

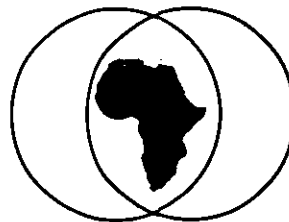
# **SOUTH AFRICA AND THE FUTURE OF WORLD ENERGY RESOURCES**

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**THE SOUTH AFRICAN INSTITUTE OF INTERNATIONAL AFFAIRS**



**DIE SUID-AFRIKAANSE INSTITUUT VAN INTERNASIONALE AANGELEENTHEDE**

SOUTH AFRICA AND THE FUTURE  
OF  
WORLD ENERGY RESOURCES

Proceedings of a Symposium  
held in Cape Town  
on 5 and 6 September 1974

Edited by  
John Barratt

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PREFACE

A Symposium on "South Africa in the Future of World Energy Resources" was held by the South African Institute of International Affairs at the BP Centre, in Cape Town, on 5 and 6 September, 1974, in association with the Cape Town and Stellenbosch Branches of the Institute. This was the first project in the Institute's conference programme to be held in the Cape, and it was an indication of the growth of the Institute's activities in that region.

The articles in this volume are based on the papers presented at the Cape Town Symposium and comments on some of the papers are also included.

The Institute is very grateful to all those who have contributed to this volume and to the many others who participated in the Symposium. It is also appropriate to acknowledge the generous support which the Institute receives from its Corporate Members, which made possible the holding of the Symposium and the publication of this volume, as well as other projects undertaken in the past and planned for the future.

At a special function preceding the Symposium the Institute was honoured by the presence of the Minister of Foreign Affairs, Dr. the Hon. Hilgard Muller, who is an Honorary President of the Institute. The text of Dr. Muller's important speech at that function and the introductory remarks of our National Chairman, Dr. Leif Egeland, are included in an Appendix to this volume.

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I N T R O D U C T I O N :

I. E N E R G Y I N R E L A T I O N T O G R O W T H.

N. STUTTERHEIM

There was a time when there were so few people on earth that they were insignificant in a world scene marked by environmental stability over thousands of years. The earth then was characterized by a flora and fauna in some dynamic equilibrium, in which man played no role of any consequence to the region where he lived. Man certainly had no influence then on the earth as a whole.

Over the millenia man multiplied in a physically hostile world of predators, cold, heat and the dangers of malnutrition and disease. Though ill-equipped physically, when compared with the animals around him, he maintained himself by virtue of an intellect that showed him the uses of the things at hand: clay, stones, sticks, water, fire, plants, animals. And being two-legged, his hands were free and well-fashioned to use the products of his environment. As population expanded, family groups, then tribal agglomerations and later national social aggregations of men were formed.

But the rate of growth of population was very slow. There is strong evidence that primitive man had an average life expectancy of only about 20 years. So communities expanded gradually, possibly with many periods of decline due to disease, climate or tribal strife, lack of communications and lack of transport away from drought or flood regions.

Current scientific thinking sets the period for the appearance of Homo Sapiens some half a million years ago.<sup>(1)</sup> From that starting point in the nebulous past, it grew to 3 500 million by 1970 and at the present rate of growth it will double in the next 33 years.

Analysis indicates that the global rate of growth has itself shown growth and that nothing that man can do short of widespread atomic war will prevent the next doubling. Moreover, a further doubling to 14 000 million seems probable, by about the year 2030, or say 65 years from now.

This is a projection, not a prediction. It lies within man's power to prevent such a catastrophic expansion, but it will require action on an international scale for which the motivation, the will and the power are not at all evident today. Unless extensive population control measures are introduced in this decade and rigorously pursued in future, the projection may well come true, unless famine or other catastrophies on a wide scale take a hand.

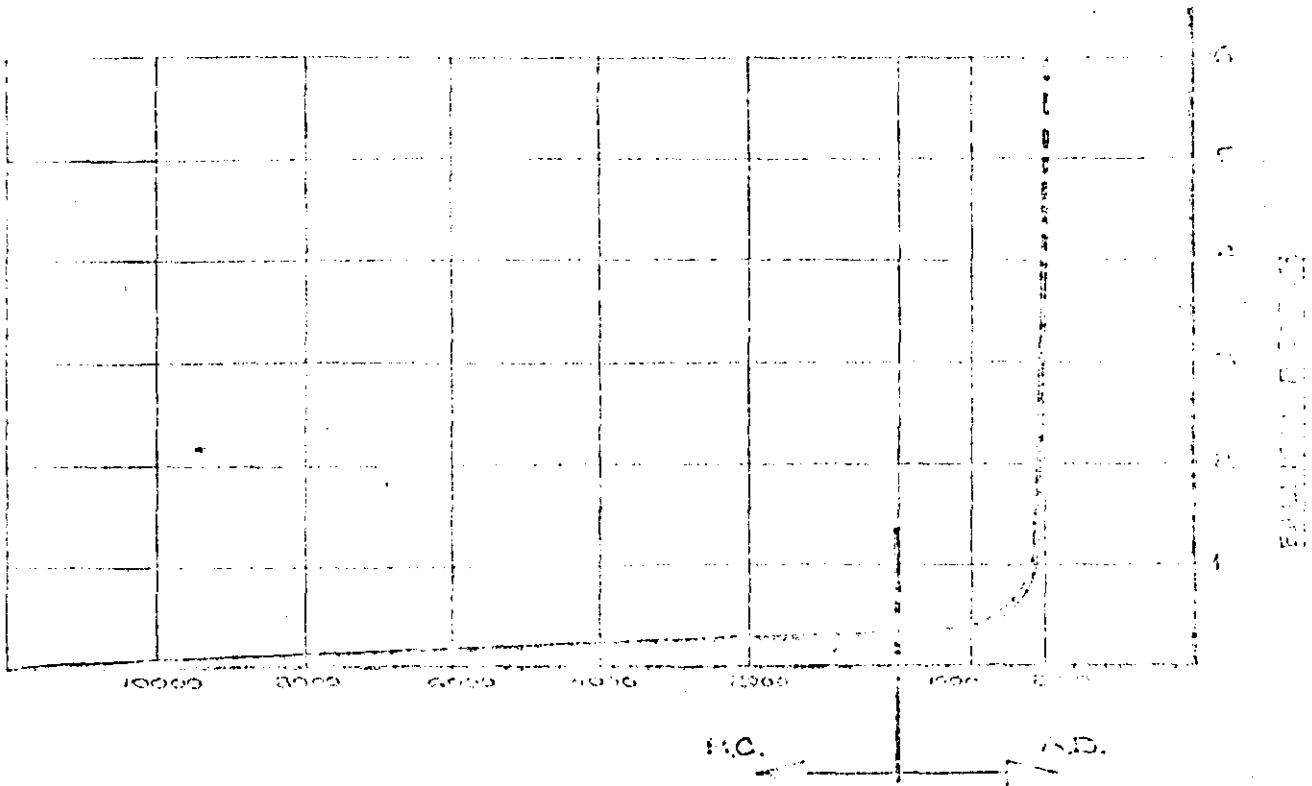


Figure 1: Increase of Global Population Since the Stone-Age<sup>(2)</sup>

It took more than sixteen centuries for the world's population to increase from 200-300 million to the half billion mark, i.e., to double in size. In the next two hundred years another half billion was added and yet another full billion in a mere hundred years with the population reaching 2 billion at about 1930. In less than a half century, 45 years to be more accurate, the population will have increased by another 2 billion. To add another 2 billion it will only take another twenty years, with the world population overshooting the six billion mark in the year 2000. The pace will quicken thereafter reaching the point sometime before the middle of the next century when it will take one year to add the same number of people as it took sixteen hundred years earlier in our era. (Mesarovic and Pestel).



The population growth that marks our era is the major causative factor in the growth of other parameters in the socio-economic scene. So food production, dwelling construction, clothing manufacture, have obvious relationships to population growth. But also metal production, world shipping, capital formation and energy requirements, the latter the main topic of our symposium, are closely related to population. We cannot look at questions relating to energy without considering population regionally as well as globally. In fact population and its exponential growth is the great central problem of today, creating, complicating and overshadowing most problems of our time. There is little evidence that governments generally have come to realize this. It has certainly not penetrated to the bulk of mankind.

Most people tend to think that man has lived long on earth and in the process has solved the multitude of problems and crises of the past. Will he not meet future crises that may appear on the horizon as he did those of history and overcome them with equal success? In this context it is perhaps worthwhile to pause a moment to review whether man's historical problems were not perhaps of a different kind to those that mark our time. The crises and problems that beset mankind were his fight against great natural odds to survive in a hostile world of disease, plague, famine, frequent aggression and bare subsistence. This relates to the period in Figure 1 before the sharp upturn in the population curve. These were in a sense evil forces and, without for a moment suggesting that each of these is not still evident locally or at certain times regionally today, the major problems of our time are the indirect outcome, strangely, of man's proud and altruistic achievements. He has conquered most of the diseases and plagues of history. He has increased the total food and clothing supply by radical improvements in irrigation, fertilizers, pest control, storage, transport and distribution. He has developed machines and industrial processes to reduce human labour and created an environment of amenity in his towns and cities to satisfy a wide range of cultural, educational and recreational aspirations. He has made harbours, roads, railway lines, power generating and distributing networks, water supply systems and health services on an extensive scale.

In the process he is over-populating the earth; making individuals ciphers in a dehumanized mechanical age; exploiting unrenovable natural resources

at a reckless pace; destroying the environment of nature with its inimitable beauty and charm, which has far more than sentimental value, for it has the important role of balancing the ecosystem and regenerating waste products.

No wonder more and more thinking people are questioning the long-term feasibility and the ultimate purpose of economic growth and technological expansion which, by its aim to give more people more material goods and comforts, tends to destroy many of those very amenities that make life worth living.

It should be clear that in a world that is finite in extent and therefore in resources, growth of an exponential character cannot continue indefinitely. This point has been made in the publication "The Limits to Growth"<sup>(3)</sup>, which describes an admittedly oversimplified global model in which a wide range of factors have been introduced to represent the complex dynamic nature of the real world with its wide range of interacting variables, its often unpredictable reactions to changes brought about by man and its evidences of increasingly severe socio-political, socio-economic and environmental stress.

These introductory remarks have been made because I find it difficult to talk about energy in relation to growth without first stressing the tremendous complexity of growth as a feature of our time, and of the role that energy plays in it.

It is also difficult to speak of energy and growth in a regional context without recognizing that most regions cannot be self-sufficient and isolated from the world as a whole. There is therefore an interaction in the field of energy between a region, such as South Africa, and adjacent countries as well as other countries beyond the ocean frontier. This makes the study of energy, as one of many resources having global importance, very necessary and worth while. Study and discussion assist those with responsibilities to formulate policies, on which meaningful energy strategies can be based, to have the benefit of objective study and debate. Our Symposium therefore has considerable topical importance particularly since delays in taking action on critical matters reduce both the number of options open to us in the future and the freedom of movement within any chosen option.

In the scientific sense energy has many forms and a multitude of sources. ~~In the context of the theme of our conference we are presumably concerned~~ mainly with the energy that man releases or converts from natural resources to suit his own purposes, primarily economic ones. For South Africa the primary sources of energy of major current economic importance at present are coal, oil and hydro-electric power, and the obvious choice for augmenting a national energy programme is nuclear energy. Each of these is the subject of one or more papers at this Symposium and I therefore propose to confine my remarks to some special aspects of the energy situation in relation to growth.

In general, energy consumption in a country with an industrial economy is directly proportional to Gross Domestic Product. The Department of Planning in their very useful report "Energy in South Africa - a Forecast", dated 1972 <sup>(4)</sup>, analyze the energy consumption by different sectors, e.g. household, industrial, mining, transport and also for the country as a whole. Fig. 2, taken from that report, gives the relationship for the period 1933 to 1968. They derived the equation

$$\begin{aligned} y &= 46,7 x - 3453,5 \text{ where} \\ x &= \text{Real GDP at 1958 prices in R millions} \\ y &= \text{Total energy in } 10^6 \text{ megajoules} \end{aligned}$$

South Africa's long term Economic Development Programme (EDP), when this report was written, envisaged a growth rate in Gross Domestic Product of about 5,5% in real terms between 1968 and 1980 and a lower value of 4,9% from 1980 to the year 2000. That implies a quadrupling of the GDP by the turn of the century. In view of the proportionality, the energy demand would therefore also quadruple by the turn of the century. Yet the report predicts only a trebling of the useful energy consumption for the period 1968 to 2000.

It is of course correct that as unit sizes, for instance, of power stations and of boiler plants increase, both features of an expanding economy, efficiencies increase. But such changes are taken into account automatically in Fig. 2 since this is based on actual GDP and corresponding energy consumption figures over a 35 year period, when considerable development in the size of energy-consuming units took place.

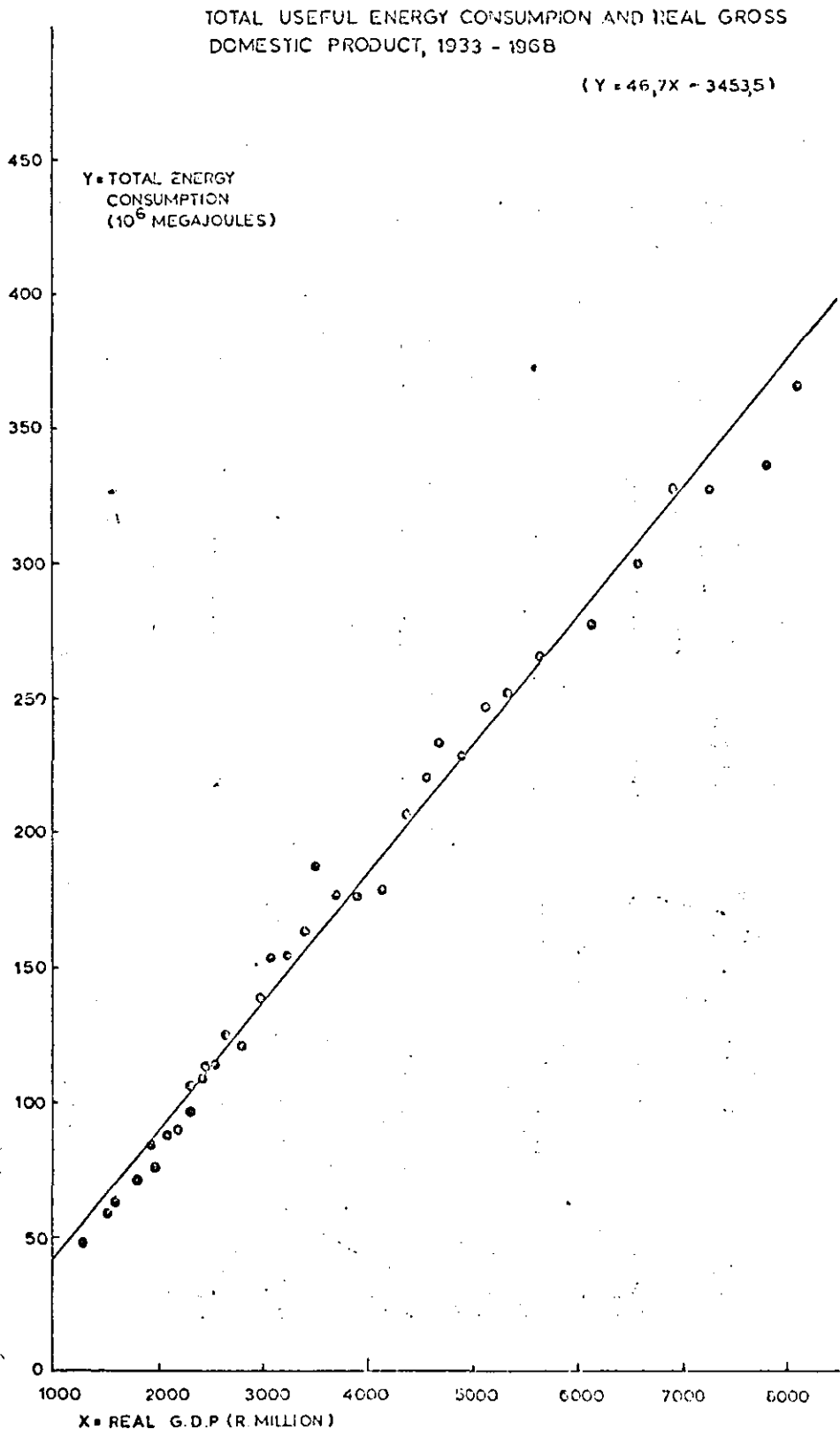


Figure 2.

However that may be, an average economic growth rate of  $\pm$  5% as envisaged in the EDP is an exponential rate and relates to both the population expansion, which according to J.L. Sadie (5) is 2,9% for South Africa, (i.e. a doubling within 25 years) and to the desire to increase the overall standards of living of this expanding population. Hence, inevitably, the demand for energy in its many forms will also grow exponentially.

Of the various forms of energy, oil is presently the most important primary source throughout the world. Warnings about possible future shortages of this commodity were sounded by various authorities from time to time, but it required a political decision by the Arab States acting jointly, to shock the world into realizing that these problems are real. For, although their action was aimed at forcing isolation on Israel, it has now also been made known widely that the main source of oil, viz. the Middle East and North Africa, is being exploited at an exponential rate that, if continued, would lead to depletion of known reserves within 35 years.

The writers of the Department of Planning Report quoted earlier have this to say in their conclusions :-

"On the supply side oil is problematical. Both Western Europe and the United States are finding themselves increasingly dependent on imports of Middle Eastern oil. In view of decreasing increments of new oil reserves in relation to local production in the United States (King Hubbert 1969), high oil consumption in the U.S.A. will have to be met increasingly by Alaskan production and imports from the Middle East. Politically the Middle East is an unstable area and, while oil is the major earner of revenue, decisions made by Middle Eastern governments are influenced by both political and economic motives. The increasing share of oil in the Republic's energy economy has obvious strategic implications."

As this was written at least a year before the oil crisis, it shows considerable perspicacity.

What was held by most people to be at worst a vague future possibility suddenly became reality. The frantic search for more oil going on throughout the world is evidence of how serious the energy position of most nations is.

No doubt much more oil will be found. But even if this is the case, the quantities and exploitation costs will preclude re-establishment of the pre-1973 situation of liberal use of low-cost petroleum products.

Depletion of a natural resource is an event of which we have little experience. At first sight one is inclined to think that depletion will tend to follow an exponential curve. This assumption for instance marks much of what is said on the subject of resources in "The Limits to Growth" by Meadows et al<sup>(3)</sup>. Their calculations of the time left to depletion of a range of important resources are based on this premise.

But, as pointed out for instance by King Hubbert<sup>(6)</sup> in his review of the petroleum resources of the U.S.A. and their exploitation, it is only the first part of the consumption curve that tends to be exponential. After using perhaps 10 - 15% of a particular resource in a region, the demand tends to exceed supply and the curve takes on more of a Gaussian character, levelling off at about the time when reserves have been half depleted and then decreasing Gaussianwise to near zero.

The important consequence of this pattern is not so much that reserves last very much longer than anticipated on the exponential curve, but rather that economics starts playing a role in the form of price increases. Unless alternatives at the same or lower prices are available, such price increases in vital commodities create inflationary pressures which can inhibit real growth.

The further the supply curve departs from the exponential demand curve, the higher the price tends to be, unless alternatives take over. These could be in the form of a substitute commodity or a new technology, which partly or wholly compensates for the reduced supplies. When the Arabs took their action, they well knew that there was no such substitute liquid fuel in sight. They realised very well that a threat to cut supplies would have a profound impact on all affected parties. Flushed with the success of this manoeuvre, they pushed up the price in rapid steps to some six times the pre-crisis price.

The fact that the price held and still holds at such a high level is proof of the absence at this stage of either a substitute or an alternative

technology. For how long this will be the case remains to be seen: there are some who are optimistic enough to believe that this is a passing phase. In an anonymous article, probably editorially inspired, in the January 5, 1974, issue of "The Economist", headed "The coming glut of energy", the writer points out that, whenever in the past dire shortages of any commodity or service developed, the reaction was invariably a period of considerable activity to counter the move, and that, because such activities are unco-ordinated, they tend to lead to pronounced over-production and consequent price reductions.

Such faith in what Dr. King of the Club of Rome called, during his recent visit to South Africa, "the technological fix", tends to ignore the complexity of the issue in the case of oil, the lag times in the development of new technologies, the seriousness of unwelcome side effects and the high costs in money, materials and highly-trained manpower that they entail.

Nevertheless, science and technology provide a great hope for solving the very complex interacting problems facing man in the field of alternatives to petroleum as a source of liquid fuel, as well as raw materials for the chemical industry. However, growth for growth's sake should be very firmly discouraged throughout the economic scene, a point made recently by Dr. P.E. Rousseau when addressing the South African Chemical Institute. The West has created a consumer society with insatiable demands for an ever-increasing range of commodities and services. This is particularly characteristic of the United States with its economy built up on planned obsolescence and conspicuous waste.

For South Africa the principal source of energy has been and still is coal. Various estimates have been made concerning the time to deplete known reserves, as well as concerning the possibility of finding new reserves. Our known reserves of nearly 18 billion tons, if used at the current exponential rate of about 4% increase per annum, are estimated to last till about the year 2025. As mentioned previously, such a commodity is in fact not exploited exponentially to depletion, and the curves of Fig. 3 which are derived from a recent article by Vogel<sup>(7)</sup> show the essential difference.

ANNUAL PRODUCTION  
IN MILLION TONNES

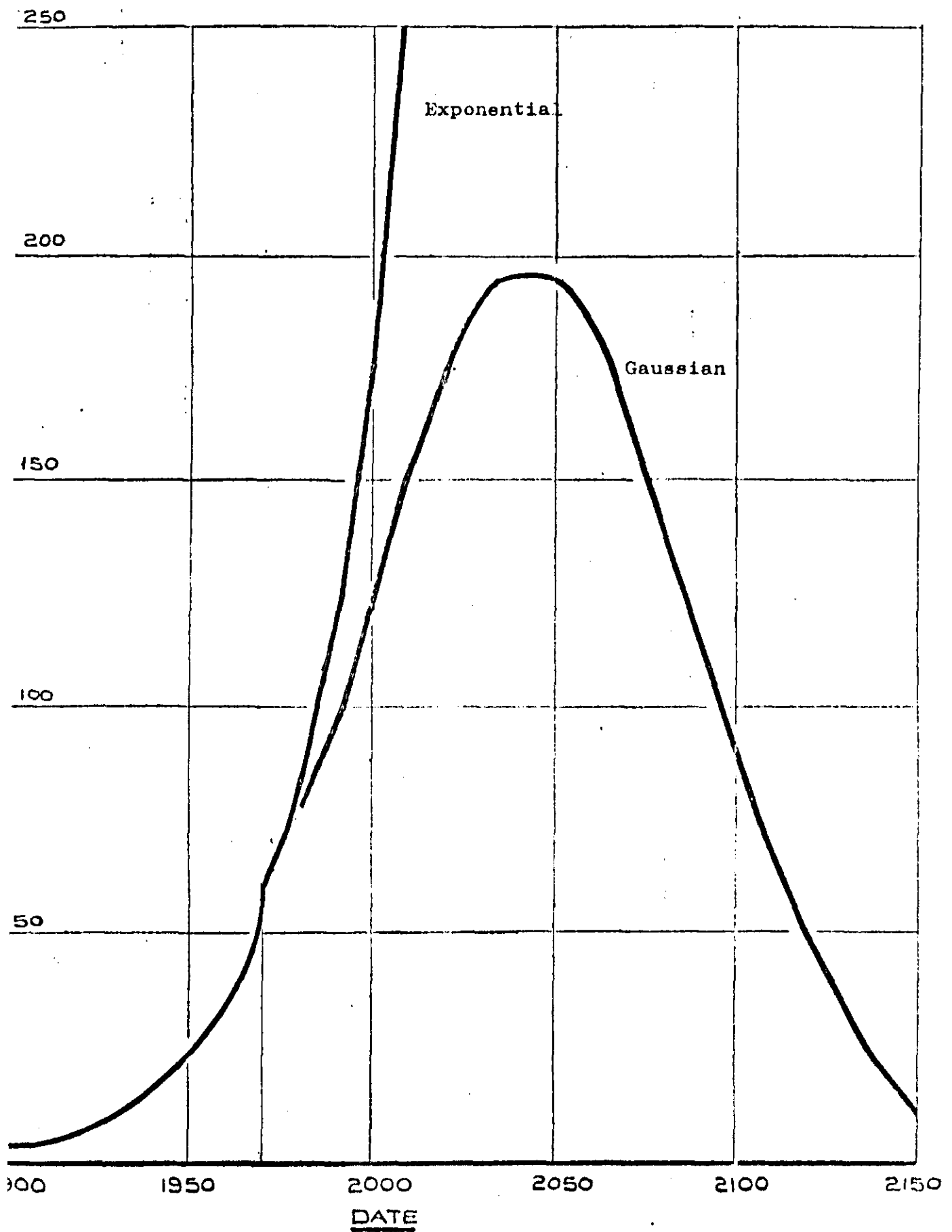


Figure 3.

