AN ENERGY AUDIT OF ANY KIND? YES____ NO____

IF YOU ANSWERED NO TO ANY OF THE ABOVE, DO YOU HAVE PLANS FOR ANY OF THEM?

YES: | a | b | c | d | NO:____

IF YOU PRACTISE ENERGY MANAGEMENT AT ANY OTHER LEVEL THAN STATED ABOVE, PLEASE GIVE DETAILS:

....

....

....

....

....

DO YOU HAVE EQUIPMENT WHICH ALLOWS CONTROL OF ELECTRICAL LOAD TO REDUCE MAXIMUM DEMAND? YES____ NO____

IF YOU ANSWERED NO TO THE ABOVE, DO YOU HAVE PLANS TO INSTALL SUCH EQUIPMENT? YES____ NO____

DOES YOUR PLANT HAVE AUTOMATIC POWER FACTOR CORRECTION EQUIPMENT? YES____ NO____

WHAT POWER FACTOR DOES YOU PLANT OPERATE AT? ....

SECTION B

ENERGY CONSERVATION

OVER THE PERIOD 1975 to 1984, HAVE ANY ENERGY CONSERVATION MEASURES BEEN INSTITUTED? YES____ NO____

IF YOU ANSWERED YES TO THE ABOVE, PLEASE GIVE DETAILS.

....

....

....

....

....

DOES ANY PART OF YOUR PLANT GENERATE ANY WASTE HEAT OR STEAM? YES____ NO____

IS USE MADE OF THIS WASTE HEAT OR STEAM ELSEWHERE IN YOUR PLANT? YES____ NO____

IF YOU ANSWERED YES TO THE ABOVE, PLESE GIVE DETAILS.

....

....

....

....

....

DO YOU EXPECT YOUR ENERGY INPUT PER UNIT OUTPUT OF PRODUCT TO CHANGE WITHIN THE NEXT FIVE YEARS FOR ANY REASON? (FOR EXAMPLE, CHANGE OF PRODUCT TYPE, INTRODUCTION OF NEW PROCESS, TECHNOLOGICAL DEVELOPMENTS, ETC)

YES____ NO____

IF YES, PLEASE GIVE DETAILS

....

....

....

....

....

SECTION C

FUEL CONVERSION

HAVE YOU CHANGED ANY OF YOUR FUEL FORMS WITHIN THE LAST TEN YEARS? YES____ NO____

ARE YOU AT PRESENT SERIOUSLY CONSIDERING A CHANGE FROM ANY PRESENT FUEL TO ANOTHER? YES____ NO____

IF YOU ANSWERED YES TO EITHER OF THE ABOVE QUESTIONS, PLEASE INDICATE THE FUELS CHANGED FROM AND TO, THE YEAR OF CHANGE AND THE PURPOSE FOR THE FUEL'S USE.

FROM .... TO .... USE ....

FROM .... TO .... USE ....

FROM .... TO .... USE ....

FOR WHAT REASONS HAVE THE CHANGES COME ABOUT/BEEN CONSIDERED?

CHANGE 1 ....

CHANGE 2 ....

CHANGE 3 ....

ENERGY QUESTIONNAIRE FOR THE PULP AND PAPER INDUSTRY

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OTHER ....

OTHER ....