ENERGY, MAN, AND SOCIETY

An Inaugural Lecture delivered at the University of Ibadan
on Friday, 3 June 1977

by

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UNIVERSITY OF IBADAN

1980

IBADAN UNIVERSITY PRESS
UNIVERSITY OF IBADAN
IBADAN · NIGERIA

First Published 1980

ISBN 978 121 073 7

PRINTED BY OFFSET LITHOGRAPHY
AT IBADAN UNIVERSITY PRESS
NIGERIA 297/80/1,500c

ENERGY, MAN AND SOCIETY

SUMMARY

Production and consumption of ENERGY have a profound influence on the society and vice versa Therefore energy is too important a matter to be left to energymen (engineers and companies) alone. The society has a responsibility to give the right directions to the technologist stating its aims and goals, definitely in unambiguous terms. In matters of energy, technology is less neutral than in other fields and once technology gains momentum in any one direction it will be difficult to counter the momentum. Therefore, society's elders and today's social scientists, should actively get involved with technology and take the right decisions today, the effects of which may last several generations. In formulating any policy, team effort is needed. If Ibadan starts building up a nucleus for energy studied in all its ramifications with all its talent, it should eventually get one of the Regional Energy Research Centres planned by the U.N. for the whole world. The responsibility of the technologist to the societal effects of what he is creating has been sufficiently emphasized so far, but the corresponding responsibility in the reverse direction has not received enough attention.

The sources of energy, the harnessing of these energies for human use are purely technological things which a technologist is able to handle very well, but he suffers often from lack of direction. Nigeria with its hydrocarbon resources, size of population, etc., has a special responsibility in African affairs and in addition to safeguarding its own interests, Nigeria should strive for a place of pride in the history of this continent which it already has in the geography of the continent. All of us have a basic responsibility in such an essential matter as Energy, to leave this world and our land as a better place than we found it when we were ushered into it.

Respected Sir, the Chairman, Distinguished Guests, Esteemed Colleagues, Ladies and Gentlemen, I feel highly honoured to have been invited by the University of Ibadan to deliver this inaugural lecture. I know the importance this University attaches to the inaugural lectures and to make my lecture befit the importance attached to it. However, before starting, let me be frank about two reasons why I feel a little embarassed. The first reason is that I have delivered inaugurals before (in West Germany and in India) and I cannot be labelling this myself as an inaugural; the second is that I have been given a chance to address this August assembly, a mere passer-by in the youngest faculty of the University - when there are so many other professors in other faculties waiting in line to lecture on what they are "Professing". Mind you, I am only using the words of one of the members of the Senate when the subject of inaugurals was discussed there. The big advantages in delivering inaugurals seems to me to be.

1. You get a very distinguished captive audience and some amount of celebration for something which should go as a matter of routine, and
2. it ensures a more or less compulsory publication as a monograph or in the University journal as a matter of course.

Friends, the time is short, the topic is vast cutting across many disciplines and still I chose this topic because of its extreme relevance to Nigeria - a society in the process of a phenomenal

transformation, a society literally at cross-roads weighing the alternatives in developing, in Professor Mabogunje's words, "developing our own way of developing".

I will come to this later on. My lecture has necessarily to be a sketchy one since I have something to say on many aspects related to this vast topic and that, quickly and more or less in telegraphic language. Furthermore, the problem has to be put into the right perspective both from "space" and "time" points of view, which alone will free us from panic and hasty decisions.

Man has always recognised the importance of energy in his life. Some very ancient societies like the Hindus and the Egyptians have worshipped Energy. The Hindus used an abstract concept somewhat anthropomorphized as SHAKTI, and the Egyptians in the more visible form of all energy, the Sun (the God of OSIRIS). In fact, we can find the solar basis for the derivation of their ancient gods or kings or dynasties in every society on earth. William Blake called energy an eternal delight in his "Marriage of Heaven and Hell". To complete the quotation,

> Man has no Body distinct from his soul for that called Body is a portion of soul discarded by the five senses the chief inlet of soul in this age. ENERGY is the only life and is from the Body: and Reason is the bound or outward circumference of Energy.

Today, Nigerians can pretty well start worshipping energy (particularly in the form of Petroleum since this seems to be the more visible God presenting things like Peugeot, Mercedes cars, stereos and quadros and all the food that is made in the world without going into the trouble of making any of them), although industry has not commanded the same unquestioned awe and reverance man had for energy as exemplified by my next quotation - a poem on - Oil. Disgusting Oil.