The alternative rates of exploitation of South African Coal Reserves.



If growth is to be maintained as planned, the gap between the two curves must be bridged by some other form of energy (and chemical raw material). Hydro-electric energy and to a very much lesser extent oil, will play a role in this. The questionmark over Cabora Bassa makes the contribution in the short term from this source problematical, and it is clear that Escom is contemplating compensating for this through the newly-announced Drakensberg Pumping Scheme and accelerated construction of coal-based power stations in the Eastern Transvaal.

An increasing demand for coal will bring with it increased prices which improves the economic viability of nuclear power. Throughout the world there is the hope that nuclear power will be able to supply the shortfalls in other forms of energy until such time as fusion power, which, if practicable, would provide an almost limitless primary source of energy from seawater, takes over. Nuclear power, if based on current thermal reactor systems, will, however, not solve the problem for very long, because of the relatively limited known reserves of low cost uranium. Thermal reactors according to Roux<sup>(8)</sup> require nearly 100 times as much nuclear fuel as breeder reactors. The latter, now receiving much attention in various parts of the world, will obviously provide a much longer term solution, if it proves feasible.

However, as pointed out by Weinberg and by Mesarovic and Pestel<sup>(2)</sup> there are serious reservations about depending on breeder reactors to meet the energy needs of an exponentially-growing world economy. There is the gigantic task of constructing the necessary numbers of power stations estimated by Weinberg at 24 000 of 5 000 MW each over the next 100 years, and the tremendous financial manpower and materials implications of such a programme.

It therefore seems that warning lights are flashing for humanity on many energy fronts. Whether those who have the scientific knowledge and technical know-how required to meet these challenges, will be able to solve the problems in time to provide energy to the world's exploding populations is an open question.

Figure 4 gives a pictorial presentation of the Department of Planning's present estimates (1972<sup>(4)</sup>) of South Africa's energy requirements in the major categories.

INLAND FINAL CONSUMPTION OF ENERGY IN HOUSEHOLDS, INDUSTRY, MINING, TRANSPORT

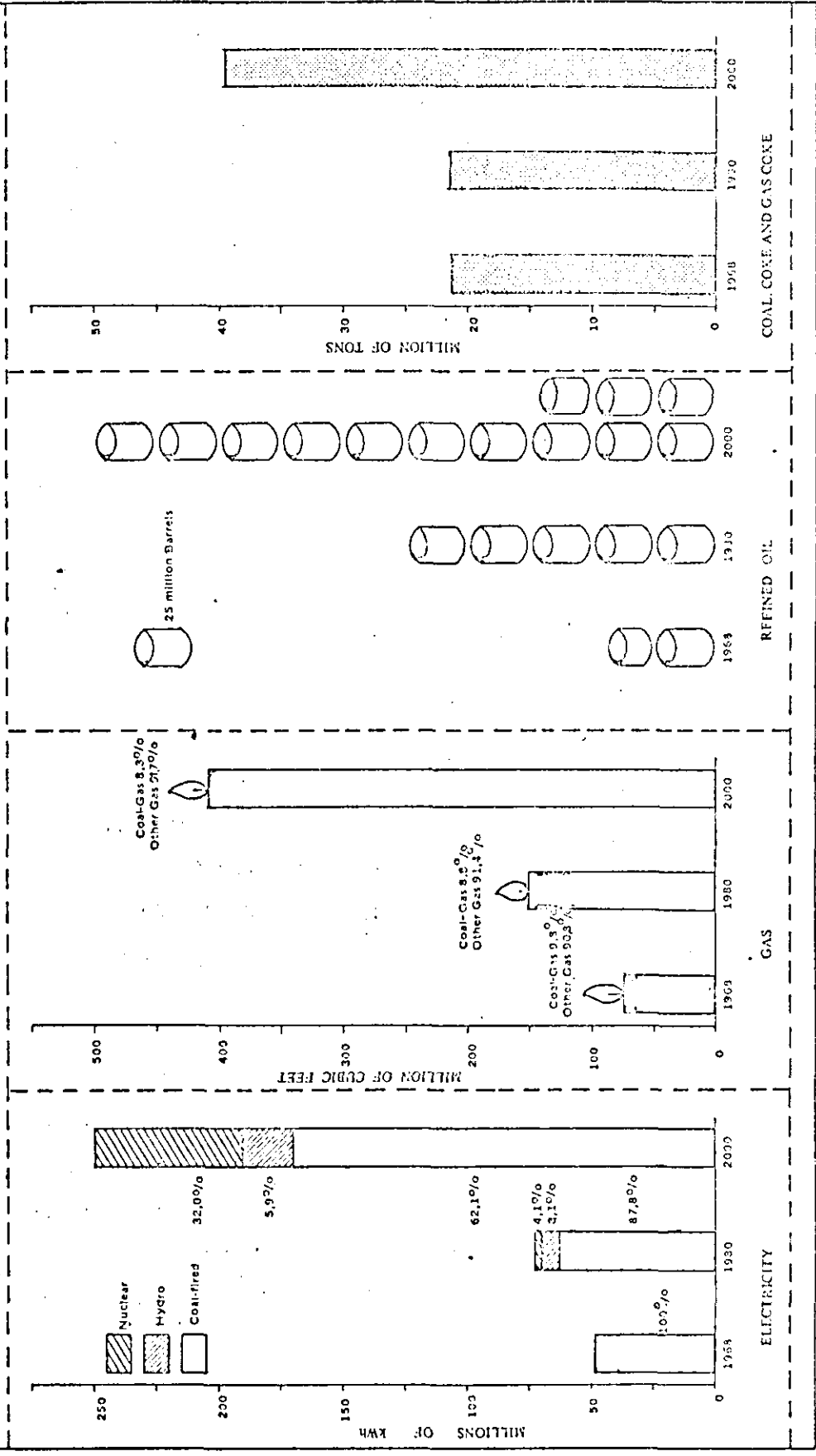


Figure 4.

There is considerable scope for also looking at other forms of energy, even if these will only provide part of man's requirements. With increasing fuel prices a feature of our time, such sources of energy as solar radiation, wind-power, waves, tides, geothermal energy, justify re-examination, particularly when taking into account that their use would be virtually or wholly pollution-free. However, they would probably have rather regional or even local applications.

May I take solar energy as an example of the potential that some of these unfortunately rather diffuse forms of energy hold? According to a recent energy review in Nature<sup>(9)</sup>, the entire world energy demand for human purposes other than agriculture is less than the solar energy falling on a region 100 km square in a favourable location. This statement, of course, ignores the efficiency of conversion and, even more important, the relatively high capital costs involved. Nevertheless, there are special situations where solar energy could play a very vital role in providing amenities which are now dependent on the use of non-renewable resources, such as coal or oil, or which would not be provided at all. A case in point is solar water heating for industrial, school, hospital and domestic uses which in countries like South Africa should have found much wider application in the past and holds considerable promise for the future. In this respect the interior of South Africa, with its high insolation and its relatively cloudless winter climate, is ideally suited. Keeping in mind the long term energy outlook, a plan with the aim that every new house be provided with a solar water heater as part of its basic design, deserves consideration. There is considerable scope for applying the information on solar water heating so readily available from the CSIR.

There is also great scope for reducing conspicuous waste of energy in our society. One need only look at the traffic congestion on our roads and the pattern of usage of our cars, to see that even a serious world-shaking oil crisis, not yet ten months old, is no longer moving people to a concern about their use of this precious commodity.

There can be little doubt that there is great scope for higher efficiencies, including more effective insulation, in a wide range of heating plants from the domestic level to those at the great power stations. Again looked at in the long term, purely cost considerations are, or should not be, the sole guide; conservation of non-renewable resources should play a bigger role in our planning and execution.

Growth as a function of population tends to follow population growth patterns. If these are exponential as at present, growth has to be exponential if living standards are to be maintained. The advantages to all of containing population growth should be obvious.

In the short term the energy demands of South Africa can be met increasingly from our own natural resources.

The interrelationships between economic growth, energy requirements, raw material resources and depletion, food supplies, pollution and population are very complex indeed and justify intensive and extensive research to ensure that sound national policies can be formulated.

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I N T R O D U C T I O N :

II. I N T E R N A T I O N A L P O L I T I C A L A S P E C T S  
O F T H E W O R L D E N E R G Y C R I S I S .

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## Introduction

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During the last two decades man has, for the first time in history, been brought to face and question an issue which is fundamental to his survival, viz. his age-old assumption about the unlimited extent of natural resources. The Arab oil embargo against the United States and the Netherlands, and the frantic responses to it, have dramatically demonstrated that the availability of oil can be limited by political fiat as well as by exhaustion. This episode has thus introduced a political dimension into what was previously considered to be a matter mainly for scientists and businessmen.

The source of all energy on earth is the sun, which provides not only the energy at present consumed in living things but has also created vast masses of hydrocarbons (formerly living matter) locked up in the crust of the earth. These hydrocarbons, in the form of coal, gas and oil, are deposited in a geological configuration over the whole of the earth's crust. This crust in turn has, from a political point of view, two major overlays, each with a different configuration of its own: first, the land masses which comprise about 30% of the surface of the earth, and which are divided into many parts, each of which is regulated or governed by a juridical and political entity called a nation-state, colony, or principality, and second, the areas covered by the sea, comprising the remaining 70% surface, over which (except for narrow strips of territorial sea along the coasts of states) no jurisdiction exists.

Jurisdiction over a territory or water area means full and unquestioned jurisdiction and power over the resources fortuitously present or absent in the earth's crust below its surface. Jurisdiction over the high seas (and deep ocean beds) in the form of an international regime, is now being discussed by the international community at the Conference on the Law of the Sea in Caracas.

Up till now, world needs and demand for energy resources have been regulated by the free market mechanism which operated internationally in all the processes related to energy, viz. capital, management, exploration, extraction, transport,

refining and marketing. Some recent developments, however, have thrown into sharp relief a number of asymmetries in this pattern. First the countries in which the energy resources are situated often lack the capital and managerial and technical ability to exploit them; other states with no energy resources have capital and know-how. Although on the surface this might appear to be a situation of complementarity, actually, bargaining takes place between unequal negotiators, viz. states and private companies (with their patron states in the background) and felt inequities were often redressed by unilateral action, usually by the producer states, with a resultant distortion of the market. A further complicating factor also developed: as the demand for oil-derived energy increased, investment in the oil industry increased, especially in the producer states, where the plant and installations came under the control of the governments of those states. In time, these governments became aware of and began using, first for economic, and later for political purposes, the leverages made available to them through their physical control of the oil installations and pipelines as well as through policies on extraction rates, export and refinery quotas, taxes, royalties and shareholding. There was thus (because of the critical nature of oil for industrial countries) a significant shift of operational decision-making to the oil producer (and exporting) countries and with the increasing participation of patron states, an irrevocable "politicization" of the oil industry, i.e. political considerations have become an important item in the decision-equation of the states participating in the total oil industry.

The development of serious international problems, mainly of a political nature, thus became inevitable. Some of these problems, stated in very general terms, revolve around the following major issues:

(a) Control of resources

Should the country in which the energy resources (especially oil) are situated have the only and final say about their extraction and use?



(b) Political agreement as a basis for oil industry

Should the countries with advanced technology, capital and skills permit the private companies which control these, to negotiate and operate oil industries without a political agreement between the states involved?

(c) Relation between consumer and producer nations

If the major oil producer (and exporting) countries have succeeded, through the coordination of their quotas, prices and extraction policies, to exert pressure (sometimes for political purposes) on the consumer countries, to what extent can and should the latter group "retaliate" and how? Or should collective agreements between producer and consumer countries make better sense?

(d) An International Energy Policy

Seen against the background of an ever-increasing demand from an oil-hungry world, is it not essential now to begin developing an international energy policy in which research on alternative sources and proper priorities in the use of oil and fossil fuels can be established?

(e) Energy Policy as part of foreign policy

To what extent should nation-states begin to include a national energy policy as an input to or a component of their respective foreign policies?

(f) The role of international institutions

What role can or should international institutions, those existing, or those still to be established, play in a world energy plan?

Major Actors in the world-wide Oil Industry

The major actors in the energy situation (which is of necessity of international dimensions) and thus in the interplay of political forces, may be briefly identified:

(a) The consumer countries (CC)

They are mostly industrialized and dependent to an increasing extent on oil as an energy source, even those which produce a portion of their oil needs from their own resources. Their need is for a regular, assured and reasonably priced inflow of oil which is used for direct combustion, electricity production and public and private transport. Because of the very limited extent to which substitutes for oil as a source of energy can be used, consumer countries are generally, in terms of bargaining power and leverages, at the mercy of the producer nations. This situation is all the more serious in view of the fact that the security situation of these countries in an age when modern military equipment is so dependent on oil-derived fuels, becomes affected by a reduced flow or high cost of storage of reserves.

The consumer states have often been criticized for excessive and wasteful consumption of oil (in relation to available resources and to the rest of the world) and for increasing the prices of their industrial products exported to the oil producing and developing countries.

(b) The producer and exporting nations (EC), on whose territory either on land or in their territorial sea, the major oil reserves are being exploited and oil extracted and sometimes refined. Their participation in this exploitation (which comprises exploration, extraction, transport, refining and marketing) may vary from minor to majority shareholdings, or complete state ownership. But what is important is their juridical and unquestioned right to take the major political decision on exploitation, i.e. permitting the surface activities of exploration, extraction, transporting and refining, the extent of these activities, the volume of extraction and export, and the prices and taxes payable on the removal of oil. Their political power lies in the leverage provided by their control of these activities.

This power of the producer countries is of course dependent on world demand and on market conditions which might produce conditions of

competition between them and thus neutralize this power among themselves. — However, if they can co-operate among themselves to agree — (on the basis of a cartel or monopoly) on volume of exports and prices, then their collective bargaining and political power, especially vis-à-vis the consumer nations, becomes formidable. This has in fact happened with the formation of the Organisation of Petroleum Exporting Countries (OPEC) and of a linked Organisation of Arab Petroleum Exporting Countries (OAPEC).

Although their basic purpose is to maintain a steady market and fair prices, the ability of these nations to regulate supply and, under conditions of artificially induced scarcity, prices, gives them such a key hold on the economic and security interests of major consumer countries, that the temptation to use this power for political purposes, becomes, at times, difficult to resist.

On the other hand, they are faced today with a single and a dwindling economic asset: after the existing resources in their territories have been extracted, they will have to fall back on other resources and on the industrial base and infrastructure they had managed to build up from royalty and other incomes during the life-time of their oil wells. This life-time of oil resources has been variously estimated at between 20 and 40 years, calculated on a world-wide basis.

The EC's have been criticized for unilaterally increasing the world prices of their product and of imposing quotas on exploration and extraction. The most serious criticism, however, has been of the recent reduction, by some Arab oil states, (also unilaterally) of the export to certain selected countries, of oil from their territories, for purely political reasons. Such action was taken by Saudi Arabia and Kuwait against the United States and the Netherlands because of their support of Israel during the recent war in the Middle East.

- (c) The oil companies, mostly multinational corporations (MNC) which are private organisations which explore, extract, refine and market oil products in terms of a global operation. Thus their activities of mobilising capital, obtaining and training managerial talent, exploring, extracting, transport, refining and marketing are spread over many countries throughout the world and they operate under many different kinds of laws, quotas, tax systems, directives and incentives.

Their main interest is in making a reasonable profit and operating under relatively stable local, national and international conditions, conditions determined largely by the political decisions of states, and especially those of consumer and producer nations. While their levels of profits may sometimes be high, they are the major risk takers in the international oil operation. Exploration through test drilling (and the variation in the existence and in the quantities and types of underground oil supplies) might be very risky and consume vast amounts in terms of money, skills, time and infrastructure investment, and, after discovering oil, the companies may still be faced with many political and economic uncertainties.

They have been criticised for making excessive profits, for not reducing retail prices and for making participation difficult in their enterprises, (especially shareholding and management) by national governments of producer countries and their citizens.

- (d) The international community of states which, though playing a passive role in the triangular struggle between CC's, EC's and MNC's are (mostly as consumers) in an ultimate sense dependent on the outcome of the oil struggle. In addition, the world community is deeply concerned about some basic principles on the basis of which the resources of the world on a global scale could be regulated. This concern is demonstrated by the present Caracas Conference on the Law of the Sea and its search for a regime over the open seas and the seabed. The principles so far generally articulated are: full access or availability of important natural

resources to all peoples of the earth and at a fair price; decisions by producers and consumers should be for economic and not political reasons; decisions should not be taken unilaterally but after consultation or agreement between producers and consumers. A number of proposals for the application of these principles to oil resources, in the interest of the whole international community, have already been made.

#### Some urgent Problems

Some of the major political-technical problems which will have to be settled through diplomacy or international collective action may be mentioned.

- (a) The formulation of a world resources policy. This should cover critical resources such as energy sources (oil, coal and hydro-systems), certain minerals and certain types of food and fibre. Such a policy would naturally cover exploration, extraction, conservation, prices, distribution, access, marketing and regulation.
- (b) The technological shift in the use of resources. This involves the development of alternative sources of energy, thus making scarce resources (especially oil) available for the chemical industry rather than to use them for burning. This would involve a form of world-wide planning and technological adaptation.
- (c) Closer agreement between the groups of CC's and EC's (after each group having reached a consensus among its own members) on availability, prices and a moratorium on the use of oil leverages for political (as distinct from economic) purposes.
- (d) Special concessionary arrangements for developing countries which lack the leverages of the CC's and the EC's.
- (e) Regulation of the MNC's in the oil industry, i.e. under some form of agreement on a world-wide basis, of their activities and pricing policies.

Conditions for negotiations

Some major conditions to ensure that negotiations begin at all and end in some agreements, are:

- (a) Symmetry: when the national interests of many countries converge, i.e. become identical, regarding the production and distribution of energy sources;
- (b) Complementarity: when the goods, services or materials which some countries produce, fill the needs of other countries and vice versa;
- (c) Great power responsibility: when the major powers, or the super-powers, with greater capabilities (economic, military, political) are considered to have a special responsibility to bring about minor as well as major agreements.

*I. F. A. DE VILLIERS*

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One could begin by agreeing that in the conduct of international relations the main purpose should be the preservation of peace and the achievement of human progress. I say "should be", because international conflicts have often been, and sometimes still are, caused by the pursuit of national self-interest at any price, including the use of violence. It is nevertheless true that the quest of national or imperial advantage can no longer be insulated from its global context. By this I mean, more specifically, that in an era of relatively low populations and unexploited resources there was often something to be gained by territorial expansion; but that the population explosion and the shocked realisation of our limited natural resources now compel us to accept that the national advantage may be better achieved by restraint.

In the course of this symposium you will no doubt be given many statistics to show that the pressure of rising populations and their increased demands on the available energy and other resources, cannot be sustained at present growth rates. I do not propose to repeat them here. The need, in fact, is not so much to prove that this dilemma exists, as to organise society in such a way that its worst consequences may be alleviated.

It is fashionable at present to speak of the energy crisis as though the threatened shortage of oil, or more immediately its increased cost, lie at the root of the new human dilemma. It is true, of course, that the actions of the OPEC countries did produce a dramatic confrontation between oil needs and oil resources. But the real issue is obviously much more than an oil or even an energy crisis.

While conventional energy resources are finite, there are other partly undeveloped or wholly untapped sources of energy that may well satisfy mankind's essential needs in the long-term future. I refer of course to nuclear fission (with the fast breeder already in prospect), nuclear fusion and the hydrogen economy, solar energy, geothermal energy, and so forth. The more acute problems lie in the shorter term, but these are mainly problems of cost, of substitution, and of planning the right spectrum of relative development between the means available. We are not yet in a state of energy penury, in the sense of irremediable calamity. If we escape calamity, we may yet have cause to give thanks to the sheiks of Araby for their timely warning.

Far closer to a calamity is the shortage of food. Grain reserves last year were down to about 8 percent of annual consumption - enough for only 29 days. Fishing catches are diminishing and certain kinds of edible fish are threatened with total extinction. Fertilizers are in short supply and are fast falling behind the needs of developing countries. Water is an even greater cause for anxiety : far from being able to irrigate barren areas and turn them into cultivated land, we are experiencing a rapid advance of the deserts.

The main connecting links between the threatened or relative shortage of energy and the absolute shortage of foodstuffs, are fertilizers and water. To produce fertilizers one needs hydrocarbons, but hydrocarbons in the form of coal and oil are the conventional fuels for energy. If fossil fuels are not burnt to produce energy, we must look elsewhere for the means to pump water. Unless other sources of energy can be provided at equal or lower cost, the price and scarcity of foodstuffs must inevitably increase.

The fundamental problem is, of course, population growth. This side of the equation is the most intractable of all. We are faced here by the contradiction that the highest rates of population growth are found not in the rich countries, but in the poor. Indeed, it is not over-population that is the cause of poverty, but poverty that is the cause of over-population.

We cannot remedy the inequality of the Third World unless we accelerate production. The transfer of resources from the developed to the undeveloped countries can only take place with the support of the industrialised countries. But here we have the further paradox that industrial growth benefits the rich more than the poor. It widens the gap between the privileged and the underprivileged, and the more complex the tools of industrialisation become, the wider grows the gap. It is notable that the major critics of international aid programmes are found today not amongst the donor nations, but amongst the recipient nations in Africa and Asia.

Now, the reproach is sometimes heard that the USA, Western Europe and Japan are consuming extravagant quantities of energy and that this disproportionate use of fuel resources will be, if it is not already, an injustice to the rest of the world. Calculated in terms of coal equivalent, each inhabitant of the United States is now consuming 13 tons a year, of Western Europe 5 tons, and of Japan 4½ tons. The average per capita for the entire world is just



over 2 tons, and in the Third World less than half a ton per person per annum.

Obviously the remedy does not lie in simply seeking to equalize consumption. Any substantial reduction in the energy consumption of the industrialised countries would cause grave social and economic dislocation, and so far from benefiting the undeveloped countries, the latter would be the most vulnerable to the world-wide consequences. One needs only to be reminded that three-quarters of the world production of soya takes place in the USA, and that that humble bean has become an essential weapon in the struggle against world famine.

Professor Louw has rightly pointed to the need for political action : for the formation of a world resources policy by international agreement. Experience in this kind of policy-making, for example at the United Nations, or at the recent Conference on the Law of the Sea at Caracas, is not reassuring. The areas of conflict between East and West, between the have-nots and the haves, tend to widen rather than to narrow.

Mr Parsons, the Executive Director of ASSACOM, said last month that world finance needs a Kissinger, someone who is intellectually resourceful, who can win the confidence of countries with divergent interests, and who possesses enormous travelling stamina. Perhaps world energy needs a Kissinger, too; and here, by way of an example, is the outline of a policy which he himself advocated at the Sixth Special Session of the United Nations in April this year :

- (i) The global economy requires an expanding supply of energy at an equitable price. This will require a massive co-operative effort to develop new and renewable fuel sources.
- (ii) The global economy requires that both consumers and producers escape from the recurrent cycle of raw material shortage and surplus. The resources of this planet must be related to man's needs, and for this purpose an international long-range forecasting and planning system must be evolved.

- (iii) The global economy must achieve a balance between food production and population growth. Additional agriculture capacity is essential and the world oil producers could play a significant rôle by using their raw materials and capital to produce fertilizers on a massive scale.
- (iv) The global economy cannot allow the poorest nations to be overwhelmed.
- (v) In a global economy of physical scarcity, science and technology are becoming our most precious resources. Science must help solve the problems it has helped to create.
- (vi) The global economy requires a trade, monetary and investment system that sustains civilization and stimulates its growth. (This presumably is where Dr Kissinger makes his third appearance - as a world financier.)

One can hardly disagree, but I am sorry to say that I remain somewhat sceptical. I do not believe that many nations have the will or the ability to instal and manage a global economy, and I doubt whether any meaningful progress will be made in that direction until disaster strikes not just at the Third World, but at the First and Second Worlds as well.

The oil crisis seemed to threaten just such a disaster. The response was immediate, and, as I have said, I believe the means will be found to overcome it. The means will be found, I suggest, not by UN resolutions to create a global fuel economy, but by the efforts of the developed nations, mainly by their own endeavours and sometimes in collaboration with their peers, to discover new remedies.

Abundant energy will help to relieve the other problems, but it will not solve them. It seems to me that, as in the financial sphere, a group of ten or twenty countries will have to take the initiative and the responsibility. It is they who produce and consume by far the greater part of the world's energy; it is they who put energy to use in order to produce the substances and artefacts the world needs; it is they who possess the capital resources, including the science and technology, to develop new and renewable reservoirs of supply. It is they, too, as the main consumers, who must exercise the greatest degree of restraint. They must also create a new philosophy of global co-operation, through restraint, in which the whole world may one day share. How shall we define that philosophy? In a recent book, "D'energie et le desarroi post-industriel", Louis Puiseux suggests that :

"Nature, without metaphor, is our common mother, the irreplaceable but not incorruptible body from which our flesh is born and which nourishes us thereafter. But increasingly, since the industrial age, nature and woman have fallen under male domination : our heroes are always Ulysses the sailor of seas, Heracles the killer of lions, Jason the recoverer of the golden fleece, Theseus the unraveller of labyrinths and Icarus of the burnt wings.

"After this tiresome exaltation of male Western heroes, conquerors, builders, inventors, adventurers, captains of industry, all of them more or less dedicated to plunder, let there be ..... a rebirth of the true feminine virtues : of that wisdom that knows the solidarity not only of all races, but of all living kinds, from the child of man to the alga and the bird - and an indivisible love of all life."

That gentler philosophy is, I believe, essential for the conduct of international relations in the changed world in which we must now live.

*DENIS WORRALL*

We are all very grateful to Professor Louw for having sketched the broad theoretical framework in terms of which the international political aspects of the energy situation may be viewed. The view I will be adopting here is more of a short term approach than that presented by Mr. de Villiers.

The energy problem and the realization of the need to develop new sources of energy, as a result of the depletion of existing sources, has been appreciated for some time. Thus in the United States in 1970 experts said that the United States would need to import 5 million barrels of oil a day - which apparently is not very much - in 1980, and most of that oil, it was expected, would come from the Western Hemisphere. But these predictions proved to be wrong, and by 1972, as a result of the failure to get oil down from Alaska, and as a result of the failure to develop natural gas, and the failure generally of American oil producers to meet increased demands, the energy question began to take on crisis dimensions as far as the Americans were concerned.

However, the element which really gave it a political dimension, and which will in the next ten years repeatedly give it a political dimension, is the Middle East situation and the ability of the Arab states to impose boycotts on the supply of oil to Western countries in particular. At this stage United States experts say that, given the development of natural gas, given the development of their own oil supply, and given, on the long term, the development of nuclear energy, by 1980 - 85 they will have resolved the problem from a United States and Western European point of view. But until 1980 - 85 there is the very real likelihood of the Arab states imposing boycotts from time to time.

As the Arab states see it, Israel is not in a position to maintain its national integrity, it is not in a position to maintain itself without United States support; and the boycott which was introduced at the time of the Yom Kippur War had a direct political and military-strategic purpose. It was intended to punish the United States for the support it was giving Israel at the time. Arab hostility to Israel runs deep,

and/

and the anti-U.S. attitude is likely to influence Arab policy over the next 10-15 years, unless the Middle East situation is resolved and a settlement found.

As a result of that crisis caused, as I have said, very largely by the trouble in the Middle East, certain developments have occurred which are of international political significance. I am not referring simply to foreign policy switches or to the realization of the enhanced importance which energy will have in our future, with the resulting change in values and appetites. But I am referring to certain broad developments of political significance which need to be faced up to.

First of all there is the fact that the developing nations, as a result of the energy crisis, have acquired a very considerable international political "clout". It is largely of a psychological nature, but it is there and it has to be dealt with. The effect is already reflected in, for instance, United Kingdom policy towards Nigeria. The present revision of British policy towards South Africa is largely a consequence of the importance of Nigerian oil to the British economy. Another manifestation of Arab political influence is the sudden switch in the attitude and policy of Japan.

The second important development is that the energy issue has now become thoroughly politicised. Until now, for example, the United States has been happy to leave the oil companies to negotiate the terms on which oil would be imported to the United States. However, now this is a matter which requires the attention of the United States Government as such, because the companies do not have the bargaining power to do this negotiation. National interest has become involved. Professor Richard Gardiner of Columbia University, who is an important American representative to the United Nations Conference on the Law of the Sea at Caracas, says "that 1974 represents a turning point in international relations. The global agenda is more important than traditional foreign policies. If the Law of the Sea Conference fails, it will harm prospects for other international negotiations on food, population, energy, security, trade. Caracas is thus a test case for mankind's capacity to deal with global problems in a rational way." So the second consequence is therefore the politicisation of the energy issue, and with it other issues of general concern to mankind as a whole.

The third important development from an international political point of view is the emergence of new international conventions and treaties to deal with fundamental global problems. In large measure this is a consequence of the oil crisis. An example is the approach adopted on the question of the Law of the Sea. The traditional conception, which goes back to Grotius in the 17th Century and which has been adopted until now, is being challenged. The rights of states, their jurisdiction over coastal waters, and their rights to economic jurisdiction and sovereignty, are being restated in terms of new needs and in terms of the development of more effective technologies.

These are the more important international political developments which have occurred as a result of the energy crisis, which in turn was caused primarily by the Middle East situation.

Now, what should our goals be at this stage? Quite apart from the very important issue of planning, which Professor Louw neatly spelt out, and the spirit of which Mr. de Villiers echoed, there are the political aspects of the situation, which are just as important. For the simple reason that the central problem of international relations, the problem of international organisation, the problem of international law, is somehow to reconcile the sovereignty of the nation-state with the obligations which are implied in membership of international organisations and in the commitment to fulfil responsibilities in terms of the rules of international law. This is one of the fundamental problems, not in the theory of international politics only, but also in the practice of international politics. I think one has to be realistic here. One has to recognise that, while it is important to think in terms of global planning and in terms of policies which involve all the dimensions of the human society, these fundamental political problems have first to be resolved. The Middle East illustrates the point nicely. As long as this problem is around, as long as the Arab countries have foreign policy reasons for imposing sanctions and withholding their oil from Western countries in particular, rational planning on a global scale is likely to be extremely difficult, if not a waste of time, and must be subordinated on the priority list to the resolution of the political problem itself.

In this regard both the United States and the Soviet Union have a common interest. The rest of us in the meantime should address ourselves to more effective conservation policies and to the alternative sources of energy, all the time hoping that the major powers will proceed to the resolution of the Middle East problem.

Introduction : Politics and Economics in the 1970's

\_\_\_\_\_ In view of the developments of the past year, it now seems that this decade will be remembered as :

- The decade of the petroleum crisis.
- The decade during which state economies and ways of living had to adjust to new dimensions, as a result of fuel supply or price problems.
- The decade of increasing prices in raw materials - unprecedented wealth and also unprecedented inflation. Whether the deflationary process, which must inevitably follow, will be a shock or an orderly affair, will depend on the skill of international economists and financiers.
- The decade in which rich nations became richer and poor ones poorer.
- The decade of bilateral trade.
- The decade of political sorrow! It is a sobering thought that there is hardly any international political leader of stature in the world today, which means that the affairs of nations may well be handled clumsily.

It is hoped that this decade will also be remembered as one of technological revolution. It is only through technological advancement on issues like nuclear power, solar energy, electricity and the like, that the present situation of uncertainty can be permanently solved. Unfortunately, however, these are slow solutions to fast developing problems.

The interactions between politics and economics cannot be ignored - the two social sciences that determine the destinies of nations. These interactions will increase in importance during years to come.

Energy Resources and Consumption

Before looking at petroleum in particular, let us first consider international energy reserves and consumption with special reference to a few countries.

Table 1 - World Energy Reserves 1971  
(in million metric tons coal equivalent)

SOURCE	NUMBER OF YEARS OF PRODUCTION EQUIVALENT	WORLD	SHARE OF TOTAL %	COUNTRIES					
				U. S. A.	U. K.	FRANCE	WEST GERM.	JAPAN	OTHER
Coal *	229	547 592	76, 8	75 196	12 227	2 800	91 080	5 804	360 485
Crude Oil	31	99 060	13, 9	6 687	315	18	103	4	91 733
Natural Gas	44	66 467	9, 3	10 516	1 500	273	517	-	53 661
TOTAL	98	713 119	100, 0	92 339	14 242	3 091	91 700	5 808	505 879

\* Measured Reserves only.

Source: United Nations Statistical Year Book 1972.

Table 2.1 - World Consumption 1971  
(in million metric tons coal equivalent)

SOURCE	WORLD	SHARE OF TOTAL %	COUNTRIES					
			U. S. A.	U. K.	FRANCE	WEST GERM	JAPAN	OTHER
Coal	2 388	33, 6	452	146	50	138	80	1 522
Crude Oil	3 029	42, 7	970	135	133	170	245	1 376
Natural Gas	1 512	21, 3	867	22	18	28	6	571
Hydro & Nuclear Electric Power	167	2, 4	39	4	8	3	11	102
TOTAL	7 096	100, 0	2 328	307	209	339	342	3 571

Table 2.2 - Crude Oil Consumption as % of Total of Energy Consumption

	WORLD	U. S. A.	U. K.	FRANCE	WEST GERM	JAPAN	OTHER
Share of Total %	42, 7	41, 7	44, 0	63, 6	50, 1	71, 6	38, 9

Sources: "Pétrole 73" Eléments Statistiques, Paris.



The Oil Industry

The topical subject of a fuel shortage (energy crisis) should be seen against the background of the complex international mechanism of the Oil Industry. The international logistics of the Oil Industry are complicated, ingenious, well calculated, and proved over many years. The Oil Industry can be an effective instrument in a country's economy, e.g. SOEKOR, EXPLORATION, SASOL, NATREF, etc., in the South African case.

Exploitation of the international oil situation can become a useful weapon in the hands of crafty and unscrupulous politicians.

The international mechanism of the Oil Industry is complex because of various factors. Let us look firstly at the international supply and demand position summarised:

Table 3 - World Oil Production & Consumption 1973  
(in million metric tons)

COUNTRY/AREA	CRUDE OIL		REFINED PRODUCTS	
	PRODUCTION	SHARE OF TOTAL %	CONSUMPTION	SHARE OF TOTAL %
U.S.A.	513,1	18,1	814,7	29,5
Canada	99,9	3,5	83,8	3,0
Central and South America	262,6	9,3	169,8	6,1
Middle East	1 061,1	37,5	71,2	2,6
Africa	277,2	9,8	48,0	1,7
France	1,3	0,1	125,7	4,5
West Germany	6,6	0,2	149,5	5,4
United Kingdom	0,1	-	112,6	4,1
Others	117,0	4,1	756,6	27,4
World (excl. Communist Areas)	2 338,9	82,6	2 331,9	84,3
Communist Areas	493,7	17,4	434,0	15,7
World	2 832,6	100,0	2 765,9	100,0

SOURCES : 1. "Pétrole 73" Eléments Statistiques, Paris.

2. B.P. Statistical Review of the World Oil Industry, 1973, London.

See: Annexure 2 for World production and trade (1972) in crude oil and refined products.

Annexure 3 for details of World Crude Oil Production 1973

Annexure 4 for Evolution of World Refined Products Consumption until 1973

World supply and demand are in the process of undergoing an evolution:

- World consumption has increased by 500% over the past 22 years
- Sources of supply are shifting - especially for the U.S.A.
- World supply and demand do not coincide geographically. The Middle East and Africa together produce 47,3% of the world's oil, while they only use 4,3%
- North America's consumption significantly exceeds its production

The control over world supply of oil can be classified as follows:

Primary control

- Capital control (Western Financing)
- Production control

The Western Countries mobilised the capital and, until recently, had the political control.

Secondary control

- Control over refining
- Control over ocean transport
- Control over marketing

It is estimated that world demand for energy will increase drastically, due mainly to the general economic growth of both industrialised and under-developed countries, and to the U.S.A.'s growth in particular. The overall world-wide energy demand will increase from 5 billion tons of oil equivalent in 1970, to 10 billion tons in 1985, and to 20 billion tons in 2000.

How is World Supply to meet such a rapidly increasing demand? Up to 1985 we can assume that there will be a slight increase in the crude oil share which is expected to rise from 2,3 to 5,3 billion tons per year, representing a proportion of 46 to 50% of the energy demand. From 1985 to 2000, the forecast range widens. Assuming a "high nuclear energy source", oil output should reach 7,5 billion tons in 2000, i.e. a cumulative volume of 90

billion tons over the 15-year period 1985-2000, which represents a tremendous figure.

With present reserves at about 90 billion tons, the future requirements necessitate the discovery of 350 billion tons of new reserves during the next 30 years, if in the year 2000 we want the available reserve figure to represent 30/40 years of current consumption.<sup>+</sup> This figure does not seem compatible with present and realistic estimates of yet undetected reserves. We can set our sights lower by considering a lower crude oil/year capital and by seeking a constant volume of available reserves. Even this would mean detecting and producing about 150 billion tons of oil, i.e. an equivalent of 12/13 current years of consumption in 2000.

This figure should not cause concern, if we can assume that by that time nuclear and other new sources of energy will be highly developed. If, however, we find that this assumption is not justified, we are then involved in a real world petroleum shortage.

It is desirable that Western orientated international oil companies should continue to play an important part in national and international economic and political structures by:

- continuing with their integrated activities of exploration, refining, transport and distribution, and
- continuing to operate according to established company norms and objectives which create public confidence and promote the interest and well-being of the States and communities.

Causes of the world-wide oil shortage and of the astronomic price rises  
The crisis has been made possible by a geographic fact, namely the over-concentration of oil reserves in the Middle East.

<sup>+</sup> See Annexure 5 for World "proved" crude oil reserves.

In 1950 62,3% of energy consumed was supplied by coal and 25,2% by oil. In 1971 coal accounted for only 33,6%, and oil for 42,7%. The inverting of roles has been very rapid and was the direct result of the respective cost of these two energy sources. The oil companies manufactured and sold products which were substituted for others, because the former were cheaper. The era of cheap oil energy has now ended, and, compared to the price of oil, American, Australian and South African coal becomes very competitive.

The shortage has been, and will still be accelerated, as a result of the following factors:

- (a) A real shortage of crude oil is developing rapidly.
- (b) Until the end of 1971, the international oil companies had at least 93% control over the production of crude. This was the era of a fully integrated oil industry, with the same economic agents controlling all stages, from exploration to marketing.
- (c) At the end of 1971, the international oil companies agreed to phase-in the producing countries by giving them an immediate 25% equity in production, increasing by ten equal annual instalments to reach 50% in 1982.
- (d) The Teheran Agreement provided for an annual increase in price to allow for inflation.
- (e) Some oil producing countries impatiently nationalised their oil production up to 60% to replace the phasing-in formula referred to in (c).
- (f) Instead of being paid royalties on company owned (equity) oil, some producing countries asked to be paid in kind, i.e. in oil, instead of in cash.
- (g) All phasing-in oil, nationalised oil and royalty oil now becomes the property of the producing countries, and in order to meet demand, international oil companies have to buy-in the shortfall from the producing countries - at uncomfortably high prices.

(h) Moreover, the producing countries keep the price file open, maintain the inflation coefficient as a regular price factor for debate, and differentiate between the various quality specifications. The result is that international oil companies must bid for their requirements, and the traditional and recognised posted prices have become relatively meaningless.

These circumstances are causing prices to escalate, and in the author's opinion the international oil companies will have to buy-in more and more of their crude requirements. It is estimated that within the foreseeable future the internationals will control only 35% of production.

The escalation of prices may therefore continue for the next few years, or until such time as a drastic technological development comes to our rescue.

See: Annexure 6 for a theoretical illustration of the evolution of control over crude oil.

There is no master plan to solve this vast problem. However, certain ill-effects of this crisis, indicated below, must be recognised as factors that will influence the solutions to world supply and demand problems.

#### The Effects of the Crisis on Africa and other Developing Countries

"We still trust the Arabs. We are fighting the same battle they are fighting. But man cannot live by trust alone. He has to have oil at reasonable prices as well, especially if he is in a developing country which would face certain economic disaster, if the cost of living went one iota above its present level."

- Times of Zambia, 26.2.1974.

The millions in the developing world are among those who have suffered most from the action of their Arab friends. The increase in the petroleum bill in 1973 of industrialised countries was about 27 times

as much as the total foreign aid received by Africa in 1972. The question now arises as to how Africa and the whole developing world will be affected by the ill-effects the higher oil prices will have on the domestic economies of the industrialised countries which supply foreign aid.

Africa is looking towards the Arab Countries for foreign aid, and here we enter the realm of politics. But so far, little has been done by Arab producers to cushion the blow to African Countries, and it is difficult to understand Black Africa's reliance on Arab assistance - non-African Arab countries owe very little to Black Africa.

To demonstrate the increase in oil bills and the effect on developing Africa, Annexure 7 gives details of balance of payments and petroleum bills in respect of six African States. For example, Kenya, with a negative balance of US \$99 million in 1972, will pay US \$120 million more for its oil in 1974. These higher bills will place African countries' sources of revenue, such as tourism, in jeopardy, and inflation in industrialised countries will have further repercussions on African countries which are big importers of consumer goods.

#### The re-opening of Suez

Annexure 8 gives details (up to 1966) of both north-bound and south-bound traffic through the Suez Canal, and of the increasing importance of the oil traffic, which reached 85,8% of the total north-bound traffic in 1966.

It is known that the vessels passing through the Suez Canal in 1966 carried 4 million metric tons of Bunker Oil.

Annexure 9 gives a variety of details of the world tanker fleet at the end of 1973. Not much can be deduced from these statistics, except that approximately 8% of the world's tanker capacity can make use of

Suez. With the re-opening of Suez, this traffic will not make use of South African harbours any longer. The effects the re-opening of Suez will have on both South Africa and other African harbours are extremely difficult to predict because:

- Suez last operated in 1966, and since then many changes have taken place in the world's tanker fleet as far as size and composition are concerned.
- The tariff that will be charged is not known yet and this will influence the number of vessels which use the canal.
- A pipeline is being built from Suez to Alexandria. It is expected that vessels will sail to Suez and that the oil will be pumped to Alexandria and loaded aboard other vessels.

The most one can say is that the re-opening of the Canal will have unfavourable effects on South African trade, but that this will not be very significant.

#### International Political and Economic Stability

The petroleum crisis aggravated the already unstable international political scene. It is imperative that international political stability be achieved before nations can hope to formulate policies to promote solutions to the fuel crisis.

A strategy must be designed to produce a more adequate flow of energy in future years. There is a need for a basic revision of the world's energy policies with a view to eliminating wastage.

A country that bases its economic policy on illusions is inviting trouble - it would mean policy-making by myth. Therefore, before a basic revision of the world's energy policies can be achieved, the masses will have to be prepared to push aside vintage illusions, such as:

- The illusion that the energy crisis is a temporary emergency situation. On the contrary, it is a long-term impasse which will send shock waves through the economies of nations during the next decade.
- The illusion that drastic and mandatory restrictions are not necessary.
- The illusion that the oil producing countries will not continue to use the oil weapon.

#### The International Monetary Dilemma

The huge rise in the price of oil is having a disruptive impact on world financial relations. By the first quarter of 1974 OPEC had increased the price of oil fivefold - a substantially more rapid increase in price than that of other critical commodities. At present levels of production this means that they will receive approximately \$110 billion yearly for their oil exports.

Of this \$110 billion the oil-producing nations will spend some \$50 billion for goods and services - leaving \$60 billion or so as a surplus to be re-invested. This \$60 billion surplus incidentally compares with a \$4 billion surplus by the same countries in 1973. Taking into consideration existing reserves, the total reserves of the oil-producing nations are likely to reach \$260 billion by the end of 1976. This is a staggering amount!

The corresponding deficits for these huge surpluses are on the balances of payments of oil consumers. The key deficit nations include highly industrialised countries, such as the U.S.A., Japan, France, U.K., etc. The deficit of developed countries is projected to increase by \$40 billion.

The developing nations will face a severe increase in their combined deficit



of close to \$20 billion a year. Countries such as India, Bangladesh and some African States will have hard times.

The end product of all this is a structural disequilibrium of major proportions in the balance of payments of countries around the world - one that could have serious implications for the world economy and international financial mechanisms.

The surpluses of the oil producers must therefore be recycled back to the deficit oil consumers. If recycling does not occur, they will be forced to deflate their economies. So far, the surpluses have been recycled back successfully over the short term - principally through the international banking system. The OPEC nations recycle mainly in Eurodollar or in Sterling with deposits usually at call, or on very short maturity. The re-lending of these amounts to oil-consuming nations is for longer periods of five to seven years - an unusual process which obviously creates an unbalanced international monetary structure.

Under the circumstances, it is obvious that:

- For long-term success, funds should be placed at longer maturity.
- Present methods can lead to imprudent credit policies.
- OPEC nations cannot accumulate bank deposits indefinitely.
- Financially weak, lesser-developed countries will need money over much longer terms to relieve the strains on the countries involved. These strains will accelerate dramatically in years to come and can only be alleviated by international governmental approaches and co-operation.

Those producing countries that lack internal absorptive capacities, commensurate with the income they will receive, will have to invest outside their countries. At present, they are concerned about such matters as world inflation, exchange risks and the possibility of expropriation of their assets.

It is clear that both the private sector and governments will have to play a significant role in the long-term investment process.

It is known that international banks have begun setting up branches in the Middle East in an attempt to channel recycle-funds towards objectives that could result in long-term monetary equilibrium.

It would appear as if the World Bank and International Monetary Fund will be called upon to play key roles in the recycling process.

Ways should be found to channel surplus oil revenues into projects designed to create alternative sources of energy. Then the producing countries could continue to participate in this source of revenue, even after their reserves have been exhausted.

An urgent need already exists to develop swiftly a new way of looking at world financial needs - a perspective that emphasizes global stability, as well as individual national credit-worthiness. To achieve this, determined co-operation between oil-consuming and oil-producing nations is necessary.<sup>+</sup>

#### The Price Structure of Oil and the Profit Dispute

We can be sure of one thing: Gone are the times when oil was both cheap and plentiful. We are on the threshold of an era of costly energy, when - for many years to come - supply will not satisfy demand.

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<sup>+</sup>Based on remarks by David Rockefeller, Chairman: The Chase Manhattan Corporation.

Worldwide energy demand patterns are based on 46% energy supply ratio for crude oil, which gives oil a paradoxical leadership. This stems from its considerable advantages: flexibility and diversification of uses, easy production and cheap production costs.

Although this is both simple and obvious, it is a major point, but little appreciated by those who are surprised by the fact that our civilisation rests on a product that is becoming expensive. The critics forget that "costs" and "prices" are quite different things. Recent technical production costs are quite low, as compared to production costs for all other sources of primary energy. Prices are a different matter; to these costs must be added:

- The income necessary for oil companies' operations.
- The taxes and royalties payable to producing countries (i.e. 80 - 85% of total price).

Between 1971 and 1973 one "economic model" has been replaced by another completely different one. Prior to 1971 we had a fully integrated oil industry, controlling all stages from exploration to marketing. By 1973 this model had changed. A new balance between supply and demand should now be found - both for volume and price levels. Raw materials are now controlled by the producing states which are fully independent from the different buyers. In 1960 the oil companies owned 93% of oil (equity oil) By 1985 they will own only 35%.

Long-term overall supply is lower than demand, and each of the major seller is in a position, singly, to restrict overall supply below demand level. The result is: perfect competition amongst buyers, versus a seller's oligopoly.

Producing states' interests lie in conservation of resources, industrial development and protection against worldwide inflation. On the other hand, industrial countries will have to take steps against severe recessions and permanent imbalance of international currencies.

It is high time that a basis for real co-operation between consumers and producers be defined and formulated. The idea is not to set up a resistance movement against OPEC, but rather to define a supply policy creating a balance between all parties concerned and to draw up a coherent and stable price system that will also take into account Third World interests.

Now, more than ever, the oil companies' competence, experience and efficiency are vitally required in the different stages of production, transportation, refining and marketing.

Government of the Free World should always maintain a healthy and stable business climate for the international oil industry. This would ensure the best efforts from the international oil companies, and is perhaps the one single factor which can offer the best security against a petroleum shortage.

The following data on worldwide capital and exploration expenditures illustrate the oil companies' capital and exploration expenditure and their net income. It should be borne in mind that funds must be mobilised and that investors from the public expect dividends on these risky investments.