> Oil!
> Beneficent oil,
> Mankind's most precious treasure in the soil!
> Oil!
> Disgusting oil,
> Father of blood and sweat and tears and toil!
> Oil, you have made this puny race
> Masters of time and Lords of space,

Have opened vast horizons for the poor,
And brought the city to the cottage door,
Or rather (which is not so good)
The cottage door to Hollywood.
Oil, you have made the mountains and the seas
Mean less than barbed wire fences mean to becs.

Methinks I see this writing in the sky:
'Those who by oil have lived by oil shall die'.

SIR ALAN HERBERT

The last time when the University of Texas arranged the first interdisciplinary course on "ENERGY AND SOCIETY" (incidentally it was a course and not one lecture), it consisted of 29 lectures from energy authorities drawn from 10 different fields geography, geology, chemical and petroleum engineering, economics, public affairs and government). (You will agree with me that I am not an authority in all these fields - in fact not even in one of them. However, my concern with petroleum economics in all its ramifications in the course of the last two years led me to get into the rudiments of these fields and encouraged me to attempt a synthesis of a kind in different fields but my brief excursions into these fields left me with utter dismay to note the really rudimentary nature of the advances in other fields.)

This interdisciplinary course examines the energy crisis facing America and comes up with various recommendations in accordance with the American social system, values and life styles, except for the lectures by the Anthropologist. He compares the lifestyles in Marakkech (Morocco) (pre-industrial city) with Austin, Texas with about the same population. He comes up with the conclusion that the quality of life would not be impaired in any way in reducing the energy use by adopting some of the ways of the pre-industrial society. However, "Quality of Life" is a very difficult term to define and nowhere else is the maxim "one man's meat is another man's poison" more true. The contribution of energy usage to the quality of life is unquestioned. Except for the anthropologist's remarks who advocated a very radical change in the lifestyles and values of the Americans, the rest of the course is of not much interest to us, except for the most important aspect;
If the suggestions of these Professors for energy self-sufficiency

for America are pursued vigorously and become realities, Nigeria would have lost a major market (taking at times as much as 50% of Nigerian production).

I am carefully refraining from making any assertions about anything. A rapid and very intensive synthesis is a necessity, whether it be in U.S.A. or Nigeria (or far greater urgency in the case of the former) and it is almost necessary for beginners like Nigeria to let the students get more knowledge about the whole problem of energy and its impact on every aspect of society. This is all the more important now since the export of energy is almost the only source of any money for Nigeria but any rapid export of energy may lead to bottle-necks in the flow of energy when the country becomes more industrialised and energy-dependent.

Last year's inaugural, the first ever from the Faculty of technology, from the Dean of the Faculty who happens to be the Head of the Department of Agricultural and Forestry Engineering, Professor F.O. Aboaba, was an ardent plea for the mechanization of agriculture in Nigeria, possibly with the latest and some intermediate technology machinery. Do not be surprised if this year's inaugural from the same Faculty examines even this ardent plea as too energy-intensive and rejects it from the net energy point of view as demanding too much energy input in a very concentrated form. Look at the fate of the 'green revolution in energy-hungry countries. This is simple because it is coming from the petroleum engineering department, a department concerned not only with the exploitation of the major energy resource of this half of the country but also with its conservation.

This year's inaugural can be seen as a plea for the greater participation of social scientists and other scientists in technology and technology assessment. The recommendation is to start a centre for energy studies (at least the nucleus of such a centre) now so that Nigeria gets one of the Regional Energy Research Institutes the U.N. is planning. Algeria already has one of the Solar Energy Research Institutes and Ibadan with all the expertise available here should eminently qualify for the total energy studies. Right now, all the expertise is scattered in different places working more or less in isolation from each other, totally oblivious of even the fundamentals of other branches of knowledge.

Most of you probably would have felt happier if I had confined myself to my own field of Petroleum Engineering and told you mor

about Nigerian oil - its past, present and future instead of trying a dilettantish attempt to go too far out of my field and present an overall picture. Anyway I will not be straying too far away from my field since over 60% (even more in U.S. and countries at that stage of development) of the world's energy needs are met by petroleum (Hydrocarbons) and petroleum products and we are living in the so-called petroleum era. The development of new energy resources, at present mostly speculative, is an investment for the future, not a means of remedying the problems of the day. Touching upon the past, is more or less a necessity to understand the present in its proper perspective and to plan for the future - a little bit of foresight aided by a lot of hindsight. The one obvious advantage is the freedom from panic and haste in taking our decisions today.