Table 4 - Capital and Exploration Expenditures

1. <u>54 Major Oil Companies of the World</u>	<u>Million \$</u>
(a) Capital and Exploration Expenditure, 1970	15 618
(b) Net Income 1970	7 228

Source: International Petroleum Encyclopedia  
1972.

2. <u>Free World - All Companies</u>	
(a) Capital and Exploration Expenditure, 1970	21 465
(b) Net Income 1970 (Net Income projected on Item (b) above)	9 934
(c) Exploration Expenditures - only 1970	1 340

Source: Capital Investments of the World  
Petroleum Industry, 1970

The oil companies must also keep their financing facilities which are the ~~imperative conditions for a true exploration diversification policy.~~ The consumers should be aware that product prices reflect not only the new requirements of the oil producing countries, but that they incorporate the very high cost of exploration and development activities in politically stable areas of the world. The public press is being looked upon to bring about that awareness amongst consumers.

The aforementioned problems are current problems of magnitude and of great concern to the leading nations of the world and to responsible international business houses. Provided they get immediate and serious attention, solutions can be found over the medium term and even the short term, which should ease the present fuel crisis considerably.

Technological development of alternative energy sources is, in the author's opinion, the only real permanent solution to the problem. However, patience is needed and, as already pointed out, this is a slow solution to fast developing problems. We should therefore, be appreciative of the valuable work carried out by scientists in the fields of nuclear power, hydro-power, solar energy, coal chemistry, etc. These scientists observe every success in their work and the world eagerly watches them take bold steps into the unexplored universe of science.

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French Petroleum Institute.

United Nations Statistical Year Book, 1972.

BP Statistical Review of the World Oil Industry, 1973.

Africa Institute Bulletin and officials of the Africa Institute of South Africa.

The Chase Manhattan Bank publications, and officials of The Standard Bank of S.A. Limited.

International Petroleum Encyclopedia.

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COUNTRY/AREA	WORLD ENERGY PRODUCTION 1971					WORLD ENERGY CONSUMPTION 1971					CONSUMPTION PER CAPITA (IN KG)
	SOURCES OF ENERGY					SOURCES OF ENERGY					
	COAL	CRUDE OIL	NATURAL GAS	HYDRO & NUCLEAR ELEC. POWER	TOTAL	COAL	CRUDE OIL	NATURAL GAS	HYDRO & NUCLEAR ELEC. POWER	TOTAL	
<u>North America:</u>	521	731	943	59	2 254	476	1 066	928	59	2 529	11 057
United States	505	637	849	38	2 029	452	970	867	39	2 328	11 241
Canada	16	94	94	21	225	24	96	61	20	201	9 327
<u>Central &amp; South America:</u>	10	345	57	11	423	15	192	57	11	275	952
Argentina	1	28	9	-	38	1	31	9	-	41	1 766
Brazil	2	11	2	5	20	5	38	2	5	50	515
Mexico	2	31	24	2	59	2	36	24	2	64	1 270
Venezuela	-	243	12	-	255	-	14	12	1	27	2 494
Others	5	32	10	4	51	7	73	10	3	93	
<u>Western Europe:</u>	376	24	136	49	585	410	789	140	49	1 388	3 887
<u>Middle East:</u>	7	1 061	33	1	1 102	7	57	25	1	90	830
<u>Far East:</u>	119	82	17	16	234	167	347	15	16	545	478
Japan	33	1	4	11	49	80	245	6	11	342	3 267
Others	86	81	13	5	185	87	102	9	5	203	
<u>Oceania:</u>	53	19	3	3	78	37	38	3	3	81	4 128
Australia	52	19	3	-	74	33	31	3	3	70	5 448
Others	1	-	-	3	4	4	7	-	-	11	
<u>Africa:</u>	64	360	5	3	432	63	53	2	4	122	340
<u>Communist Areas:</u>	1 246	548	333	25	2 152	1 213	487	342	24	2 066	2 500
China	394	33	-	5	432	394	41	-	5	440	560
U.S.S.R.	461	490	283	16	1 250	441	368	288	15	1 112	4 537
Others	391	25	50	4	470	378	78	54	4	514	
	2 396	3 170	1 527	167	7 260	2 388	3 029	1 512	167	7 096	1 931

ANNEXURE 2.

PRODUCTION AND TRADE 1972

(in million metric tons)

COUNTRY/AREA	CRUDE OIL			REFINED PRODUCTS		
	PRODUCTION	IMPORTS	EXPORTS	PRODUCTION	IMPORTS	EXPORTS
<b>NORTH AMERICA:</b>	573,7	157,1	49,8	744,2	139,5	16,5
United States	493,6	115,9	-	663,6	132,2	11,6
Canada	80,1	41,2	49,8	80,6	7,3	4,9
<b>CENTRAL &amp; SOUTH AMERICA:</b>	255,4	157,2	122,1	287,3	17,8	141,3
Argentina	22,6	1,6	-	24,2	0,7	0,2
Brazil	8,7	25,6	1,1	34,2	1,4	1,4
Mexico	26,4	1,6	-	22,2	2,2	1,1
Venezuela	168,4	-	111,5	58,8	-	50,3
Others	29,3	128,4	9,5	141,9	13,5	88,3
<b>WESTERN EUROPE:</b>	19,7	729,0	25,8	717,2	152,8	136,7
<b>MIDDLE EAST:</b>	947,9	34,5	864,6	126,7	2,7	65,7
Iran	263,4	-	235,3	29,2	-	12,5
Iraq	75,6	-	75,1	5,0	-	-
Israel	6,3	5,7	5,5	6,4	0,4	0,9
Kuwait	156,8	4,1	142,1	19,6	-	16,2
Saudi Arabia	299,8	-	272,1	29,8	-	18,0
Others	146,0	24,7	134,5	36,7	2,3	18,1
<b>FAR EAST &amp; OCEANIA:</b>	98,7	312,5	58,4	359,5	72,8	35,1
Australia	17,1	9,3	0,6	25,9	3,5	2,3
India	8,1	12,9	-	20,5	3,5	0,2
Indonesia	56,5	0,1	42,7	14,8	1,6	6,6
Japan	0,7	214,2	-	214,0	40,1	1,2
Others	16,3	76,0	15,1	84,3	24,1	24,8
<b>AFRICA:</b>	297,0	28,6	281,9	40,6	14,0	8,7
Algeria	55,0	-	52,1	3,0	0,3	0,5
Egypt	11,1	1,3	4,3	6,7	1,0	0,4
Libya	117,1	-	115,8	0,5	0,8	-
Morocco	-	1,9	-	2,1	0,4	-
Nigeria	95,0	-	92,6	2,3	0,1	0,1
South Africa	-	13,0	-	12,1	4,3	3,5
Tunisia	4,5	1,0	4,1	1,2	0,4	0,2
Others	14,3	11,4	13,0	12,7	6,7	4,0
<b>COMMUNIST AREAS:</b>	464,4	60,6	84,5	405,3	10,6	43,4
<b>WORLD</b>	<b>2 656,8</b>	<b>1 479,5</b>	<b>1 437,1</b>	<b>2 680,8</b>	<b>410,2</b>	<b>447,4</b>

SOURCE : "Pétrole 73" Eléments statistiques, Paris.



WORLD CRUDE OIL PRODUCTION 1973

(in million metric tons)

COUNTRY / AREA	1973	Share of Total %
<u>NORTH AMERICA:</u>	613,0	21,6
United States	513,1	18,1
Canada	99,9	3,5
<u>CENTRAL &amp; SOUTH AMERICA:</u>	262,6	9,3
Venezuela	175,6	6,2
Others	86,7	3,1
<u>WESTERN EUROPE:</u>	15,5	0,5
<u>MIDDLE EAST:</u>	1 061,1	37,5
Abu Dhabi	65,5	2,3
Saudi Arabia	364,7	12,9
Iran	293,8	10,4
Iraq	95,0	3,3
Kuwait	138,3	4,9
Others	103,8	3,7
<u>FAR EAST &amp; OCEANIA:</u>	109,5	3,9
Indonesia	66,0	2,3
Others	43,5	1,6
<u>AFRICA:</u>	277,2	9,8
Algeria	51,0	1,8
Libya	104,5	3,7
Nigeria	100,9	3,6
Others	20,8	0,7
<u>COMMUNIST AREAS:</u>	493,7	17,4
China	50,0	1,8
U.S.S.R.	421,0	14,8
Others	22,7	0,8
<b>WORLD</b>	<b>2 832,6</b>	<b>100,0</b>

SOURCE : "Pétrole 73" Eléments statistiques, Paris.

WORLD REFINED PETROLEUM PRODUCTS CONSUMPTION

(in million metric tons)

COUNTRY / AREA	1970	1971	1972	1973	CONSUMPTION PER CAPITA IN KG/YR (1971)
<u>NORTH AMERICA:</u>	767,6	818,1	855,1	898,5	3 562
United States	694,6	741,5	775,8	814,7	3 934
Canada	73,0	76,6	79,3	83,8	3 566
<u>CENTRAL &amp; SOUTH AMERICA:</u>	139,6	150,2	159,6	169,8	517
Argentina	21,2	21,5	22,0		906
Brazil	25,4	28,1	30,2		288
Mexico	25,2	25,9	27,2	29,2	501
Venezuela	10,0	10,6	11,3		975
Others	57,8	64,1	68,9		600
<u>WESTERN EUROPE:</u>	623,1	650,8	701,0	747,7	1 808
France	94,4	102,6	114,1	125,7	1 993
Italy	91,7	96,6	98,2	104,5	1 785
United Kingdom	104,4	104,7	109,7	112,6	1 877
West Germany	121,7	130,7	140,9	149,5	2 126
Others	210,9	216,2	238,1	255,4	1 578
<u>MIDDLE EAST:</u>	53,8	63,4	66,9	71,2	561
Iran	13,9	17,0	17,0		564
Saudi Arabia	8,1	10,9	12,8		1 305
Others	31,8	35,5	37,1		476
<u>FAR EAST &amp; OCEANIA:</u>	309,8	336,2	357,2	396,7	280
Japan	192,3	209,0	234,3	267,2	1 984
Australia	25,7	27,1	28,5		2 110
Others	91,8	100,1	94,4		92
<u>AFRICA:</u>	35,2	40,1	44,5	48,0	110
Algeria	2,0	2,4	2,7		157
Egypt	5,7	6,5	6,8		189
Libya	0,9	1,1	1,2		528
Morocco	1,7	2,1	2,3		133
Nigeria	1,5	1,8	2,0		31
South Africa	10,1	11,5	13,0		510
Tunisia	1,0	1,4	1,7		260
Others	12,3	13,3	14,8		63
<u>COMMUNIST AREAS:</u>	335,0	359,4	393,7	434,0	305
China	21,1	22,5	24,8		28
U.S.S.R.	258,0	277,3	306,2		1 126
Others	59,8	59,6	62,7		428
<b>WORLD</b>	<b>2 264,1</b>	<b>2 418,2</b>	<b>2 578,0</b>	<b>2 765,9</b>	<b>646</b>

SOURCES: 1. International Petroleum Encyclopedia 1973, U.S.A.

2. BP Statistical Review of the World Oil Industry, 1973, LONDON

ANNEXURE 5.

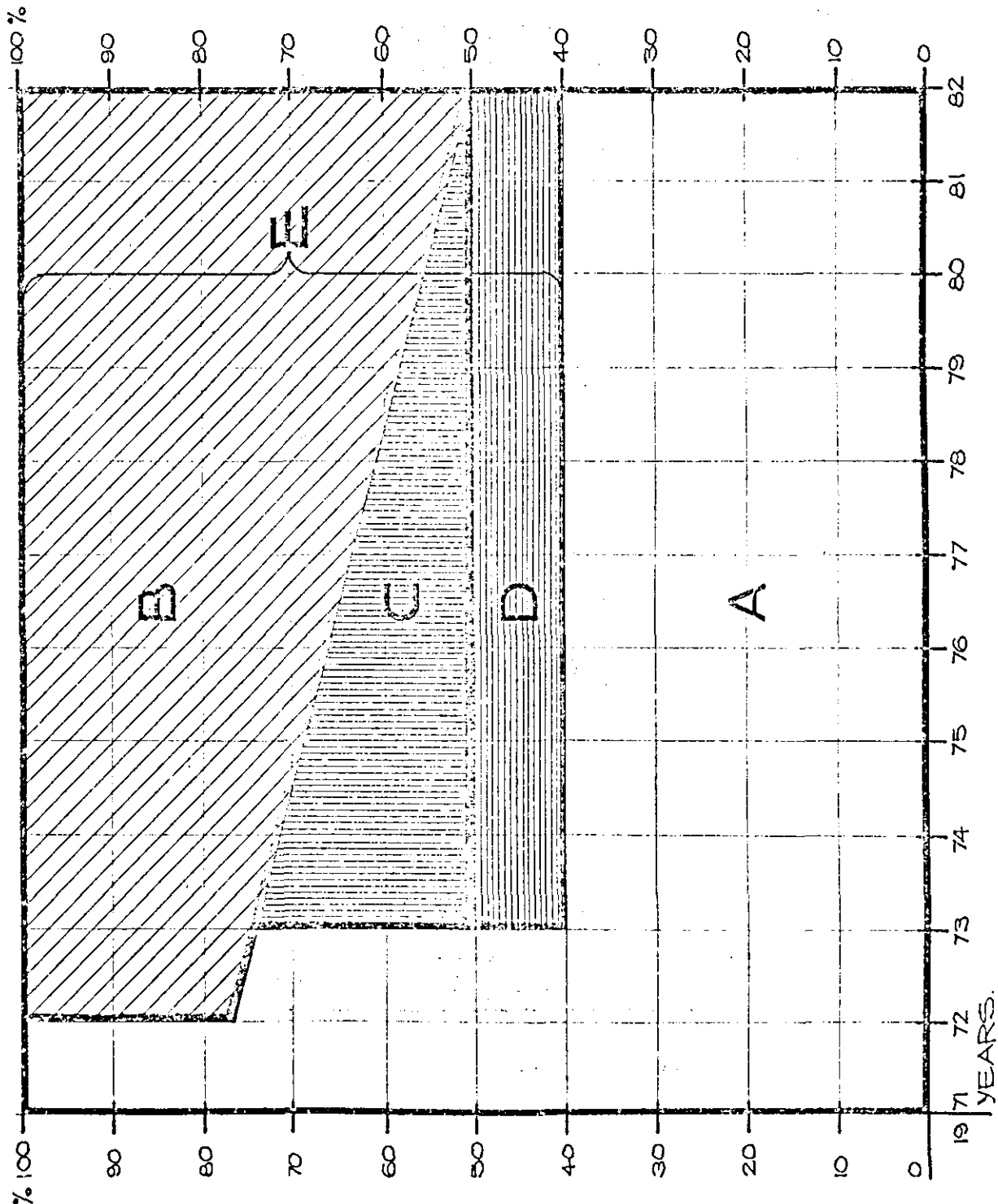
WORLD "PROVED" CRUDE OIL RESERVES

(in million metric tons)

as on January 1 COUNTRY/AREA	1972	1973	1974	1974 SHARE OF TOTAL %	NUMBER OF YEARS OF PRODUCTION EQUIVALENT (BA- SIS 1973)
<u>NORTH AMERICA</u>	6 215	6 396	6 007	7,0	9,8
United States	5 066	5 008	4 722	5,5	9,2
Canada	1 149	1 388	1 285	1,5	12,9
<u>CENTRAL &amp; SOUTH AMERICA</u>	4 292	4 433	4 303	5,0	16,4
Venezuela	1 891	1 863	1 904	2,2	10,8
Others	2 401	2 570	2 399	2,8	27,7
<u>WESTERN EUROPE</u>	1 934	1 856	2 171	2,6	140,1
<u>MIDDLE EAST</u>	49 964	48 396	48 324	56,6	45,5
Abu Dhabi	2 475	2 828	2 923	3,4	44,6
Saudi Arabia	19 761	18 768	17 955	21,0	49,2
Iran	7 548	8 840	8 159	9,6	27,8
Iraq	4 894	3 944	4 284	5,0	45,1
Kuwait	8 979	8 826	8 701	10,2	62,9
Others	6 307	5 190	6 302	7,4	60,7
<u>FAR EAST &amp; OCEANIA</u>	2 081	1 920	2 123	2,5	19,4
Indonesia	1 415	1 360	1 428	1,7	21,6
Others	666	560	695	0,8	16,0
<u>AFRICA</u>	8 008	9 602	8 463	9,9	30,5
Algeria	1 666	1 523	1 038	1,2	20,4
Libya	3 400	4 135	3 465	4,1	33,2
Nigeria	1 523	2 037	2 723	3,2	27,0
Others	1 419	1 907	1 237	1,4	59,5
<u>COMMUNIST AREAS</u>	13 437	13 437	14 004	16,4	28,4
China	2 761	2 761	2 761	3,2	55,2
Others	10 676	10 676	11 243	13,2	25,3
<b>WORLD</b>	<b>85 931</b>	<b>86 040</b>	<b>85 395</b>	<b>100,0</b>	<b>30,1</b>

Sources: "Pétrole 73" Eléments Statistiques, Paris.

"The Oil and Gas Journal", U.S.A.



**A** **B** **C** **D** **E**

SUPPLIES CONTROLLED BY INTERNATIONAL OIL COMPANIES.

PHASING-IN OIL.

NATIONALISED OIL.

ROYALTY OIL.

B+C+D BRIDGING OIL.

19 71 72 73 74 75 76 77 78 79 80 81 82  
 YEARS.

% 100 90 80 70 60 50 40 30 20 10 0

BALANCE OF PAYMENTS

UNIT : Million U.S. \$

COUNTRY	YEAR	Balance of payments		PETROLEUM BILL	
		Balance of Trade	Total Goods & Services	1972	1974
ETHIOPIA	1973	+ 58,6	+ 47,6	17,5	70,0
GHANA	1972	+ 154,4	+ 89,0	25,0	100,0
KENYA	1972	- 183,6	- 98,9	40,0	160,0
TANZANIA	1972	- 89,0	- 45,7	20,0	80,0
ZAIRE	1972	+ 16,6	- 288,4	17,5	70,0
ZAMBIA	1971	+ 114,0	- 91,0	23,1 *	80,0

\* 1973

Source : International Financial Statistics of the I.M.F., June 1974.

SUEZ CANAL TRAFFIC  
(in thousand metric tons)

YEARS	NORTH - SOUTH			SOUTH - NORTH				
	TOTAL TRAFFIC	CRUDE OIL TRAFFIC	SHARE OF TOTAL TRAFFIC %	TOTAL TRAFFIC	CRUDE OIL TRAFFIC	REFINED PRODUCTS TRAFFIC	TOTAL OIL TRAFFIC	SHARE OF TOTAL TRAFFIC %
1920	6 318	263	5,7	10 729	1	786	787	7,3
1930	9 434	398	4,2	19 077	1 451	2 611	4 062	21,2
1939	7 517	229	3,0	17 161	164	4 825	4 989	29,0
1946	5 995	73	1,2	15 931	2 254	6 117	8 371	52,5
1950	12 141	111	0,9	60 468	35 042	12 484	47 526	78,5
1955	20 082	1 905	9,4	87 426	61 978	4 915	66 893	76,5
1960	29 253	3 007	10,2	139 630	103 281	11 138	114 419	81,9
1961	32 795	6 300	19,2	139 599	104 909	9 367	114 276	81,8
1962	31 207	5 543	17,7	151 220	111 776	12 893	124 669	82,4
1963	34 050	5 010	14,7	159 482	119 980	13 039	133 019	83,4
1964	38 518	6 136	15,9	172 463	132 685	11 976	144 661	83,8
1965	42 001	7 908	18,8	183 441	143 664	11 422	155 086	84,5
1966	47 725	8 953	18,7	194 168	154 092	12 626	166 718	85,8

NOTE: Bunker Oil carried by ships from South to North through the Suez Canal in 1966 -  $\pm$  4 000 000 metric tons.

Loaded at Djibouti -  $\pm$  2 000 000 metric tons  
 Loaded at Aden -  $\pm$  2 000 000 metric tons

August 14, 1974

WORLD TANKER FLEET AT END 1973  
 (EXCLUDING 36,8 MILLION D.W.T. COMBINED CARRIERS)  
 (2 000 D.W. Tons and over)  
 BY FLAG AND OWNERSHIP

FLAG	OWNERSHIP						CHANGE 1973 OVER 1972	SHARE OF TOTAL 1973
	OIL COMPANY	PRIVATE	GOVERN- MENT	OTHER	TOTAL 1973	TOTAL 1972		
	MILLION TONS DEADWEIGHT							
Liberia	13.9	45.1	-	0.3	59.3	50.2	+ 9.1	27%
Norway	0.5	20.9	-	-	21.4	19.9	+ 1.5	10%
U.K.	18.0	9.8	0.2	-	28.0	25.3	+ 2.7	13%
Japan	3.3	23.6	-	-	26.9	22.6	+ 4.3	12%
U.S.A.	3.8	4.3	1.6	-	9.7	9.7	-	4%
Panama	3.7	4.0	-	-	7.7	7.6	+ 0.1	3%
France	6.7	2.9	0.1	-	9.7	8.3	+ 1.4	4%
Greece	-	12.7	-	-	12.7	10.5	+ 2.2	6%
Other Western Europe	10.6	16.1	0.1	-	26.8	24.2	+ 2.6	12%
Other Western Hemisphere	5.0	0.4	0.3	-	5.7	4.9	+ 0.8	3%
U.S.S.R., E. Europe & China	-	-	6.4	-	6.4	6.4	+ -	3%
Other Eastern Hemisphere	1.9	3.7	0.1	-	5.7	4.3	+ 1.4	3%
TOTAL	67.4	143.5	8.8	0.3	220.0	193.9	+ 26.1	100%
Fleet as at end 1972	59.3	125.4	8.9	0.3	193.9			
Net Increase 1973	8.1	18.1	-0.1	-	26.1			

Introduction

Coal, which supplied 95% of the world's commercial energy in 1900, now only supplies about one-third of the total, with oil and natural gas having risen to 65%. As a result of the "energy crisis", attention has, however, been focussed not only on the price of oil, but also on the reserve availabilities of both oil and coal.

In a paper by Nelson, Carlsmith Goeller & Carter prepared for the World Energy Congress in September, 1974, world resources of coal are estimated as follows :-

	<u>Total Resources</u>	<u>Recoverable Reserves</u>
	(Thousands of Megatonnes)	
U.S.S.R.	5 713	136
U.S.A.	2 926	186
China	1 011	38
Canada	109	6
Europe	608	127
Other	<u>388</u>	<u>58</u>
	<u>10 755</u>	<u>551</u>

Current world production is about 2 300 megatonnes per annum, which gives world reserves a life of about 240 years at current consumption rates.

By contrast potential cumulative total world oil reserves have been estimated around 300 000 megatonnes of which 41 000 megatonnes have already been produced. Reserves in 1973 were estimated around 92 000 megatonnes, yielding a reserve life of only 33 years at the 1973 consumption rate of 2 780 megatonnes. Taking reserves plus historical production, we also therefore have fairly low expectations of new discoveries.



One quotes these numbers with extreme hesitation, because definitive figures would demand a godlike omniscience, and writers in different countries use widely different assumptions and discounting factors. They are, however, the best information we presently have, and we use them hoping that they are sufficiently correct in orders of magnitude to allow reasonably accurate decisions to be taken. If nothing else, they certainly explain the renewed world interest in coal.

At this point it is worth noting that recoverable reserves are expressed as being only a small proportion of total resources. We have had a great deal of fairly emotional talk about wasteful mining in South Africa over the last few years, and it is perhaps worth bearing in mind that the low percentage recovery is a worldwide problem, not just a local one. For interest, it also applies to oil and other fuels. Putting South Africa into this picture, the Coal Advisory Board report of 1969 estimated South African reserves as being:

Total Resources	37 thousand megatonnes
Saleable Reserves	18 thousand megatonnes

At current consumption rates of 60 million tons this yields a 300 year life, which is much better than the world average.

The reserve figures quoted have, however, been queried by the South African mining industry, which feels the actual reserves are much higher. It must, however, be emphasized that one cannot accept that our own reserve estimates and those for the world are necessarily prepared on the same basis of estimation.

If one assumes exponential demand increases, however, one can quickly reduce all reserve figures to frighteningly small future cover figures. But speaking pragmatically, the people in the coal industry in the major producing countries have not yet come to regard reserve shortages as a significant problem, and for practical decision making we have no choice but to continue working on this assumption.

#### Various Coal Types

We are all familiar with the broad divisions of coal, in descending order:

Anthracite  
Coking Coal  
Bituminous Steam Coal  
Lignite or Brown Coal

For reasons of space we shall concentrate on steam coal which is the main interest for the energy market. Anthracite is scarce worldwide, and good coking coal very scarce. It is, however, hoped that research will remedy shortages within a few years by the production of substitutes from coals of lower rank.

#### World Production

The larger national producers of coal during 1973 were as follows:

1.	U.S.A.	597 million tons
2.	U.S.S.R.	510
3.	China	410
4.	Poland	156
5.	U.K.	130
6.	Germany	97
7.	India	78
8.	South Africa	62
9.	Australia	60

These nine countries together produced 2 100 million tons of coal, or 91% of the global figure of 2 300 million tons, in 1973. If world coal demand continues to expand, the only country presently expected to join the "big league" is Canada which, like Australia, will produce mainly for export.

#### A Landlocked Industry

Excluding Australia, coal has been very much an internal consumption industry, as is evidenced by the fact that the world sea-borne coal export trade is running around 110 million tons annually, or under 5% of total world consumption - and the bulk of even this relatively low figure is coking coal. For practical purposes, therefore, coal had by 1973 dwindled to an almost insignificant contribution to the internationally traded world energy supplies, which have been almost totally dominated by petroleum products, of which sea-borne trade was equivalent to 2 200 million tons of coal annually.

The fact that coal is now again being seriously discussed in terms of the international energy market therefore represents a virtual revolution in energy thinking.

We must, however, at the same time maintain our perspectives. Even the largest practicable increase in steam coal moving internationally for energy production in the next decade, will still leave oil as the dominant fuel, and for the world as a whole we must regard coal as a supplementary rather than a dominant source of energy, even under today's circumstances.

So far we have simply talked about "coal". Let us have a slightly closer look at our subject. The range of variation in steam coal qualities might help us to understand how many different products we are in fact discussing and how easily generalisations can become nonsensical.

A broad analysis of the range of bituminous coal presently produced in South Africa, with top and bottom quality ranges and the end products of combustion of coal constituents, is given below.

	<u>Bottom Quality</u>	<u>Top Quality</u>	<u>End Product</u>
Calorific Value Mj/kg	20,1	30,3	
Fixed Carbon %	42,7	66,1	Heat
Volatile Matter %	27,0	22,7	Some heat, but mainly air pollution
Ash %	27,6	10,1	Mainly a waste disposal problem plus limited pollution
Sulphur %	2,8	0,4	Major polluting element.

Note. The above are more or less normal ranges.  
Bituminous or sub-bituminous coals go right down to products with the following analyses:

Calorific Value	16,1 Mj/kg
Fixed Carbon	29,6 %
Volatile Matter	22,3 %
Ash	46,5 %
Sulphur	6,0 %

At what point does one draw the line and decide that the quality is so low that it is not worth mining or including in the national energy reserves? This dividing line is, like that for all other minerals, tending to move lower over time. This creates one of our first major uncertainties. There is no such thing as an absolute world or national reserve figure, merely a very wide range of qualities and prices.

### Transport Costs

Having quoted a coal analysis, let us use it to pinpoint the essential features of the coal market.

The fact that about half the weight of coal as indicated above consists of unwanted or useless ingredients provides a very good explanation for its eclipse over the past few decades. As nobody wants to move two tons to get one useful ton, plus a major pollution-cum-waste disposal problem, it is obvious that transport is a major factor in coal utilisation. This problem is aggravated because bulk solids are not normally as convenient to transport as bulk liquids. In South Africa best quality coal selling at the controlled pithead price of R2,58 per ton doubles its price after about 300 km, i.e. it costs as much to move a ton 300 km as the producer receives for mining it. To move a ton worth R2,40 to the producer 1 600 km from Witbank to Cape Town costs the consumer around R7 in transport charges. The ruling value of coal in Europe is in the R20 - R25 ton range, and the export structure can be rounded off as follows:

Railage from mine to port plus harbour charges		R 5
Shipping costs to Europe	...	R10 plus
Price to mine	...	<u>R 5 plus</u>
		<u>R20 plus</u>

Transport, therefore, accounts for at least 75% of delivered price.

This gives us a few important characteristics of the coal market:

- (a) Coal is most effective when consumed at pithead without transport costs. This is the secret of Escom's very cheap electricity in South Africa, where coal has managed to expand its market and keep other fuels out of contention right through the period of declining usage elsewhere, because it moves on a single conveyor belt from pitmouth to power station.

(b) If transport is unavoidable, far off customers should buy highest possible coal quality.

For example, if one works on the heat units in coal, one might expect that a buyer would regard prices of R5 for a 25 Mj/kg coal and R5 x 116% (i.e. R5,80) for a 29 Mj coal (25 Mj x 116%) as equivalent. But in fact on the export transport cost structure of R15 per ton quoted above, the buyer could pay up to R8,20 at pithead for the equivalent delivered cost in heat units, because he is paying transport costs on more concentrated energy.

### Research Directions

The other obvious point to be made from this analysis is the means of improving coal's acceptability and competitive posture for the future: simply get rid of the sulphur, ash and volatiles and put it into a conveniently transportable form. This is precisely what the major research programmes in the United States are aiming to do and have in many instances achieved in pilot plants. The consumer is also being given his choice of his refined energy in gaseous, liquid or solid form, and there are very few source materials which can offer this option.

This is not just salesmanship. In the U.S.A. there is a very extensive pipeline system for distribution of natural gas, which is beginning to become scarce. Coal gas is being transmitted instead. Sasol, of course, also supplies gas to the Reef complex.

If we take gas from coal plus Fischer Tropsch synthesis, we have oil from coal. Other techniques of liquefaction are currently under intense investigation overseas, and are expected to reach the commercial operation scale by the 1980 - 1985 period.

Another very interesting technique is the Solvent Refining of coal. In layman's language a solvent derived from coal is used to separate the energy containing carbon from the waste and polluting materials. The end product has an identical very high calorific value, with minimal sulphur and pollutants, regardless of the coal source from which it comes. It is

a solid, but with a relatively low melting point if it is desired to reduce it to fluid form.

For us in South Africa these techniques are very exciting, as they indicate the route by which our large, but mainly very low grade, coal reserves might one day enter the international market in a form which minimises the incidence of transport costs on heat values, or which produce pollution-free fuels.

### The Future of Coal

Having described our present position, "warts and all", let us look at our future. This falls naturally into a few phases:

- (a) The next five years. One cannot use coal if one does not have appliances designed to burn it. The immediate result of the oil crisis is that dual-fired appliances will tend to convert from oil to coal. A very large immediate jump in demand is not, however, really very likely, because the new appliances and coal handling facilities cannot physically be built in time. New coal production facilities can also not be multiplied too quickly in the short term.
- (b) The next five to fifteen years. Here the world energy industry requires the wisdom of Solomon. Oil may be scarce and expensive, but the position may improve. Nuclear power from breeder reactors may be "just around the corner". This means that present generation nuclear plants face possible early obsolescence, but new plants face teething troubles. There will probably be considerable scope for coal as an interim fuel. Even this small section of the world market will involve a very large new demand for coal. Decisions must be taken on a time scale of about 5 years to construct a new power station, at least 3 years to start a mine, and possibly at least 5 years for new harbours, etc.
- (c) Beyond 1990. With the exception of abnormally favourable circumstances, such as South Africa's pithead power stations, one cannot really forecast a long-term demand for coal in unprocessed form as a direct fuel. It has too many disadvantages, and it will require processing to find its place in the energy equation.

### Oil from Coal

It is a sincere compliment to Sasol that any talk of coal processing immediately jumps to "oil from coal". But coal should not be regarded as the only source of energy for transportation. Oil has been so cheap that energy research has not been worth while. In today's changed circumstances we are likely to see a steady stream of new fuels over the next decade. Without restricting ourselves to any particular use, we should simply accept that our coal will be wanted in a concentrated, non-polluting, easy to transport form. We might, within a decade, even be using it to produce proteins, which also are becoming very scarce.

### National Policies

The above expectations of the duration of revived coal demand and the potential for coal processing are fairly generally shared at present, but national policies differ fairly widely.

The U.S.A. is encouraging a doubling of its already massive output, but it is a wealthy enough country to enforce simultaneously strict regulation of safety procedures and measures to protect the environment, which will add substantially to the production and consumption costs of coal.

Britain will spend huge sums in an effort to bolster its flagging output, primarily for home consumption. Here it is interesting to note that this huge expansion programme has been launched despite Britain's expectations of North Sea oil.

Canada and Australia do not use a great deal of their own coal, but they will substantially increase export production. The Australian Government in particular seems anxious to ensure that export customers pay a satisfactory price to the producer.

In South Africa, the Government has co-operated very constructively with private enterprise in anticipating the energy crisis by deciding in 1970 to go ahead with Richards Bay, thereby gaining three very valuable years. Ever since that decision, however, the voice of the conservationist has been growing ever louder in the land, and there is strong pressure being exercised against all coal exports on the ground that we need all our energy reserves for ourselves. This is perhaps the biggest issue in the

local industry and worthy of more detailed attention.

Conservation of National Reserves - Pro's and Cons.

Our argument started with the publication of the Coal Advisory Board report of February, 1969. This report reduced previous estimates of very large reserves to a figure of 37 billion in situ, of which only 18 billion might be saleable. Of this total, 9½ billion was indicated as being in the quality range 9 to 11 lbs/lb, which is very low indeed, and 6 billion in the mediocre 11 to 12 range, leaving only 2½ billion in the good quality range of plus 12 lbs/lb. The demand side was then projected and the conclusion drawn that, at a 4% annual growth rate, total reserves of all qualities would be exhausted by the year 2023. At a 5½% growth rate reserves would be exhausted by 2013. (An independent study by the Atomic Energy Board estimated exhaustion by 2015).

The coal mining industry objected violently to this report, and the Petrick Commission was subsequently appointed to study the position again. No report has yet been published, but on the information submitted to the Commission by the mining industry it is possible that the estimated reserves may be about twice as large as those previously estimated. No matter how large reserves are, however, a technique of doubling demand estimates every few years must eliminate them very quickly.

The Department of Planning has recently published energy balance studies indicating that South African coal production will peak at about 200 million tons in the year 2026, declining steadily thereafter to an annual production of about 20 million tons by the year 2100. By far the greatest consumer will be Escom. These studies do not attempt to alter the reserve estimates, but treat the estimated demand in a more sophisticated fashion, making the studies thus somewhat more realistic. They were completed before the full impact of the energy crisis was felt, and they may thus understate the requirements for further Sasols. They also ignore export possibilities.

Our coal marketing specialists, the Transvaal Coal Owner's Association, have produced estimates of the tonnages South Africa could reasonably expect to export for the rest of the century, based on foreign demand and other supply sources, as well as our qualities and ability to produce.



These estimates are, in million metric tons:

<u>Period</u>	<u>Average Annual Tonnage</u>	<u>Cumulative Tonnage Sold</u>
1976/80	15	75
1981/85	25	125
1986/90	35	175
1991/95	45	225
1996/2000	50	<u>250</u>
	<u>Total</u>	<u>850</u>

Could our reserves stand this level of export? On the 1969 Coal Advisory Board figures this total represents about 1½ years' usage between around, say, mid-2021 and 2023. The later, more sophisticated, projections of the Department of Planning would probably allow a slightly higher rate of annual output over the next century. Both answers are in any event well within the scope of the mathematical error inherent in the assumptions as pointed out above, and there appears to be no question of quantitative problems.

Could the quality of our reserves sustain exports of this volume? This is a much more relevant question, and the argument is too complex to be considered in detail here, as it quickly reaches the point of arguing about what types of fuels, from what sources, will be in use by the turn of century. As soon as non-polluting Solvent Refined Coal is freely available, it will be so superior to our present high-grade coal that the high-grade coal will simply be unsaleable as a direct fuel, and will merely be useable as a source for Solvent Refined Coal which can be equally satisfactorily made from low-grade coal.

Thus, if we as a country decide on a policy of total conservation of high-grade coal, we will forego the foreign exchange earnings on, say, the above 850 million tons at an absolute minimum of R15 F.O.B., equivalent to R12 750 million. Should sophisticated fuels become a reality, our conservationists will then have cost our country a fantastic volume of badly needed foreign earnings, with no corresponding long-term advantage.

On the other hand, if we deplete our higher grade coal too early, we will

have to use medium grade coal domestically, involving higher transport costs per heat unit, but without any significant effect on coal availability.

#### An Individual Forecast

I have a personal predilection towards assuming the development of sophisticated fuels, because the world as a whole needs them so badly. For this reason I rather believe that the conservationists are repeating the allegedly standard military error of fighting the previous war all over again. If we export our high-grade coals and improved fuels fail to materialise, the worst that can happen is that domestic consumers will have to be satisfied with medium-grade coal, or convert to electricity or gas made from low grade coal. For this risk R12,75 billion is fair consolation.

The cynic would, of course, argue that this is a logical attitude for a coal producer, but I believe the United States Government at least shares my view. Their Project Independence, designed to rid them of all reliance on imported energy, is being worked up by Congress to a 10 year, 20 billion dollar, research programme. Results already achieved in their research indicate that we will be discussing a totally different fuel position within a few years, and that current preoccupation with coal in the raw form, as we know it, will simply be a joke.

Coal will, however, be required for processing to the maximum extent to which production facilities can be increased, and for this we require a healthy, steadily increasing industry.

The increased mining, plus processing, will demand enormous increases in the availability of capital, scientists, professional miners and specialised machinery, and these may in fact prove to be the biggest limiting factors facing the industry world wide. They can be made available by organic growth, but they will certainly not be available at some theoretical date in the future, unless they are steadily built up in the present.

COMMENT

George Palmer

We are indebted to Mr. George Clark for his characteristically frank and provocative approach to coal's central policy problems. I intend now simply to make a few layman's comments on the central points of his paper.

In my view one of the really pressing issues that we have to confront soon, is whether we should take the fullest advantage of whatever export opportunities develop in the coming years, and so maximise our foreign currency earnings from this key energy resource; or whether we should rather conserve it and keep it for our own domestic needs.

As you have heard, Mr. Clark's conclusion was quite clear. He conservatively estimated that R13 000 million approximately could be earned from potential exports of some 850 million tons of coal between 1976 and, say, the year 2000, assuming a conservative price of R15 per ton. His conclusion clearly is that this is a "bird in the hand" that we should go for, and indeed there is no guarantee that the development of alternative energy sources, such as uranium, harnessing the sun, etc., will not, over the next three decades or so, devalue the coal resources which we might otherwise succeed in conserving.

On this issue, then, Mr. Clark comes to the opposite conclusion from that which was reached, for example, by Dr. J.C. Vogel and others, to whom Dr. Stutterheim has referred, and I think it is worth repeating the central argument of these conservationists concerning the relation of exponential growth to resources.

In the July, 1974, issue of "Nuclear Active" (the Journal of the South African Atomic Energy Board) Dr. Vogel wrote an article entitled "The Coal Fallacy". In this article he argued that, if the curve of the expected production of coal follows the curve that Dr. Stutterheim referred to (i.e. the traditional bell-shaped probability curve associated with the utilisation of major mineral resources mined by a large number of comparatively small units), then, if one assumes an exploitable reserve totalling some 19 000 million tons, peak production

of about 159 million per annum tons would be reached by about the year 2054, or in 80 years time from now. Even if one assumes the reserves to be 50% larger than that, say 28 300 million tons, peak output would rise to 205 million tons annually and be reached only 20 years later in about the year 2074.

However, and I think this is Dr. Vogel's main point, long before either 2054 or 2074, supply will be lagging behind demand to such an extent, that economic growth will be seriously retarded if no substitute energy resource is discovered.

When one assumes the long term average growth in the demand for coal (and 4% per annum exponential growth is assumed, against for example Escom's experience of something like 9% per annum growth in power output, which incidently last year expanded by almost 12%) and one sets this projected demand curve against this Sauss curve, Dr. Vogel comes to the conclusion that already by 1984-86 demand for coal will exceed output by 20%, and that serious shortages will develop. There will be a corresponding rise in the coal price, which he argues will in turn adversely affect the cost of electric power. He concludes that in order to avoid this, nuclear power stations will have to contribute at least 12% to total generating capacity by 1990.

Thus Dr. Vogel's conclusion for coal conservation policy is that South Africa's coal reserves are strictly limited and a considerable shortage can be expected in the years to come. I quote from his article: "In fact coal will become a scarce commodity in South Africa long before it will become so in the world, and serious consideration should be given to its conservation. If one adds to this the increasing value of coal as a resource material for the petro-chemical industry, it seems imperative that conservation measures should be initiated soon and earnest attention be paid to the development of other resources of energy."

The policy alternatives facing South Africa could thus not have been more crisply posed by Mr. George Clark, on the one hand, and by the advocate for conservation from the National Physical Research Laboratory, Dr. Vogel, on the other hand.

As Mr. Clark points out, of course, coal's export potential depends upon how competitive South African supplies will be at the point of delivery. This depends much more on the trend in the cost of rail transport from the mine to port, handling and freight charges, as well as transport costs to the point of consumption, than on likely upward trends in the cost of coal at the pit head. These on-costs are about 75% of the delivered price of coal to export markets, and payment accrues to the suppliers of services, with only 25% to the mine. Price is thus largely in the hands of the South African Railways and Harbours, and of the shipping lines providing the bulk carriers that substantial coal exporters require.

This brings me to a major point that Mr. George Clark did not deal with - perhaps because he was reluctant to appear as a spokesman for a vested interest - namely the question of price policy. Discussing coal's future without examining the effects of price policy is like trying to stage Hamlet without the Prince. For the relative costs and prices of the various sources of energy - coal, nuclear power, oil, gas, hydro-electric power and so on - must be a major factor determining their market shares in South Africa and abroad, and therefore in determining the rate at which they are assessed.

Certainly, until the oil crisis came to a head at the end of last year, the price of coal - whether as determined for collieries supplying Eskom, or for the general coal trade - was too low to attract investment on the scale needed, if coal is to achieve the larger market share that the oil crisis now suggests is desirable. In the case of Eskom contracts, the coal producers are facing a monopolistic buyer with the ability to resist price increases. In the case of the general coal trade, the price controller sets prices according to a formula which, in providing for a maximum return of 2½% on historical investment, makes no allowance whatever for the steep rise in capital replacement costs.

The general result, therefore, has been that, in competing for new finance in today's overstrained capital markets, coal producers have extremely serious handicaps. Indeed I should like to pose the question as to whether anyone in his right mind would today commit risk capital to an undertaking yielding a fixed ceiling return of 12½%. Since, for most industries, the cost of coal is not an important item, one must conclude that government is, in effect, subsidising a major consumer, the South African Railways, and also, though perhaps to a lesser extent,

Iscor, at the expense of the coal mining industry.

What is needed is a more realistic pricing system which relates coal prices more closely to real costs. First of all, this would result in improved methods of extraction, by making better methods worthwhile installing. Secondly, higher coal prices would lead to improved methods of heat extraction and so reduce the heat wasted in burning coal today. Thirdly, more realistical pricing would end the technological stagnation in industry. Fourthly, it would allow industry to expand in the way that is now desperately needed. The historical or capital cost in the industry is roughly R4 per ton of coal. The replacement cost of that capital today is more like R14, and it is still rising.

I should like then to pose this related question: Is it possible for us to have a rational energy policy at all, unless free market forces affecting trade and consumer preferences, technological advances and long term cost and supply conditions, are allowed to have their full effect on relative prices? In my view one of the first steps towards evolving a more rational energy policy in South Africa is to scrap price control. Its retention is bound to distort the necessary adjustment process, to lead to wasteful overconsumption and debilitating under-investment, and to render suspect all predictions of future demand and supply.

Under the circumstances, can there be any doubt as to the compelling economic logic of Mr. George Clark's case for allowing as much coal to be exported as world markets can take at profitable prices, and which our transport system can carry economically to the coast? Is not the "bird in the hand" of R13 000 million of foreign exchange worth more than having an additional 850 million tons in hand in 80 years time, representing in any case no more than a year and a half's production?

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THE FUTURE OF NUCLEAR ENERGY :  
SOUTH AFRICA IN RELATION TO  
WORLD DEVELOPMENTS

J.W.L. DE VILLIERS

Comment by

I.F.A. DE VILLIERS

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## Introduction

The first conference on the peaceful applications of nuclear energy was held in Geneva in 1955. It is perhaps significant to note that even before this conference, in 1951, the first electricity had been produced by a nuclear reactor at the National Reactor Testing Station near Idaho Falls in the USA. It is perhaps even more significant that this first nuclear electricity was produced by the Experimental Fast Breeder Reactor - EBR-1. In June, 1954, a 5 MW(e) graphite moderated, watercooled power reactor started producing electricity at Obninsk near Moscow in Russia. At the Conference in 1955 views were confidently expressed that nuclear power would, apart from other applications, find immediate and widespread application for the generation of electricity. Although progress in the commercial application of nuclear energy has been slower than was optimistically predicted during this conference, it was abundantly clear during the third Geneva conference in 1971, that nuclear energy had attained its maturity. The relatively slow progress in nuclear energy application during the intervening 16 years was not altogether unexpected : Firstly, many developing countries had only started developing domestic resources of fossil fuels at the time when nuclear plants became available. Secondly, the trouble-free operation of large, commercial nuclear power stations of differing designs has been proven only in the course of the last decade, and the tendency has been for the developing countries to let those countries which could best afford it, bear the cost of the engineering improvements. Thirdly, because nuclear power plant is capital intensive, the unit power cost is particularly sensitive to plant size. Because of this, the manufacturers of nuclear power equipment concentrated their efforts on the largest possible plants acceptable to the supply systems of their own countries. This affected the competitive position of nuclear stations in the smaller and developing countries through the limitation on the maximum size of such installations imposed by the relatively small capacities



of the supply systems into which they would be connected. Fourthly, most countries had to embark on preparatory educational and legislation programs, and had to cope with the problem of financing the substantial outlays of capital required for the introduction of nuclear power.

Despite these factors, and the accelerated inflation which affected the capital intensive nuclear plants particularly, it was proven even before the oil problem of October 1973, that nuclear power plants in sizes of the order of 1000 MW(e) and larger, were economically competitive in many situations and could be operated safely within the stringent controls set down by the authorities. The oil problem has therefore only served to add momentum to the rapidly increasing orders for nuclear power plant, in that most countries are more than ever desirous of being less dependent on petroleum as far as their power needs are concerned.

For example, <sup>(1)</sup> by June 30, 1974, the United States had 203 400 MW(e) of nuclear generating plant in operation or on order, and it might realistically have a nuclear capacity of 280 000 MW(e) operational by 1985. In France it has been announced that all future stations are to be nuclear. This means that 20 plants in the 1000 MW(e) size range will have to be commissioned between now and 1980. (Twelve PWR's have already been ordered by EDF). Likewise Germany has also assessed that she will require an additional 19 nuclear stations with a total capacity of 18 800 MW(e) by 1980. Japan's nuclear capacity will exceed 5 000 ME(e) by the end of this year, while Taiwan is planning to have 8 nuclear power stations with a total capacity of 7 742 MW(e) in operation by 1986. Even Iran is "going nuclear".

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(1) The Reuter Applied Atomic's Report (EEC Estimates) July and August, 1974

This is current proof of the rapid development that is taking place \_\_\_\_\_ in nuclear power and serves to underline the fact that nuclear energy has taken its rightful place among the other methods of producing electrical power.

World Energy Demand (2)

The future of nuclear energy must be seen in relation to the projected total energy production by all means in the world. Over the two decades from 1950 to 1970 the total world energy consumption rose at a rate of 5,2% per annum overall and 3,3% per annum per capita, almost trebling from about 22 million million KWh(th) in 1950 to about 60 million million KWh(th) in 1970.

Up to the turn of the century, the overall per capita growth rates are likely to decrease only marginally; the slowing down in rates of growth of per capita consumption in industrial countries being substantially offset by the acceleration likely to take place in developing countries. A correlation of energy consumption with relatively modest per capita increases in gross domestic product indicates a possible quadrupling of energy demand by the year 2000, reaching a level of 240 million million KWh(th). (Other projections give very much higher figures, for example, Häfele<sup>(3)</sup> predicts a 9 fold increase over the 1970 figures by the year 2000). The rapid increase in total energy consumption over the past 20 years has been accompanied by radical changes in the shares of the different fuels in the production of energy. For instance, the ratio of solid fuel to gas and liquid fuels which was close to 3:2 in 1950, was completely reversed, so that petroleum and natural gas accounted for more than 60% of the total energy production by 1970. Nuclear fuel contributed less than 0,5% at this time.