One main reason for involving society in a lecture which should normally be only on man and energy is that technology of energy shapes the society. The society has to take a definite stand in the matter of energy almost at the beginning, since the inexorable force of technology will force a society to say 'B' to ('Z') once it has said 'A' to the demand of technology. The external power of a nation depends on the energy-resource base it has. Only energy - rich nations have the wherewithal to dominate larger areas and develop for economic growth, military adventures, transport and communications and even administrative organisations. Even, mighty powers lose their ability to maintain their influence economically, militarily and centrallyas we have seen in the case of U.S.A. in Vietnam. It is the society ultimately which has to take the decisions regarding energy production and usage and eventually bear the consequences. Economic processes are subject to the basic energy laws and standard economic measures will have their expected effect only when ample energy supplies can be taken for granted - treated as "external" which is what the economists are doing now. I am anxiously waiting to read the new work on ENTROPY and the economic processes which is the first treatment of the role of energy in economic processes.

Ladies & Gentlemen,

"The artful manipulation of energy has been an essential component of man's ability to survive and to develop socially. The

use of energy has been a key to the supply of food, to physical comfort and to improving the quality of life beyond the rudimentary activities necessary for survival. The utilization of energy depends on two factors: the available resources and the technological skill to convert the resources to useful heat and work. Hubbert calls this man's "progressive conquest of energy" and then goes on to review the ecological and human consequences of man's conquest of energy in the last million years in terms of the history of the earth.

The second major reason for involving the society is the historic role of the energy producers in the social fabric of the society right from the very early days. Whatever be the form of energy available, whether it is human muscle power, domestic animal power or at the present era of chemical fuel energy from the hydrocarbons, never did ruthless man fail to try to control the energy source. It has been a continuous battle between the society at large and those ruthless men. Never did man hesitate to press the use of energy to its uttermost limit think of the Ancient Pyramids of Egypt, the Roman galley-slaves and the more recent history of this continent itself with mass depopulation. Strangely, the society including its most liberal thinkers acquiesced in even utterly inhuman things like slavery as long as no other source of energy was visible at the end of the tunnel. As soon as an alternative appears even in the distant horizon, we usually see liberal minded people starting to press for a change.

Even today, muscle power should not be underestimated. In countries like India and China, Singapore etc., fifteen to eighteen-storey buildings and mighty dams are built entirely by muscle power alone (men and women together) with the minimum of machinery and that too in record time. In China, even in the manning of a giant oil-field like Taiching it is the workers' muscle-power which is the main source of power. Elephant power is as good as a crane with the added advantage of not requiring a special road for its movement from one place to another.

Please do not forget also that the modern U.S.A. was built quite a bit by the muscle power of the imported slaves and the early acquisition of capital was only through this source. The loot of Bengal, the treasures built by centuries of muscle power, provided the capital for the railroads in U.S.A., England and even distant Argentine.

Oliver Goldsmith briefly lamented the woes of the coal-miner and in its hey-days the coal-mining companies were not exactly pieces of corporate virtue and veneration by people. Today all the abuses and mass hatred expressed against the slave-trader is being transferred to the oil-companies - the modern equivalent of the ancient slave-trader.

Even in this fierce aggrandizement of the most versatile energy resource of this century, you can see the hand of the society in the actions of the oil companies. While Great Britain went into the oil business directly through state participation in BP, the American Government gave every financial incentive to its oil companies and backed up these companies with all the diplomatic support they could give.

The increasing use of nuclear energy in advanced countries and the possible implications for the society is permeating to the level of 8 year olds writing a 4-line essay on "Our Village"

> "We are right now living in a beautiful village and are having a comfortable existence. Nevertheless we are moving out of this village because very soon a nuclear power plant will be coming up in the neighbourhood. My mum and dad are opposed to this and want to remove us all away to a safer place".

The disposal of radio-active waste is going to become more and more of a social problem and the actual solution will depend on who controls the energy resource and who directs its usage. Even if completely in public hands, people as a whole do not trust scientists and technologists in charge, who in their cost-consciousness may try to cut corners.

It is almost axiomatic that a private company interested only in the rate of return and maximization of profits will do that first. People are already talking about "Solar Derby" and who is going to win the race, because although the sun shines free for all, the concentration of solar energy and making it available to the consumer requires elaborate technology and attendant organisational forms.

Advanced, industrialised countries have started examining the need for an unlimited growth and unlimited need for energy. They are asking themselves as to why not go to a steady-state economy

and not get into the syndrome of inventing labour or time-saving machinery only to use the saved time to invent more time-saving machinery. However, in our very underdeveloped state we are not faced with that question but we certainly have the choice on where to stop and how to get there before thinking of stopping.

Lastly, after showing the close relationship between Man, Energy and Society in general, I am more or less forced to make a comparison between the two major forms of society we have in the world today with the Third World in between. The approach to energy problems is totally different in the two forms of society although both of them have the same ultimate goal of providing their people with a better standard of living.