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(2) Purik Kryman : IAEA Bulletin. Vol. 15, no. 5 (1973)

(3) W. Häfele : IAEA Bulletin. Vol. 16, no. 1/2 (1974)

This stupendous rise in the use of liquid and gaseous fuels was to a large extent based on the low pricing policies made possible by the development and exploitation of extremely low cost reserves in the Middle East and North Africa. A combination of commercial, political and social factors led to the current energy problem, generally referred to as the oil crisis, representing a discontinuous jump in energy prices when the Middle Eastern countries, which were the leaders in the downward price trend, became the leaders in the upward swing.

The previous disadvantage of nuclear power plant, namely its high capital cost, might become an advantage in that, where the total nuclear fuel cost contributes but approximately one fifth to the unit cost of electricity produced by the current water reactors, and approximately  $\frac{1}{4}$  of this is attributed to ore costs, a doubling of the uranium price would constitute only a 5% rise in the unit price of electricity.

#### Predicted Growth of Electricity Production

A further trend that deserves attention is that the market share of electricity is on the increase. It is within this region of the energy market that nuclear energy is expected to have the biggest impact, as the development of nuclear energy has up to the present almost exclusively been directed towards the generation of electricity. The share of electricity in the total energy production has increased from 18,7% in 1960 to 25% in 1970 and is expected to grow to 31% in 1980, 39% in 1990 and 40% by the year 2000.

From a modest contribution of less than 2% in 1970, nuclear electricity generation is expected to contribute respectively 21%, 45% and 55% by 1980, 1990 and the year 2000 to the total electricity production. This would mean that of the total energy production, the contribution by nuclear power is expected to rise from less than 0,5% in 1970 to 6,6% in 1980, 7,5% in 1990 and 27,7% by the year 2000.

In terms of total energy consumption these figures may seem to indicate that the rôle of nuclear energy as a potential substitute for fossil fuels is relatively limited up to the year 2000. It does, however, imply a growth rate of 40% per annum for the next 10 years and approximately 10% per annum thereafter. One must remember that the total fossil fuel resources are limited, and serious shortages in oil and gas are expected in the beginning of the 21st century. Estimates<sup>(4)</sup> show that 80% of the world's ultimate oil reserves will be consumed during the next 58 years. (The relatively large resources contained in oil shales and tar sands could only be exploited at high cost). The estimates for coal are more reassuring, indicating about 80% depletion only after approximately 300 years.

Fossil fuel prices can, therefore, be expected to rise further, so that an increased penetration of nuclear energy may be required. Such an increased expansion in the share of nuclear energy by the turn of the century could be achieved by various means :

Firstly, an increased nuclear share in the total electricity production would require that nuclear power stations be operated in the demand region of the load curve, where in the past, because of their relatively high capital cost, they have always been used as base load stations.

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(4) Uranium Resources, Production & Demand :

Joint NEA/IAEA Working Party Report (August 1973)

Secondly, an increase of the share of electric energy in the total energy demand would call for the development of individual and mass electric transportation systems, as well as for more efficient electrical industrial and urban heating systems.

Thirdly, the development of applications of nuclear heat to industrial processes such as steelmaking and coal gasification and the use of the waste heat of nuclear power stations for water desalination and urban heating, will be required.

These possibilities will call for an increased effort applied to the development of high temperature reactors, and to the urban siting of nuclear stations. Apart from the required engineering developments mentioned above, the application of nuclear energy in these fields would call for the solutions of problems inherent in the rise of a radically new technology, such as : Safety and environmental constraints; waste disposal problems; the optimal use of economic and industrial resources in the available time; avoidance of short-term price fluctuations which has so frequently occurred for other fuels in the past; the setting up of efficient prospecting policies for uranium, and lastly but equally important, the education of the public to accept this new technology.

#### Nuclear Fuel Resources (Uranium)

Apart from research and development efforts, the increased application of nuclear power must be based on the assumption of the continued availability of nuclear fuels - notably an assured and adequate supply of uranium.

A world survey by the joint Nuclear Energy Agency / IAEA Working Party<sup>(5)</sup> on "Uranium Resources, Production and Demand", indicates that from a present production level of just over 19 000 Te/year, the demand (for the medium growth case) will rise to an equivalent annual production requirement of 60 000 Te/year by 1980, 100 000 Te/year by 1985 and 160 000 Te/year by 1990.

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(5) Uranium Resources, Production and Demand : Joint NEA/IAEA Working Party Report (August 1973)

These forecasts imply that the uranium production industries will be called upon to plan for a nearly 10 fold increase in production over a period of 16 years - a truly formidable task. It might mean that possibly up to 10 times the present number of uranium mines will have to be planned and brought into production by 1990.

The NEA/IAEA Study shows that present below \$10/lb "Reasonably Assured Resources" (Equivalent to Reserves in the mining sense) amounted to 866 000 Tonnes of uranium at the middle of 1973. About one quarter of this is allocated to South Africa. Of the "Estimated Additional Resources", of 196 000 Tonnes (below \$10/lb  $U_3O_8$ ), only about 8 000 Tonnes were allocated to South Africa.

The figures for Reasonably Assured Resources in the price range of \$10 - \$15/lb are 680 000 Tonnes with an "Estimated Additional Reserve of 632 000 Tonnes, with South Africa's share about 62 000 Tonnes and 26 000 Tonnes respectively. This means that South Africa's share of the free world's reasonably assured resources of uranium up to \$10/lb  $U_3O_8$  is approximately 25%, and of the total reasonably assured resources below \$15/lb  $U_3O_8$  it is of the order of 17%.

South Africa is therefore in an excellent position as a supplier of uranium to the free world.

In view of the fact that the demand for uranium is expected to increase sharply from the beginning of the eighties, the South African uranium industry, which in the past has been founded on a sound basis, will have to do everything in its power to ensure that not a single kg. of uranium is lost in a manner that will result in its subsequent recovery being uneconomical.

If all of the world's present low cost reserves could be made available, they would just be sufficient to provide fuel up to approximately 1987, but if a forward reserve equivalent to 8 years' consumption is maintained

to assure supply at the projected rate, a satisfactory reserve situation would only be maintained up to about 1979.

If no new exploration efforts are undertaken up to 1979, the annual discovery rates thereafter would have to be of the order of 150 000 Te per annum. Such a discontinuity in exploration efforts should definitely be avoided.

A desirable reserve position, resulting from an orderly planned increase of the mean discovery rate of recent years (Approximately 65 000 Te U per year) to a rate of 230 000 Te U/year in 1990 should be the objective of the uranium industry, thereby maintaining an eight year forward reserve up to 1990.

The magnitude of this challenge becomes apparent when viewed in relation to the lead time required to bring new discoveries into production.

It seems therefore that although no shortages of uranium supply should be expected until 1979, the rapid growth in demand thereafter cannot be satisfied on the basis of the present exploration activities. With a lead time of about 8 years between discovery and production, it is essential that steps be taken now to increase the exploration rate for uranium so that an adequate forward reserve can be maintained.

### Breeder Reactors

Although the situation as set out in the preceding discussion seems alarming, one need not be unduly pessimistic, as technological developments such as the recycling of plutonium and the breeder reactor will serve to alleviate the position to a large extent. The primary justification for development of the fast breeder reactor system lies in its utilisation of uranium, which is better by a factor of about 60 than is possible with thermal reactors alone. This gives rise to lower basic fuel costs and

reduces uranium ore requirements, which can have considerable strategic and economic significance. The lower fuel costs, even after allowance for the differences in plant capital costs and in costs for fuel fabrication and reprocessing, offer the potential for lower power costs from fast reactors than from thermal reactors. Early recognition of these potential advantages has led to substantial research and development of the fast reactor system, since the early 1950's, mainly in Russia, France, Britain and the USA. The result of these efforts has been the construction of these prototype power stations, all utilising sodium cooling, two of which are already producing power. BN 350 in Russia and Phenix (250 MW) in France are feeding electricity to the grid, whilst the PFR in Scotland is expected to reach full power well before the end of 1974.

Extensive development facilities have provided substantial experience and understanding of the technology of this system and have brought it to the threshold of commercial exploitation.

The next important step will be to obtain operating experience with the prototype reactors, including the acquisition of additional data on fuel and component performance that will give confidence in the commitment to construct large commercial stations.

On the subject of fuel, it is relevant to note that the approximate effects of changes in fuel prices on power generation costs are as follows : (1973 figures).

Fossil fuel	A 100% increase in fuel costs increases generating costs by 60% (European conditions)
Thermal reactors	A 100% increase in ore costs increases generating costs by 5%



Fast reactors

A 100% increase in ore costs increases generating costs by less than 1%

It is therefore obvious that the incremental fuel cost for the breeder reactor is extremely low. As a result, the extraction of uranium from very low grade deposits - for example for granites, basalts or even seawater, might become an economic feasibility. As stated previously the predicted rate of growth of world nuclear power capacity will require a tenfold increase in current rates of production of uranium by the year 2000, even with the introduction of breeder reactors. Without breeders, the demand by then would be over half as much again and would be increasing rapidly. Despite intensified uranium prospecting activities, the price of uranium is certain to rise substantially. It is for this eventuality that a viable design of the Commercial Fast Reactor is being prepared. There is no question of a headlong rush into a new technology, and it is expected that the commercial fast breeder will only be installed from 1985 onwards.

The thermal breeder, notably the high temperature gas-cooled reactor, which is in a more advanced stage of development than the sodium-cooled fast breeder, should be capable of utilising thorium as fertile material, to achieve near breeding (or very high conversion efficiency) of U-233 as fuel for subsequent plants. Thus thorium, approximately twice as abundant as uranium, could also be used as a nuclear fuel. Although these new developments will in the long term stabilise the nuclear fuel situation, uranium is expected to remain in short supply at least until the end of this century.

### Fusion

I do not intend to dwell on the possibilities of fusion as a future energy source. Suffice it to say that I am not alone in the opinion that fusion

energy will not provide a significant contribution to the world's energy needs within the next 30 years. However, once fusion energy can be commercially exploited, the deuterium contained in the oceans will provide a virtually inexhaustible supply of fuel for the fusion reactors.

#### Uranium Enrichment

Most of the proven reactor types envisaged for commercial operation over the next two decades, require enriched uranium as fuel. Even if a larger share of the power market is assumed for the natural uranium fuelled heavy water reactors, and breeder reactors are introduced on a commercial scale at an early date, enriched uranium fuelled thermal reactors will have to supply the bulk of the nuclear capacity up to the turn of the century.

Hence the adequate supply of enrichment capacity at the lowest possible cost, is just as important as ensuring a solid basis of uranium ore reserves.

According to the Joint study on Uranium Supply, Production and Demand<sup>(5)</sup> by the NEA and the IAEA, the separative work requirements (for the medium power growth case) will rise from about 10 000 Tonnes separative work units per year (TSWU/a) in 1973, to 40 000 TSWU/a in 1982 and of the order of 90 000 TSWU/a in 1990 even if the installation of breeder reactors is taken into account. The projected requirements are shown to be more dependent on the total nuclear power growth rate than on the particular reactor strategy assumed. If the USA realises its intention to increase the production of its three existing enrichment plants to 27 700 TSWU/a, and a production capacity of 3 600 TSWU/a is assumed for the rest of the free world, the total capacity would reach 31 300 TSWU/a by 1981/82. From these figures it is clear that after 1981, new plants would have to be brought to production - and at a predicted rate of 7 000 TSWU/a each year from 1982 onwards<sup>(6)</sup>.

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(6) Atomic Industrial Forum Forecasts in 1972

(A plant with a capacity of 7 000 TSWU/a would require a feed of 12 000 Te  $U_3O_8$  per year, which is higher than the planned production of South Africa by 1982). If based on the gaseous diffusion process, such a plant would cost of the order of R800 million if erected on the basis of USA technology, excluding the cost of an 1800 MW(e) power station to supply the power required for its operation. These figures serve to underline the tremendous cost of such an undertaking.

South Africa is in the fortunate position to have developed a new process that promises to be substantially cheaper as far as SWU cost is concerned. Nevertheless, the capital required to erect a plant of commercial size, and the industrial effort needed, would still stress our resources to the utmost. However, the rewards, economic and otherwise, which could be realised by the erection of an enrichment plant in South Africa, are of such a magnitude, that all possible efforts should be made to make such a venture a reality.

#### Nuclear Power in South Africa

We are all aware of ESCOM's declared intention of embarking on a nuclear power programme which will begin with the erection of a twin reactor station of 2 000 MW(e) in the Western Cape, planned to come into operation in 1982/83.

If one assumes that our installed nuclear capacity will double every 7-8 years, it would provide about 4 000 MW(e) by 1990 and in the region of 10 000 MW(e) by the year 2000.

The orderly introduction of nuclear power in South Africa could reserve our coal resources for the petro-chemical industry and in particular for the gasification of coal and the production of our own resource of liquid fuel. In view of the current petroleum situation this might be one of the most important considerations for an accelerated nuclear power programme in this country.

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### Fuel Element Manufacture and Reprocessing

The introduction of nuclear power in South Africa would require fuel element fabrication and reprocessing facilities. This demand will increase steadily during the 1980's, reaching 130 tonnes/year in the middle eighties and approximately 300 tonnes/year by 1990. Although a modest fuel development programme is being undertaken by the Atomic Energy Board at the present time, a more ambitious effort in the immediate future is not uncalled for, and in fact has been included in our development programme.

### Conclusion

In the space of this short talk I have attempted to review the future of nuclear power in the world, and South Africa's participation and contribution to it as objectively as possible. I do not for one moment think that the position as sketched presents the whole and final picture, but it does, I think, serve to indicate that a large and continued effort will be called for on the part of the nuclear industry in this country.

Although South Africa's record in this field is one to be justly proud of, there is no reason for complacency, and an even larger and well planned effort on the part of all concerned will be needed to retain our position, and even to improve on it, to enable our country to reap the full benefits presented by this new venture. In this regard I may state - without fear of contradiction - that the greatest need in South Africa today is certainly that of men with trained minds and willing hands, to undertake the necessary research and development to enable us to make these new technologies our own.

COMMENT

I.F.A. de Villiers

As a result of a recognition of a need, the Atomic Energy Board was established as South Africa's own research and development centre. As one who has had some contact with it, I feel certain that it has admirably fulfilled its purpose. It has done a great deal to establish South Africa's prestige in this particular field in the outside world. It has succeeded remarkably well in keeping abreast of progress and development in the scientific and nuclear world, and we have cause to be grateful to the Atomic Energy Board for its achievements. If I venture one or two criticisms, they are not directed at the Atomic Energy Board as such, but uttered more in the sense of comment on general policy and as constructive criticism for future development.

I would like to refer first of all to the question of uranium. It tends, in my view, to be too easily assumed that South Africa is a major producer of uranium and will remain so. The production of uranium in South Africa does not follow the ordinary economic laws which govern the production of uranium in other countries. Until recently the kind of grades of uranium which were economically viable in the rest of the world were of the order of 2½ to 5 pounds of uranium per ton of ore. It is only at these levels that it is economically possible to mine uranium, to mill it, to extract it, and to sell it on world markets. We have practically no uranium of this grade in South Africa. Most uranium in South Africa comes to the surface as a by-product of gold mining. We are, with a few important exceptions, wholly dependent on gold mining, and, if gold mining fails in South Africa, we will have to write off a substantial part of our uranium reserves.

The average grades in South Africa are of the order of half a pound of uranium contained in a ton of ore. This ton of ore is brought to the surface, free of charge, by the gold mining operation; the sludge left after the extraction of the gold is treated for uranium, and it is only on this account that uranium is an economic proposition in South Africa. I have said "with a few exceptions", for there are mines in South Africa with higher grades. An exception also exists in the case of opencast mining, where the mining operation is considerably cheaper and where lower grades are mineable and exploitable. But, by and large, I believe that we should never forget, in South Africa, the almost total dependence of our uranium industry on the viability of the gold mining industry.

As you know, some rather remarkable things happened to the gold mining industry recently. At \$35 the ounce, or, more recently, \$42,5 the ounce, the working costs of gold per ounce obviously had to be kept below that price. At those prices certain grades of ore were mineable and those grades were determined mainly in terms of the gold and not in terms of the amount of uranium contained. If, however, the price of gold increases, the gold mining industry might find it economic to extend its reserves by mining lower grades of gold bearing ore. When the price rose to \$140 and \$150 upwards per ounce the mining industry obviously had to have another look at its grades to decide at what lower levels these would be economically exploitable. It is, in fact, prolonging the life of the gold mine by mining lower grade ores, but it should be remembered that these grades are again determined as a function of the gold price and only marginally as a function of the uranium contained in those ores. Moreover, it is usually the case that the amount of uranium contained in those ores drops as you drop into lower gold grades.

One should bear in mind the effects of inflation as well. The gold mining industry is conducting its business in a way that is justified by the new price of gold. It is, of course, incurring higher working costs.

If it were to continue at the present working costs, but the price of gold suddenly dropped, shall we say, back to \$42,5, there would not be a single mining company in profitable business in this country any more. This is simply because the working costs, on average, are now above \$42,5 an ounce. The industry could, of course, revert to mining only the very high grade ores and it could possibly survive on that basis. This would mean that we would be sacrificing a great deal of gold underground, and I think we would also be losing a lot of uranium in the process. So I would again like to make this qualification, that while our uranium industry is a most important one, a big contributor with an enormous strategic value, we must never forget its almost total dependence not only on the gold mining industry, but on the variable economics of the gold mining industry.

I want to touch now on a rather different matter. We are anticipating in South Africa the advent of a nuclear energy system. I believe the time has come to take a careful look at this and to consider precisely how it is going to be done. What has happened in certain other countries, is that this power system has run into considerable difficulties, notably with the environmentalists, with the conservationists and a large number of splinter groups which have in fact set their faces and minds against the advent of nuclear energy. If we are going to consider seriously introducing nuclear energy on a substantial scale in South Africa we will have to take a good hard look at this. There have recently appeared in the popular press, and there will continue to appear, articles dealing with the great hazards of nuclear power systems. These have built up, in the public's mind, not yet so much in this country but to a large extent in some other countries, a fear of nuclear power. The fear is mostly of an illogical kind as I will try to illustrate. The fear of nuclear power relates firstly to the fact that many people believe these nuclear power stations to be built underground. There is an idea that nuclear power stations are terribly dangerous, are therefore being built in caves

underground and will go on proliferating in caves underground. This is a very real fear, and its existence was confirmed by extensive enquiries conducted to find what it is that goes on in the public mind that makes people hostile to nuclear power stations. This cave syndrome is a very important one; people really believe it.

The other is a fear of radioactivity. Radioactivity is not fully understood by the general public but it is seen as a kind of slow poison that constantly leaks out of nuclear power stations. The idea has been strengthened by popular knowledge of the atomic bomb. People have read that radioactivity can get into the air, into the rain, on the grass, cows then eat it, cows produce milk, the babies drink the milk and suffer radiation damage. This leads to the idea that nuclear power station coolants get into the sea or into lakes, fishes swim through the water, the fish are caught, we eat fish and we become sterile. These sorts of ideas do have some factual foundation, but they are of course highly exaggerated, highly coloured, and people, through this, develop an irrational fear of radioactivity. The fact is that radioactivity is a natural phenomenon - it is all about us. If one looks at the amount of radioactivity naturally present long before the advent of a nuclear bomb or a nuclear power station, one will find that natural radioactivity consists of something like 50 millirems from cosmic rays coming from outside our planet, another 50 mR coming from Terrestrial bodies, that is to say from rocks containing radioactive material and so forth, and no less than 25 mR contained by the human body itself. In our bones we contain enough radioactivity to register 25 mR. As for other sources, apart from natural sources, if you go for an X-ray you will be exposed to 50 mR; if you watch television you will be exposed to 10 mR; if you have a luminous watch, 2 mR. As compared with all these things, the fallout so far into the atmosphere from nuclear bombs has increased your personal radioactive environment by the same amount as you receive from your luminous watch. The increase of radioactivity caused by nuclear power stations is even lower. There are places remote from any kind of fallout, or nuclear power stations which



in fact register far higher degrees of radioactivity, and the body tolerates this perfectly well. What we are dealing with here is something which is infinitesimal compared with an ordinary natural radioactivity which is all around us in this world and was here long before nuclear fission was achieved by man.

I believe nevertheless that this is an important matter. It is no good just indicating the fear or just dismissing it as an exaggeration or a horror story. It is real in people's minds and it has in fact set back nuclear development by years in the USA. As this is a reality, it must be dealt with seriously as an important problem to be overcome in the further development of nuclear energy.

My own belief is that it is time that nuclear power was humanised, that nuclear power was brought into the public orbit, that nuclear power should no longer be a matter dealt with by mandarins isolated in tall towers. I have great admiration for the mandarins, but this matter must also be brought down to the ordinary public democratic level. It is my view, for example, that nuclear power should become a common subject for debate in Parliament. The representatives of the public should be fully acquainted with its cost, with its dangers, with its implications, its importance, and these things should be a matter of active public discussion.

I believe that when a nuclear power station is established in a particular place it should be there by public demand. In other words, through the local democratic process the public should look at the need, should consider the alternatives and reach agreement that they themselves want it. They should not be given the impression, even if it is a false impression, that somebody in a remote place has made a decision and has simply imposed it upon them. I believe that this is not the way to create confidence; it is the way to create hostility and fear, it is not the way to encourage

the acceptance of nuclear power. There is a fear also that it is anti-environmental, that it will do harm to the landscape. With the exception of hydro-electric power, it is quite easily demonstrable that nuclear power causes the least offence in this respect. It does not make any smoke, it does not do any harm and it can be very carefully engineered, very carefully controlled.

That there are certain dangers, would be idle to deny. There is a danger of a malfunction, there is the danger that radioactivity could escape, and nuclear power stations have to be most carefully designed, and are most carefully engineered, to provide for just such a possibility. There is a serious difficulty in that the waste product, the fuel waste, has to be looked after very carefully, because it remains highly radioactive for a long time. Once again the most careful planning is necessary by engineering to ensure that this stuff does not do harm. We have to develop a technique for putting away, or rendering harmless, the nuclear waste products from these power stations. These are real problems that have to be looked after, and I believe that it is the duty of public representatives, as well as the authorities in charge of nuclear development, to make sure that these things are properly controlled and, that the public is given complete confidence in the conduct of nuclear power policy in this country.

What a nuclear power station will not do is blow up like a bomb. The skills needed to make a nuclear bomb are quite considerable, for there are various parameters that have to be most carefully calculated in order to make the thing go off. The nuclear power station, likewise, for it is not easy to create the conditions for a sustained nuclear reaction of the kind that is required to produce electricity for our cities. The engineering required for the one, and for the other, involves two different kinds of technique. In fact, were you to take a nuclear power station and put in some of the best atomic engineers and ask them to convert this nuclear power station into a bomb, they would find that the only way to do

it would be to break it down to the ground and start all over again. So much for the fear that a nuclear power station can act like a bomb! However, I do believe that it is time these questions were brought under public scrutiny and that there were public debates about them, so that the public may have confidence in what is being done.

I believe that the enrichment project being carried out by the Atomic Energy Board is a most admirable one; I believe it holds high promise. I do not know the secrets, but I have no reason to doubt the scientific value and potential of what has been discovered.

There are, however, economic questions which need to be asked. As Dr. de Villiers has said above, this project is going to cost a great deal of money : R500 million or upwards to create an isotopic separation plant in South Africa. I believe that this cost needs to be looked at very carefully. I have no doubt that if the scheme succeeds, if it produces what is expected of it, that it could be a high earner of foreign currency, a greater producer of energy. Nevertheless, there may be other earners of exchange, there are other demands on the public purse, and the mere fact that one particular system, one particular breakthrough, looks likely to produce valuable returns, does not necessarily entitle it to an absolute priority. There must be a system of confrontation, there must be a system of economic judgement, measuring one set of values against another, and I believe that it is not possible for men sitting in high towers to do this in isolation.

I believe that it is the duty of the public to extend its interest into these fields. We have parliamentary standing committees which deal with many things like railways, public accounts, irrigation and so forth, and I think it time that Parliament had a standing committee to look at scientific and technological matters. I believe that it is right at this time,

particularly in consequence of the energy crisis which now obliges us to look hard at the whole spectrum of energy production in South Africa, that there should be some public forum where these things can be discussed, where they can be weighed one against the other, and where decisions can be made. Only if this argument is conducted by democratic method, will the public ultimately have confidence in what is being done.

Table 1<sup>+</sup> shows the approximate installed electric generating capacity in Megawatts of the countries of Southern Africa and how this is divided between thermal power stations and hydro-electric stations. The use of electricity is a measure of a country's economic development, and the leading position occupied by South Africa will immediately be evident from Table 1. South Africa in fact generates about 60% of the total electricity generated in the whole of the African continent.

### South Africa

Before looking at the future, it is worth dwelling briefly on the history of the growth of electricity generation in South Africa and of its present structure. An understanding of the past is necessary to understand the potentialities of the future.

South Africa has the distinction of being amongst the earliest countries in the world to use electricity commercially. Electric street lighting was installed in Kimberley in 1882, a mere 3 years after Thomas Edison began to supply electricity to New York City and even before London had electric lights.

In common with what happened in most countries the supply of electricity in South Africa began under the auspices of the various municipalities. Kimberley introduced a reticulation scheme in 1890, Johannesburg in 1891, Pretoria in 1892, Cape Town in 1895, Durban in 1897, East London in 1899, Bloemfontein in 1900 (under military rule ) and Port Elizabeth in 1906. It was, however, the advent of deep level gold mining on the Witwatersrand which gave a tremendous boost to the generation and use of electricity.

The demand for electric power and light led, shortly after the Anglo-Boer War, to the formation of an electric power supply company to supply electricity to the gold mines. This particular development is significant in that, instead of each large consumer generating for its own use, power

<sup>+</sup>Tables 1 - 5 below at end of this article.

was generated in large central generating stations and transmitted and distributed to the consumers.

The power supply company referred to was the Victoria Falls Power Company formed in 1906. As the name implies, the intention was to harness the waterpower of the Victoria Falls on the Zambezi and to transmit this over a distance of about 1 000 kilometres to the Witwatersrand gold mines. As it happened, that plan was about 70 years ahead of the times, and the Victoria Falls Power Company in the short space of about 6 years commissioned four large power stations totalling over 160 MW, to make it one of the largest power supply utilities in the world and the largest in the British Empire. One of the four power stations was built on a coal mine at Vereeniging. In addition to supplying the gold mines, it also supplied the towns and industries that sprang up round the mines, with the exception of Johannesburg which had its own power station. The Victoria Falls Power Company was a private company whose formation was based on the co-operation of the gold mining houses.

Even before the first world war, the possibility of electrifying the main railway line from Durban to the Transvaal was being considered, and plans for this were again taken up after the war. An eminent engineer, Dr. C.H. Merz, was invited to South Africa to investigate and report on the problem. His report, which went far beyond the needs of electrification of the railways, was to have momentous consequences for South Africa. He reported in part as follows:

"The coal and iron deposits of South Africa, besides other natural resources and advantages, point to a great future for the industries of the country, and, in order that development may proceed rapidly, the adoption of a definite policy as regards electric power supply is second only in importance to the provision of proper transport facilities.

"If such a policy be adopted today, before further industrial development takes place, South Africa will have an advantage compared with other countries, where due to lack of a definite policy on the one hand and the growth of vested interests on the other, power production and distribution have developed piecemeal and at unnecessary high cost."

The South African Government wisely and promptly acted on the recommendation of Dr. Merz, and this resulted in the passing of the Electricity

Act in 1922 and in the establishment of the Electricity Supply Commission of South Africa (Escom) in 1923. Dr. H.J. van der Byl was appointed the first Chairman of Escom and guided it for the next 25 years. In 1948 Escom took over the Victoria Falls Power Company.

At present Escom generates about 84% of the electricity produced in South Africa. About 99% of the electricity generated in this country is produced in coal fired power stations. The one notable exception is the Table Bay Power Station which, a few years ago, was converted from coal to oil firing, as oil was then cheaper than coal in Cape Town. The recent dramatic increase in oil costs has, of course, changed this.

South Africa's coal fields are largely confined to the Transvaal, Northern Free State and Northern Natal. Transporting coal by rail or ship from the coalfields to the Cape increases the cost about fourfold.

As the electricity requirements of the load centres away from the coal fields became large enough it became economical to erect generating capacity on the coal fields of the Eastern Transvaal and build power lines to transmit electric power to the distant load centres. A 400 kV transmission grid has been established connecting the Transvaal with Natal and also with the Western and Eastern Cape. This system also interconnects the Escom generating capacity with those of the few large municipalities which at present still generate the bulk of their own electricity requirements. These municipalities are no longer intending to expand their own generating capabilities, as it will be more economical for them to obtain their future extra requirements from Escom. The growth of Escom, therefore, is practically synonymous with the growth of electricity generating in South Africa. Of the increase in Megawatt-hours generated in 1973 in South Africa, over that of 1972, Escom generated 99,3%.

South Africa is favoured with a relatively abundant supply of coal. Also the coal can be mined at relatively low cost. The bulk of this coal is in the Southern and South Eastern Transvaal. Escom's newest power stations are built in this area, and further ones are planned to be placed there.

The existence of a country-wide network makes it possible to place the

power stations where power can be generated at lowest cost. Also economy of scale can be taken advantage of, in that large sets can be installed. The first of six 500 MW sets at Kriel Power Station will come into operation in 1975. 600 MW sets for a further station will shortly be placed on order. Diversity between the loads in various parts of the country can be taken advantage of, and also a lower margin of reserve plant is necessary. Advantage can be taken of the particular characteristics of various types of plant, so that they can be used to the best advantage. As an example, it can be mentioned that, if the hydro-electric station installed on the Hendrik Verwoerd dam was to supply an isolated local network and provide a firm supply even in dry years, its capacity would have had to be limited to 30 MW. But, being connected to the main 400 kV transmission grid, the hydro-sets can be used for peaking and emergency duty. The station is being extended to double its present capacity of 160 MW to 320 MW.

The existence of the national grid allows the coastal stations, which are the smaller and less efficient stations, to be used mainly for peaking duty, with very considerable savings on high cost of coal. This provides relief, both because less coal need be burnt in the more efficient stations and because the burden of transporting coal by rail to the distant, i.e. coastal, stations in the Western and Eastern Cape and in Natal is reduced.

The development of electricity usage in South Africa is strongly dependent on its cost, while this is probably not so true in some sectors of South Africa's economy, it certainly is so in others. South Africa's gold mines, which still use about 26% of Escom's production, could not have developed without an abundant supply of low cost electricity. The growth and viability of the ferro alloy industry, as well as the aluminium smelting and other metal processing industries, are dependent on low cost of electricity. Table 2 shows how the average electricity cost in South Africa compares with that in some other countries.

Forecasting the future is an occupation fraught with many pitfalls. This was never more so than in the present uncertain times in the world at large and in Southern Africa in particular. When a pessimist was asked why he was a pessimist he replied that it was because he had lived



too long with an optimist. The roles of the pessimist and the optimist in the story could be interchanged. South Africa, however, has so many economic advantages, as well as the will and ability to capitalise thereon, that it can look forward to the future with confidence, if wise use is made of the opportunities and resources.

Electricity plays a more dominant role in South Africa than in most industrialised countries. In 1972 31,6% of the energy used by the final consumer was in the form of electricity. The corresponding figures for Britain and the United States are 16% and 10%. Predictions are that this proportion will grow substantially in the next 25 years. The oil crisis will accelerate this development in South Africa, as the country has substantial coal reserves, and unfortunately oil has not yet been discovered in useable quantity.

Table 3 forecasts the amount of electricity to be used in the Republic and postulates the primary sources of this energy. As will be noted, Escom will become practically the sole generating authority. Thermal generation, i.e. from coal or nuclear fuel, will predominate. The main hydro potential in Southern Africa is the Zambezi. There is only limited potential within the Republic. (This subject is dealt with below in the article by Dr. Henry Olivier.)

It is now known that Escom is planning to build a Nuclear Power Station on the coast about 40 km north of Cape Town. Two sets of between 800 and 1 000 MW each are to be installed. The first one is to go into service late in 1982. The transmission grid makes it possible to use sets of this size. Enriched uranium fuel for these sets will initially have to be imported from abroad. But it is hoped that South Africa will soon successfully launch its own uranium enrichment plant, and that South Africa will then be able to obtain its nuclear fuel at a preferential price and so retain the cost advantage of its electricity over other countries.

Modern power stations with large generating units operate at higher steam pressures and temperatures and thus at increased efficiencies. The thermal efficiencies of Escom's stations range between 18,0% for the oldest and 33,8% for the latest station. Table 4 shows how the average

Coal consumption per unit of electricity generated on the whole Escom system has dropped over the past 25 years. Although the efficiency of future stations is expected still to improve marginally over the best stations now in use, it is likely that future stations will be required to burn coal of a lower quality, i.e. of a lower heat content per kilogram. The coal transported to the distant stations is usually of the best quality, as the high cost of transport makes it uneconomic to carry low quality coal.

The bulk of South African coal is of low heat and high ash content, very abrasive and not of very good grindability by world standards. High capacity boilers use coal in a finely pulverised form. The abrasive quality of the coal, due mainly to silica inclusions, causes rapid wear of the grinding mill elements and also erosion of the boiler internals. Poor quality coal requires larger mills and also larger boilers to reduce gas velocities. It is possible to design a station to burn coal of practically any given quality, but, when once built, it cannot effectively use coal much poorer than that for which it was designed. This has resulted in a certain amount of selective mining to meet the quality standards to suit the pithead stations.

It has been emphasised above that from the earliest days the trend in South Africa has been to place power stations on coal mines, as the cost of transport of coal relative to the pithead cost is high. A ton of coal costing say R2-50 at Witbank Colliery would in 1973 cost R9-20 delivered in Cape Town, and even at this rate it does not represent a profitable cargo to the South African Railways. When large blocks of power have to be transported, high voltage transmission becomes more economical.

Escom has, together with the coal mining companies, in recent times given much thought to increasing the percentage coal extraction rates from its pithead collieries by going to opencast mining and also to longwall type of mining. Much work is yet to be done in this direction. By returning ash underground, further extraction of coal is also facilitated. Escom and the Collieries are in partnership in this matter, to evolve the most economical long term solution.

Escom already uses more than half the coal mined in South Africa, and its proportion of the total production is increasing. Escom is therefore vitally interested in a vigorous and progressive coal mining industry. Co-operation in the improvement of mining methods to increase the yields, which in the past have been pitifully low, is called for.

It is appropriate to comment here on Cabora Bassa which has been much in the news of late. It is a magnificent engineering venture, not only from the civil engineering side, but also from the electrical side. It is a joint venture between Mozambique and South Africa, and the building of the dam has given Mozambique a vast hydro-electric power potential. The south bank power station is designed to house five 400 MW sets. South Africa, with its large power grid, is the only potential market and user of this power. The transmission of the power to South Africa is by direct current ultimately of plus or minus 533 000 volts, which is the highest in the world. The rectified equipment at Cabora Bassa, together with the inverter equipment at the South African end, is a new type of equipment, using thyristors which are, so-called, solid-state electronically controlled devices, built up in banks of series and parallel elements. This is a new departure from the conventional mercury arc type of rectifier and converter equipment. There is tremendous interest in the electrical transmission field in this installation. To function satisfactorily, it has to be tied in to a large capacity network, such as the South African grid system.

The Cabora Bassa project will be a major revenue earner for Mozambique, and any responsible government will recognise it as such.

In considering the development of the South African picture, mention must be made of pumped storage schemes. Except in a battery, electricity cannot be stored, and on an electric power grid electricity must be generated continuously at the identical tempo as it is consumed. If the load exceeds the generation, the network frequency falls, and, if there is excess generation, the frequency rises, i.e. the mechanical inertia of the system provides the additional power or absorbs the excess, and the steam input to the generators has to be varied continuously to keep the frequency correct. In a pumped storage scheme excess generation

capability, during low load periods in the daily or weekly load cycle, is used to pump water from a lower reservoir to an upper one, and then the water flow is reversed later to drive hydro-electric generators during high load periods. The overall efficiency of such a scheme is about 70%.

Two of these schemes are being planned at present. One is on the upper reaches of the Tugela, which is a combined project with the Water Affairs Department. It will pump water over the Drakensberg to assist water requirements in the Vaal River basin, and water pumped up at low load periods will be used to augment generation requirements during high loads. The second scheme is in the Western Cape near Wolseley. By this means energy is stored for later use.

#### Rhodesia

Rhodesia's electricity requirements are supplied from the hydro-electric station at Kariba, which is interconnected with thermal power stations in Rhodesia, as well as with thermal and hydro-electric stations in Zambia. Rhodesia has considerable coal deposits, and its load growth will be provided for by additional thermal generation.

#### South West Africa

With the establishment of the South West Africa Water and Electricity Corporation (Pty) Ltd., the major power stations and load centres in the Territory were interconnected, and a new thermal power station of 90 MW capacity was built at Windhoek to supply the country's present needs.

A hydro-electric power station is being built on the Kunene River at the Ruacana falls. This is a joint scheme with Angola; dams for the water supply are being built in that country, and the sale of water energy will be of major benefit to Angola. In addition to electricity, the scheme will also supply water to the northern parts of South West Africa. The scheme is scheduled to go into service in 1977, and its final capacity will be four 80 MW sets.

The load growth of the Territory, due to mining and industrial development, will require the installation of some diesel plant before the Kunene scheme comes into operation.

#### Mozambique

As referred to above, the giant hydro project at Cabora Bassa is under construction and is planned to start operating in 1975. It will supply some power locally, but the bulk of the power is for export to South Africa. It cannot function effectively without the South African load, as hydro generators cannot operate without severe erosion problems at light loads.

South Africa presently exports a considerable amount of electricity to Lourenco Marques, and, when Cabora Bassa comes on line, part of that power, after transformation in South Africa, is to return to Lourenco Marques through Escom's network.

#### Swaziland

Swaziland is also in part supplied from South Africa. It has a coalfield near its eastern border, and the erection of a large thermal power station, to be interconnected with the Escom system, is under consideration.

#### Botswana

Botswana also has coal and is in the process of erecting a thermal power station to supply its growing mining loads.

#### Lesotho

South Africa supplies the bulk of Lesotho's electricity needs at the moment, which are as yet very small. Lesotho has some potential hydro generation sites. But, for these to be viable on any large scale, they would need to be interconnected with the South African power system.

#### Conclusion

The picture of electricity power production in Southern Africa has been briefly sketched above. Great expansion of this production lies ahead.

The South African Railways, for instance, are in the process of vigorously expanding the electrification of their main rail links. Iscor's Sishen-Saldanha ore railway line is to be electrified, and this will also assist in the bringing of low cost electric power to the rich mineral area of the North Western Cape. There are ambitious new mineral and metal beneficiation schemes in prospect, or already under way. All this will be a challenge and an opportunity for South Africa, and wise planning will be required to make the best use of the country's resources.

T A B L E I

COUNTRY	THERMAL MW	HYDRO MW	TOTAL MW
South Africa	12 540	160	12 700
Rhodesia	540	720	1 260
Mocambique	240	120	360
South West Africa	150	-	150
Swaziland	10	20	30
Botswana	8	-	-
Lesotho	2	-	2

Installed Electric Generating Capacity (1973)

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T A B L E 2

COUNTRY	YEAR	SALES Mil. kWh	COST/kWh Cents
Australia	1969/70	41 806	1,59
New South Wales	1971	18 140	0,93
British Columbia	1971	14 833	1,42
Hydro Ontario	1970	46 743	0,847
Rhodesia ESC	1971	2 042	0,98
RWE Western Germany	1969	58 729	1,35
ESCOM SA	1971	38 040	0,58

Comperative Electricity costs in various countries  
in South African cents per kWh.

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T A B L E 3

YEAR	TOTAL	TOTAL ESCOM	FROM COAL	FROM OIL	NUCLEAR	HYDRO
1975	69 100	58 000	68 800	100	-	200
1980	99 600	90 800	81 600	-	-	10 800
1985	140 000	133 000	109 200	-	13 000	10 800
1990	201 000	195 400	154 400	-	26 000	20 000
1995	285 000	280 000	195 000	-	60 000	30 000
2000	395 000	393 000	243 000	-	120 000	35 000

Forecast of Electricity consumed in South Africa  
in millions of units

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T A B L E 4

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YEAR	AVERAGE kg/kWh SENT OUT
1950	0,82
1955	0,75
1960	0,68
1965	0,62
1970	0,57
1975	0,53
FUTURE	0,50

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Average quantity of coal burnt in Escom  
Power Stations in kilograms per unit of  
electricity sent out.

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T A B L E 5

YEAR	COAL REQUIREMENTS IN MILLION METRIC TONS
1975	34,4
1980	40,8
1985	54,6
1990	77,2
1995	97,5
2000	121,5

Future Coal requirements for electricity  
generation in South Africa.

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ELECTRIC POWER IN SOUTHERN AFRICA:

II. THE DEVELOPMENT OF HYDRO-ELECTRIC  
POWER

HENRY OLIVIER

The terms "Southern Africa" and "hydro-electric power" should first be defined. The old definition of "Southern Africa" covered everything south of the Sahara. For the purposes of the author's philosophy of making the waters of Africa work for Africa, that is for all Africans, the northern boundary of Southern Africa would be the borders between Gabon and Cameroun; between Zaire, Central Africa and Sudan; between Uganda and Sudan; between Kenya and Ethiopia and Kenya and Somalia. It should be stressed that this boundary is drawn for a discussion of water and energy, not of politics.

For the purposes of this non-technical paper "hydro-electric" energy will be defined in the simplest terms. The two essential elements in producing electricity from water power are the pressure or head or height of water and the quantity of reliable water flow available. The two multiplied together is a measure of power that can be produced. River flow varies with the seasons and thus on this basis the energy output would be variable. Depending on the economics of the dam and reservoir sites this can be improved by building reservoirs to regulate by storage the river flow throughout the year.

A high dam (high head), with small river flow, could thus produce the same energy output as a low dam, with high river flow. The ideal situation is of course where you have large river flows, together with the opportunities for high dams. Such is the case of the two major projects on the Zambesi: the Kariba and Cabora Bassa projects.

The stored water is dropped down appropriate conduits and then passes through the turbines, where the water energy is extracted and transformed to electric energy. The de-energized water thereafter returns peacefully to the river through tail-races.

Thus a hydro-plant does not "consume" water. There is also no pollution.

Moreover, by virtue of the regulation of the river through the storage dam, the downstream flow is generally improved creating more reliable flows per riparian users, i.e. new water. The massive storage at Kariba has made it possible to regulate the Zambesi at this point so that periodic minimum flows of 200 cubic metres per second would ultimately be ironed out to the average flow of the river of the order of 1000 cubic metres a second. The additional reliable flow could be called "new water". Apart from downstream re-use aspects, this regulation has an important bearing on reduction of floods and on navigation. This will be referred to later.

Another unique feature of hydro-electric energy is the speed with which it can be brought "on stream", i.e. effective within the national grid. This assumes increasing importance as the national grid expands and the demand curve is influenced more and more by unpredictable factors from different regions or causes.

Recent experience indicates that the traditional daily electricity load pattern is altering. In modern conditions rapid fluctuations can occur due to sudden cold snaps, peak suburban rail traffic, or such for instance as the "television peak" which occurs at the end of a popular item when several million people switch off their television sets and switch on all the lights and their electric kettles.

It is not yet possible to accelerate or decelerate the output of nuclear generators within the time limits as may be required by a national grid. The present function is to operate these stations as near to constant output as possible, i.e. as baseload stations. To a large degree this is also true of thermal stations where the current trend for economic reasons is to install larger and larger units of the order of 500 and even 1000 Megawatt units. Thus in order to provide for sudden surges of power demand the most flexible and economic instrument has been hydro-electric plant. Peak power is not rated according to normal energy concepts at so much per kilowatt hour. At the moment of

surge in system demand you either have it or you don't. If you haven't got it, and a part of the country is blacked out, as happened in the U.S.A. recently, the economic consequences can be very serious indeed.

The stage is gradually reached in developing countries where transmission networks are adequate to absorb all the energy produced under the load curve which makes possible the most economic integration of all forms of energy, graded according to availability and efficiency. This has two major advantages: export/import relationships between regions become possible whereby surplus power can be supplied for short or long periods to power-hungry neighbouring areas and it becomes possible to deal with peak loads which, in isolated developments, have to be taken care of by costly and often inefficient excess installed capacity.

The matter of peak capacity has become so vital to the economy that in recent times pumped storage schemes have been developed. In essence the pumped storage is designed to use surplus power available in off-peak periods - say between midnight and dawn to pump water back to a small storage reservoir with sufficient head to produce the required peak capacity over the short period of excessive demand say between 5 and 7 p.m. in the evening. These schemes are designed for increasing rapid rates of load pick-up. For instance, the Ffestiniog Scheme in the U.K. had been completely loaded in 51 seconds and even more rapid rates are contemplated for future installations.

It should be stressed that there are not so many high dam sites left but that need not deter us from pursuing studies of potential capacities since power can also be generated by a series of dams on the main stem of a river system and its tributaries. Famous examples are the North of Scotland Hydro-electric projects and the Snowy Mountain Scheme of Australia where every available unit of water was brought by tunnels and aqueducts to the point of concentration of head and utilized.

Energy is indispensable for development and hence the promotion of uplift of standards of living. The importance of power as an "Industry" may perhaps

best be illustrated briefly by quoting from the survey of national resources in the U.S.A. in 1963 which ranked electricity (with an indicated steady growth rate of 10% per annum for both energy and peak demands) as by far the largest of the six major national industries: Electric power, Petroleum refining, Railroads, Communications, Metals and Natural gas. As regards capital assets electric power out-ranked the next largest, petroleum refining, in the ratio 70 to 40.

This one example is enough to illustrate the importance of energy and why a crisis in this industry is of such fundamental national importance. Add to this the fact that, in the past two decades, the U.S.A. and most European countries had switched to oil fuel thermal generation, whether for reasons of conserving coal reserves, for ease of transport and handling or on account of the then ruling price comparisons. Thus one realises what a tremendous threat can be mounted to national planning and development by retarding electrical output, from whatever source.

Hydro-electric generation in South Africa is a very young "industry". The first small installation by Escom was at Sabie in 1927, and, until the Hendrik Verwoerd dam was commissioned in 1971, it remained the only hydro-electric power station in the country erected by Escom. The feeling in the thirties was generally to the effect that there was not great potential in the country for this type of generation. This attitude can be attributed to many influencing factors.

In the first place, South Africa was considered to be a water-thirsty country. This is of course true, but not necessarily in this context. In such an atmosphere the necessary surveys were not undertaken to establish the real potential. Another factor was the cheap coal and labour then available.

The most important factor was that the national network of high voltage electric transmission lines (400 000 volts) created by Escom over the past two decades was not yet available and it would have been costly to integrate hydro



and thermal power at that stage. How the scene has changed since then!

The great breakthrough for hydro-electric generation came with the Royal opening of Kariba on the Zambesi in early 1960. Now it was proved that massive blocks of power could be transmitted economically up to 500 kilometres over high voltage (330 000 volts) lines. Kariba, which since then has served Zambia and Rhodesia faithfully and continuously, must forever be regarded as the doyen of hydro-electric generation in Southern Africa. From that moment onwards the meaningful enquiries began. Surveys were undertaken. Old calculations were recast and recalculated and a different picture began to emerge.

The author was invited by the sponsors of the Symposium on "The Future of the Vaal River" to deliver the Keynote Address in October, 1961, in Johannesburg. With the information then available to him in London he was able to draw attention to the fact that the hydro-electric potential of the Orange River, on a very conservative basis, was at least 1000 Megawatts, that is more than 30% larger than that of the newly completed first stage Kariba project.

What was really exciting at the time was the discovery - on the available rough data - that the hydro potential of the Tugela and Transkei basins, again on a very conservative estimate, was of the order of 1000 to 1500 Megawatts. Nearly 20 per cent of the total run-off from rainfall over the Republic takes place in this area which also had steep gradients towards the sea and thus we have both quantity of water and head. It was also noted that the power transmission grid was being extended at a steady rate all over the country and that the South African rate of growth in demand for electricity was remarkably steady, on a par with that of Europe, and likely to increase. Thus it could be visualised that the day was drawing near for this type of generation to come about and be allowed to play its proper part, not just to provide essential peak power by suitable integration with thermal power but in multipurpose engineering, that is as a partner in irrigation development, in the supply of industrial and domestic water and in the regulation of rivers to mitigate the effects of periodic flood occurrences in the downstream regions.

The White Papers of 1962 and 1963 by the Department of Water Affairs in collaboration with Escom also estimated the potential on the Orange River at about 1000 Megawatts with an additional 250 Megawatts available in the Sundays-Fish sector. With these White Papers there was launched the first major multipurpose project in the Republic. It is noteworthy that the capacities installed at the Hendrik Verwoerd dam and to be installed at the P.K. le Roux dam already exceed the White Paper estimates for these two dams and it must be remembered that the head and reservoir capacity can be increased by raising the Hendrik Verwoerd dam at some date in the future.

Since then the Department of Water Affairs has announced the launching of the Drakensberg Scheme in the Tugela basin which apart from supplying water to the Vaal area will incorporate our first pumped storage scheme for peak power generation. In this connection Escom has estimated recently that some 2500 Megawatts can be installed in the Tugela basin for peak power requirements.

Following the launching of the Orange River Project a realisation of the immense economic and other benefits associated with hydro generation began to seep through in earnest, and in 1965 the late Dr. Henry van Eck, Escom and the Industrial Development Corporation began to take serious note of the potential of the Zambesi downstream of Kariba, at Cabora Bassa. This culminated in 1969 with the signing of contracts between South Africa and Portugal for the construction of the project and the sale of energy to the Republic: a truly courageous act in forward planning when one takes into account that to transmit some 2000 Megawatts southwards to Irene over a distance of some 1 400 kilometres by Direct Current was considered experimental. The project, now nearing completion, is being built to only half its potential capacity, When extended to its full capacity one day by duplicating the underground power station on the North bank of the river, it will generate 4 000 Megawatts or more than six times the present Kariba capacity.

At the same time an agreement was also signed with the Portuguese authorities for the joint development of the Cunene river. The scheme now in progress will

provide 400 Megawatts of power but the potential is much bigger.

Such then is the present position. We may have started late in this field - but we are rapidly embracing the principles of clean and cheap electricity generation, of catchment engineering, and above all, of regional co-operation.

Before turning to a rough forward estimate of hydro potential in Southern Africa, let us pause briefly to consider some pertinent factors in this changing world.

Last year there came, out of the blue, the oil and energy crisis which has stunned not only the Western world but also our African neighbours, indeed all Africa. When the oil prices were suddenly increased to very serious and totally unpredictable levels it was at first thought that the Afro-Asian block will remain in partnership and that price concessions will be made in their cases. This did not prove to be the case. All the African territories are in a state of serious concern, and to some disaster looms.

Luckily South Africa is not in a serious position yet, as regards an energy crisis, because we have never converted to oil generation as did Europe and the U.S.A. But our coal will not remain cheap. Our labour costs are rising and will continue to rise. In thermal generating plant we are importing inflation from countries where an inflation rate of 15% per annum is no longer the exception but the rule. Interest rates are now in the two-digit range. Therefore, whereas our average national cost of generation today is of the order of 0,60 cents per unit, who will venture to estimate what it will be by 1990 or 2000?

Let us compare this with hydro-electric power. Admittedly hydro-power is capital intensive but once the loans or credits have been extinguished or the capital amortised the operating costs are minimal and the life of the major civil engineering structures, such as dams and tunnels, can be taken to be anything up to 100 years. Take the Snowy Mountain Scheme in Australia as an example. The entire project, over the 25 year programme cost some R800 million, but the operating cost is only of the order of R1 million per annum against an annual

revenue of around R40 million. Many of the stations are operated by automatic control. Inflation from staff and materials is therefore insignificant. Thus, in an inflationary world one can say that this is the only type of generation which can only become cheaper. Moreover, the Snowy Mountain Scheme subsidised, i.e. supplied free the water to irrigate more than 1 million morgen in the fertile Murray and Murrumbidgee valleys.

Apart from this aspect of the economics of hydro-power it is still the best and overall cheapest means of providing peak power because of the speed with which the electrical load can be taken up. When integrated with fossil and nuclear stations linked by a national or international transmission grid it will permit the best operational use of the nuclear and thermal stations because it will permit the installations of the largest turbo-generator sets with resultant economic benefits in reduced costs per unit of electricity produced. This is indeed the policy whereby Escom has in the past managed to reduce inflationary effects and to hold down the costs of electricity in the Republic. At present they are installing 600 Megawatt sets, that is the capacity of one turbo-generator unit is equivalent to that of the present Kariba.

What is most important in such an integrated plan is the grid. When there is a glut in agricultural produce one can change the crop pattern, or export. But there is little one can do with surplus energy unless there is an effective transmission grid so that electricity can be exported or imported making the best use of the stations of various ages and sizes all over the region on a day by day basis. In Europe some 13 countries are so linked and the hydro potential of France, Switzerland and Spain is integrated with thermal potential on a best use export/import relationship basis.

Let us then look briefly at the potential of Southern Africa as defined at the start. To the north of water-thirsty South Africa lie the water-rich regions with rivers such as the Zambesi, Shire, Congo (Zaire), Rufigi and Rovuma.

Rhodesia on an area by area basis of comparison has an annual water yield of 20 per cent more in run-off than that of the Republic. The Zambesi, at Victoria

Falls has by itself an annual run-off amounting to 60 per cent of that of the Republic. At Cabora Bassa the annual average flow of the Zambesi is 60 per cent greater than the entire average run-off in the Republic.

The total hydro-potential of the Zambesi and its tributaries has been estimated, on a conservative basis, at 11 000 Megawatts, the equivalent of 18 present Karibas or the same as the total present installed capacity in the Republic. Further to the north is the mighty Congo (Zaire) river with a potential of about 27 present Karibas.

A conservative estimate of the total potential capacity of the Southern African rivers excluding the Nile, is 40 000 Megawatts of which approximately 7 000 Megawatts can be generated in the Republic and the Homelands. Taking the average revenue to be as low as 0,5 U.S. cents per unit of energy, the potential revenue earnings are of the order of U.S. \$1 000 million a year and the potential savings in oil or coal come to around at least 150 million tons a year. Think what this could do for the budgets of some of the developing countries in the region.

Here is a great opportunity for regional co-operation. What is needed? A pan-African transmission network such as links 13 countries in Europe with such beneficial economic results. Impossible? But it is already slowly becoming a fact.

The South African, Rhodesian and Zambian grids are there. The line linking Mozambique with the Republic has been completed. The Cunene scheme is proceeding apace and the transmission lines will come south and can go north. Zaire has recently let a contract for a high voltage transmission line from Inga on the Congo river to Tungu Fungerumo near the Zambian-Rhodesian border in connection with large mining developments there. The line is very similar to the Cabora Bassa-Pretoria link. The Shire project is barely 300 kilometres from Cabora Bassa. Thus this pan-African grid is already far advanced and hardly a matter of theory.

Such a grid can be in existence within a decade, and will make possible the beneficial use, in thermal stations, of the coal reserves some of which are now lying fallow in countries like Swaziland, Botswana, Rhodesia and elsewhere. The coal gasification techniques now being pioneered in South Africa, Germany and Canada will make it possible to develop also the lower grade coals in these territories.

The benefits would not end there. The infrastructure necessary to develop the water and coal resources in remote areas will help to "open up" these regions. This in turn will spark the development of mineral resources and industries.

Perhaps the greatest benefits will flow from the extension of irrigation using the storage capacities of the hydro-projects. The greatest danger of the population explosion is that its rate is highest in the least developed countries. By linking the resources of the wet north with those of the dry south, including capital resources, one could visualise that the entire region could be made self-sufficient in food and basic items, and then could become one of the biggest granaries or food banks for the rest of the world. There are examples in the world where such common sense regional co-operation functions well despite different political or ideological outlooks.

Reference was made above to another major by-product which can be of incalculable economic benefit to the entire region - including South Africa. When the great storage capacity at Lake Kariba began to function there was a significant reduction in the devastating floods which occurred virtually every rainy season in the Zambesi estuary. But the downstream catchment area fed by such rivers as the Kafue and Luangwa still produced tremendous flood run-off. Now when Lake Cabora, which is about two-thirds the capacity of Kariba, begins to store in October-November this year the peak flood incidences will be at least halved. This is of local interest.

What is of general interest is the fact that the steady discharges through the turbines of Kariba, Kafue and Cabora Bassa will regulate the flow downstream

of Cabora to an almost steady average flow of the Zambesi - of the order of 2 300 cubic metres per second (80 000 cubic feet per second). One way to express this is to say that the lifting of flow at Cabora from a minimum of 20 000 cubic feet per second to an average reliable annual flow of 80 000 cubic feet per second will create "new" firm water to the extent of 60 000 cubic feet per second.

The other way to express this, which is more readily appreciated is the fact that such additional regulated water will lift the water surface in the river downstream to create additional draft or depth of at least 10 feet. Hence with minimal engineering training of the river it should be possible to make the river navigable from Tete to the ocean by ocean-going barges of up to say 1 000 tons capacity and possibly more. This will provide immediately an outlet for minerals and products from Mozambique and Malawi and also Rhodesia.

The Republic, although blessed with vast coal reserves, is short of coking coals, and as and when our semi's and steel factories expand we shall face an important problem possibly from Australia. Some of the best coking coal deposits are at Moatize, only 12 kilometres from Tete. It will make a great difference to the economics of our factories if coking coals can be delivered to Richards Bay and Saldanha harbours by short haul ocean transport.

Eventually, when the Feira dam is built at the borders between Zambia, Rhodesia and Mozambique, and other dams downstream of Cabora Bassa such as the Mpanda Uncua, Boroma and Lupata are completed it will be possible to operate cargo and passenger hovercraft all the way from Kariba Lake to the sea with immense economic benefits for Zambia, Rhodesia, Mozambique and the Republic.

Kariba Lake has been an example of how a fishing industry and tourist facilities in such a beautiful setting can effect the economy of a country beneficially as regards sport, recreation, nutritional standards and foreign exchange earnings. This can be repeated in the even more beautiful setting of Lake Cabora Bassa and the other dams.

The water, the land, the forests, minerals and other resources of a region or nation are all closely interrelated and will usually dictate the essential elements in the best plan of development for the commercial, agricultural, and industrial economy that they will support. Thus basin by basin water resources blend thoroughly and intimately into, and in reasonable measure, control other types of development. To this extent their utilisation will promote, define or limit the economic life and livelihood of a nation.

The engineering, scientific, financing and managerial skills are available. It is a field in which South Africa, by virtue of her industrial and financial strength, could and should make a major contribution, if permitted. The potential prizes for all the populations involved are so great that we can only foster the hope, indeed the prayer, that statemanship will prevail.

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A P P E N D I X

A. Introductory Speech by Dr. Leif Egeland, National Chairman of the S.A. Institute of International Affairs

In welcoming you all this evening, I wish to recall that the South African Institute of International Affairs was first established in Cape Town in 1934, at a time when similar Institutes were being established in other independent states of the Commonwealth. Like its sister Institutes in Australia and Canada, it was then affiliated to the Royal Institute in London. In the fast changing world of the past forty years and in the growth of our own country, the Institute has, of course, not been unaffected. It has grown with South Africa, and, since the coming of the Republic in 1961, has been a fully independent, national body. It has now six Branches throughout the country, with a seventh about to be founded, and its headquarters in Johannesburg at Jan Smuts House (completed in 1960) has become a centre for international studies, recognised not only in our own country, but in many other parts of the world.

While much of the Institute's rapid growth and activity in recent years, notably its conference programme, has been centred in Johannesburg, our National Council (on which all Branches are represented) is resolved to do whatever it can to ensure an increasingly effective role in this region. The establishment of a Branch in Stellenbosch in 1970 was a significant and important contribution to this goal. Now for the first time we are holding a national conference here, with the active co-operation of both our Cape Branches.

This event is a sign both of the Institute's growth as a truly national organisation and of our recognition of the importance of the Cape in the Institute's work. It is our hope, therefore, that it will serve to make the Institute's role better understood, and that it will encourage wider support and participation by individuals and organisations.

It is not my intention to refer here to the highly relevant and important topics which will be discussed at the Symposium beginning tomorrow morning. The distinguished authorities who will be playing a leading role are present here this evening. I merely wish to express the Institute's profound gratitude to them and our confidence that their contributions will make this a successful and constructive Symposium.

On this important occasion, which is truly historic for the Institute, it is highly appropriate that our distinguished guest of honour should be Dr. Hilgard Muller, whom we welcome here tonight in two capacities. In the first place, we welcome him as Minister of Foreign Affairs. There is no need to emphasise the relevance of the work of the Minister's Department to the field of study of the Institute. Although the Institute is fully independent of any Government Department, and it cannot as an Institute support or oppose any particular policy, its work would be impossible if it had no meaningful communication with the Department of Foreign Affairs. I am pleased to say that we have very cordial relations with that Department, which have been encouraged by the Minister, and by the Secretary for Foreign Affairs, Mr. Brand Fourie, who to our regret has been prevented by other commitments from joining us.

In the second place, we welcome the Minister as an Honorary President of the Institute. In graciously accepting this office, Dr. Muller continued the tradition set by former Foreign Ministers from the time of General Smuts. As you may know, our other Honorary Presidents are the Chief Justice of South Africa, the Leader of the Opposition and the Chancellor of the University of the Witwatersrand, on whose campus the Institute has its headquarters. In this regard we regret that Sir de Villiers Graaff was not able to be present tonight.

Before asking the Minister to address us, I wish to say how pleased we are to have several distinguished Ambassadors, as well as other diplomatic and consular representatives, present here. We owe a special debt of gratitude to Heads of Mission and their staffs for the support which they give to the work of the Institute by their willingness to address meetings of our Branches, by the provision of material for our Library, and by their cordial co-operation in other ways. I am sure that this co-operation stems from a recognition of the importance of the work of an Institute of International Affairs in any country, and it helps us in our function of fostering understanding through exchange of views and personal contacts in an objective, non-narrowly political, spirit. All this is vital in leading to regional co-operation, as well as wider international co-operation, both of which are essential, if satisfactory solutions are to be reached to the grave challenge posed by the subject of our Symposium tomorrow.

Finally, in welcoming you all most cordially, I must make special mention of the representatives of our Corporate Members in the Cape region. Our Institute depends for its continued growth on the support of those companies which are aware of the importance for our country of a serious and balanced study of international relations; of the encouragement of a more informed public interest in international issues, including in particular issues of direct relevance to South Africa's external relations; and of contacts and communications with Africa and the rest of the world. These are the endeavours of our Institute, but they can only be fulfilled with continued and ever wider support from South African companies. We are confident that increased support will not be lacking from the Cape.

Now, on behalf of the Institute - in particular our oldest and youngest Branches of Cape Town and Stellenbosch - I have the honour to call on Dr. the Hon. Hilgard Muller, Minister of Foreign Affairs.

B. Speech by Dr. the Hon. Hilgard Muller, Minister of Foreign Affairs and Honorary President of the S.A. Institute of International Affairs.

In die loop van die volgende twee dae sal u as individue of verteenwoordigers van organisasies en ander belanghebbende persone gedagtes wissel oor een van die belangrikste wereldvraagstukke, naamlik die toekoms van die wereld se energiebronne, veral sover dit Suid-Afrika raak. Daar sal van Suid-Afrika se bekendste wetenskaplikes en deskundiges op die gebied van energiebronne, as hoofsprekers optree. Ek sal nie vanaand probeer om hulle kalklig te steel nie - trouens ek sal dit nie eers waag om selfs tot 'n geringe mate hulle gebied to betree nie. As 'n leek sal ek slegs as 'n leek kan praat; maar daar is natuurlik aspekte van die vraagstuk in verband met die wereld se energiebronne wat ons almal raak, deskundiges sowel as leke. En daar is ook aspekte wat 'n direkte verband hou met ons internasionale verhoudings in die algemeen. Dit is daarom gepas dat u Instituut hom in die aangeleentheid interesseer, en miskien ook toepaslik dat ek iets oor daardie sy van die saak moet se.

In die jongste tyd het nywerheidsontwikkeling in meeste dele van die wereld teen versnelde tempo voortgegaan. Hierdie ontwikkeling was grootliks afhanklik van 'n bepaalde energiebron, naamlik olie, waarvan die voorgesette toevoer as vanselfsprekende aanvaar is. Dit is wel waar dat heelwat navorsing bestee is aan die ontwikkeling van nuwe oliebronne en die ontwikkeling van alternatiewe energiebronne. Die harde feite is egter dat die wereld se nywerheidsproduksie in 'n groot mate afhanklik was en nog is van olie - en dat daardie olie van slegs 'n beperkte aantal lande verkry kan word. Op 'n sekere stadium het daardie lande, altans die meeste van hulle, besluit om saam te staan en om, as 'n middel ter uitoefening van politieke druk, of geheel en al die verskaffing van olie aan hulle gereelde kliënte te staak, of te verminder. Terselfdertyd het hulle as voorsieners die pryse aansienlik verhoog.

The result must have surprised even themselves. In the United States, for example, even though only some ten per cent of the oil the country consumes was imported, a situation bordering on the chaotic rapidly developed in their road transportation system, with trucks stranded all over the country and the distribution of even some food items temporarily disrupted. In England, where the oil shortage coincided with industrial strikes, much of the country went on to a 3-day working week. Almost everywhere, the ordinary individual, the man in the street (especially if he was normally a motorist in the street) felt the impact, by way of restriction on his supplies of petrol, curtailment of his accustomed freedom of movement and the like. We are all familiar with the effect here, in terms of limitation on our motoring speeds and a shortening of the hours when petrol can be bought.

This standing together of a small group of producer countries, mostly Arabs, was certainly an impressive show of strength, but it had certain unforeseen consequences too. It was aimed primarily at the major industrial countries of the West; to compel them to refrain from assisting Israel in the latter's confrontation with the Arabs; but inevitably it had an important effect also on the poor and developing countries, with whom the Arabs are generally bracketed in descriptions such as "The Third World" or the "non-aligned". For as oil supplies were restricted and the oil price shot up, and later when the restrictions on supply were largely removed but the price continued to rise, so did the prices of other things affected by the oil price, which proved to be basic to a very wide range of other goods. The impact was felt especially in the "three F's" - beside the original F for fuel - namely on food, fertilizer and freight; all absolutely fundamental to countries in process of development.

One spectacular result was that the whole of the increase in direct aid promised during the last session of the United Nations General Assembly nearly a year ago by the advanced industrialised countries to the developing countries was more than wiped out by the increased price of the goods involved and the cost of getting them to their destination.

To begin with, the developing countries looked on the coup pulled off by their Arab friends with admiration, and accepted unquestioningly their argument that, after years of exploitation, the producers of this vital raw material were at last standing up for and actually getting what they deserved for their natural resources. In fact there was excited talk about other countries following their example, and unilaterally determining the prices of the commodities they produced for export, such as bananas or cotton. After a while, they had to accept rather ruefully that such things lacked the qualities that had given the oil producers their strength, namely essentiality for the world economy, scarcity of sources of supply, and the ability of all the producers to combine effectively.

Thereupon they began to look less kindly on their Arab partners, and some skilful window-dressing became necessary; even the holding of a Special Session of the U.N. General Assembly last April and May, concerned with raw material supplies and other economic issues, to prevent an actual split within the hitherto fairly solid ranks of the so-called non-aligned group of countries. There is indeed now recognition that within that large and very amorphous grouping, there are marked gradations of prosperity and advancement, that there are "least developed" within the general category of "developing" countries, that even if all the members are equal, some are more equal than others. The hard fact is that, in consequence of the oil producer's action, especially in its pricing aspect, a major redistribution of resources has got under way which, in terms of the calculations of certain experts, will see within a generation the concentration of 90 per cent of the world's wealth in the hands of 5 per cent of the world's population.

Now where does South Africa stand in this new set-up?

In the first place, although we have so far not located economically exploitable deposits of oil within our own boundaries we do have immense deposits of another traditional source of energy, namely coal. We have therefore been less dependent on oil to provide energy for our economic activity than many other countries and were thus relatively better able than they to withstand the problems posed by a sudden drop, in the availability of imports.

Secondly, we are fortunately endowed - exceptionally well endowed - with our own supply of the energy source material of the future, namely uranium. At the risk of trespassing in the experts' field, I quote what I have been told, that while nuclear power reactors will supply about 50,000 megawatts of electricity in 1976, the figure should be over 550,000 by 1985 and double that by 1990; and the nuclear energy will supply 23 per cent of total world requirements of electricity by the year 2000, compared with less than one per cent at present. Since enriched uranium is the fuel used for most nuclear power reactors, and since we are moving towards the stage of doing our own enrichment on a commercial scale in this country, we are in this sense too very fortunately placed compared with most other countries.

Are we then to sit back and just look after ourselves, thankful for the good luck to have been naturally so well endowed? Thankful we must certainly be, and careful for our own interests, but to be so selfish is not and has never been in our aim. Perhaps I can quote here what I said in the course of my statement in the general debate at last year's General Assembly of the United Nations, last October 5th, on the then developing energy crisis:

It is necessary that there be the closest co-operation between the developed and the developing nations in the consideration of this matter, for after making due allowance for the need for protecting the quality of our environment, energy is the key to the material development of man's estate. We are faced with the possible gross depletion of the total known reserves of all source of energy if energy is in future consumed at the rate forecast today. It is therefore essential for all of us that the different energy producing resources of the earth be rationally exploited in the interest of mankind as a whole.

Ek herhaal hierdie laaste woorde „in belang van die mensdom as geheel", want ek glo dat dit veral belangrik is. Ek het hierdie woorde gebruik, nie omdat ek wil voorgee dat Suid-Afrika spesiaal grootmoedig of onselfsugtig is nie, maar omdat wat in belang van die mensdom in geheel is, natuurlik ook in ons eie belang is - of uit 'n ander oogpunt beskou, as ons alleen ons eie belange oorweeg en die res van die wereld ignoreer, sal ons eersikerlik uitvind dat ons onself op die lang duur 'n ondiens bewys het.

Alhoewel Suid-Afrika inmenging deur andere in ons eie sake teenstaan, en sal voortgaan om dit teen te staan, glo ons nie in isolasie nie. Daarom kan daar gese word dat ons, ten opsigte van energiebronne in die eerste instansie strewe na die behoud vir onself, as 'n produseerder van waardevolle en skaars grondstowwe, van genoeg energie om in ons eie toekomstige behoeftes to voorsien. Hier dink ek o.a. veral aan die vinnig groeiende industrialisasie wat ons kan verwag in die snel ontwikkelende swart tuislande. Maar terselfdertyd is dit ook ons strewe en beleid om 'n gedeelte van ons eie bronne aan die res van die wereld beskikbaar te stel, veral daardie bevriende lande wat nie so goed bedeed is met natuurlike hulpbronne as ons nie.

Eksel en ander woordvoerders van die Regering, het menigmaal by die Verenigde Nasies en ander forums, beklemtoon dat Suid-Afrika gewillig is om saam te werk met die hand van vriendskap te reik aan alle ander vreedeliewende nasies en in die besonder nasies met wie ons die vasteland van Afrika deel. Die voorsiening van energiebronne is een gebied waarop ons graag hierdie indermewing wil uitvoer. Die voorwaardes wat ons stel sal slegs wees dat die reëling ordelik geskied, en in 'n gees van vriendskaplike samewerking tussen ons en die betrokke lande en dat dit tot ons gemeenskaplike voordeel strek. As dit uraan is wat ons voorsien, sal daar natuurlik bevredigende waarborge moet wees om te voorkom dat dit aangewend word vir doeleindes wat nie vreedzaam is nie. Ons wil seersikerlik nie medepligtig wees, onwetend of andersins, aan die vermeerdering van die aantal lande wat atoomwapens in hulle arsenale het nie.

These are hard times, uncertain times, for most of the nations of the world. Change, sometimes rapid change, is a feature of the times we live in and as several speakers noted at the Special U.N. Session I referred to, after what has happened to create this new energy situation, the world will never be the same again. We in South Africa ought not and do not want to set our face

oil in the past twelve months amounts to a fundamental change in the balance of economic power in the world as a whole. This change is continuing and we, who have already been affected by it, have our part to play in the future too, as the pattern unfolds and new international relationships develop. With the supplies of alternative sources of energy over which we are fortunate enough to dispose, we in this country are in fact in a position to make a material contribution to the new equilibrium which has still to be found. I believe there is no reason to be pessimistic about the shape of things to come or our part in them; but we must keep our heads, we must be objective and sensible and not be overcome by the temptation to exploit the situation just for our own short-term advantage. In short, we must recognise that we have obligations to the wider society of nations too and that the future of our own nation cannot be seen in isolation from that of the world at large. Let us, therefore, in charting our own course wisely and deliberately, along the lines and in accordance with the standards we have set for ourselves, consider also how best we can fulfil our duty, in best disposing of our resources, to ensure the maximum benefit for all!