Looking from the production end, in a highly capitalistic country like the U.S. where everything is left to private initiative, individual enterpreneurs have been gambling their last shirts on their back in the hope of striking it rich. The Soviet planners on the other hand have been almost reluctant to allocate any money to speculative oil exploration and preferred to depend on the known coal, peat and lignite deposits even though they were aware of the tremendous advantages of the hydro-carbons. It required the advocacy of eminent scientists like Gubkin and other influential people to start looking for hydrocarbons in areas like Urals, Western Siberia etc., outside the traditional oil producing areas of Baku and Batum.

Scientists in some semi-dirigistic societies like Hilter's Germany were busy trying to convert the abundant reserves of coal and lignite to the more usable form of hydrocarbons by artificial hydrogenation processes, irrespective of the cost. The intervention of the society in the shape of the government in France in the energy field starting from petroleum is too well known to be recapitulated here.

In the same way, the idiotic "law of capture" alone led to millions of feet of useless drilling, not so much to take oil out of your own ground but to steal from your neighbour's field. If U.S.A. today is crying for energy independence and all that jazz, it is mainly due to the system or society in which people had to operate neglecting all technology and science and even basic prudence in husbanding resources. Even when the conservation

practices became law, what was really conserved was the profit margin and not the resource as such.

At the consumption end, every time a finance-minister finds a gap in his budget he fills it up with taxes on gasoline (besides tobacco and alcohol), knowing full-well that car-crazy people will pay the extra-taxes. In countries like India which encourage public transporation and actively discourage private cars, the taxes are raised on gasoline and reduced on diesel etc, used for public transportation. Moscow spends millions of roubles for the building and maintenance of subways while New York subways have to languish for lack of money and become more or less derelict. This is just one aspect in which society affects and effects a transformation in one aspect of usage of energy. We can go on citing examples ad infinitum, even from a purely technical angle.

It was, after all, the invention of agriculture, the first organised use of solar energy in the cultivation of food that led to the settlement of nomads in permanent places.

After settling down, and with every improvement in agriculture like irrigation (water supplied by the hydrologic cycle motored by sun) the need for greater and greater co-operation and centralisation of authority to take care of the public works became a necessity. If the early man used 2000-2500 calories of energy, the minimum needed to sustain himself, his need for energy grew up as he advanced up the scale of civilization. The domestication of fire may have raised it to 4000 kilocalories.

In a primitive agricultural society with some domestic animals, the rate rose to perhaps 12,000 kilocalories per head (mind you, it still lives on the income of the solar energy and not on capital like fossil-fuels etc.). More advanced farming societies may have doubled that consumption. At the height of the low-technology, industrial revolution, say between 1850 and 1870, per capita daily consumption reached 70,000 kilocalories in England, Germany and the U.S. Today, working on the maxim of what is good for General Motors is good for the country, the number of gas-gargling cars have proliferated and not one city in U.S.A. has a decent public transportation system. They would rather go to war to get the energy they need than device ways of reducing energy consumption. The net result is that today's technological man needs close to 230,000 - 250'000 calories to maintain himself in his present style and comfort of which 25% is for transportation alone.

This is a syndrome which worked both ways. The ready availability of energy for easy and independent transportation gave rise to sub-urban living, away from the maddening crowds of the city, in U.S.A. and in fact, it is ready transportation which has given rise to Megalopolises.

In peace or war, energy has been too important a matter to be left to energy-men (I mean engineers or companies) alone and the politicians of the day have always had a hand in developing the energy policies of their country. Look at the 39 different regulatory bodies dealing with energy questions in Washington and let us not forget that it was (Sir) Winston Churchill, as first Lord of the Admiralty, who founded the BP and backed it up with all the might of the British Empire. To-day we can see the last shreds of energy as a private industry being thrown away and society leaders taking an active part in the production, conservation or consumption of energy. Energy has become political topic No. 1. Even today, the four or five-fold unilateral increase in the price of crude oil by OPEC countries is an exercise in political power and after all, a new form of imperialism, demanding more services and products from others for the same amount of energy.

The international oil industry has never operated as an industry "per se" - instead it operated more or less as one more arm of their governments. The role played by the British Ambassadors and politicians in getting Iranian and Iraqi concessions are too well known: The diplomatic dispatches of the Americans in those days of Anglo-American rivalry continually refered to oil matters. On the one hand you will see the oil companies shouting for free enterprise; On the other hand they are the first ones to rush to their governments for aid and succour, whenever their interests are threatened. Are you so naive as to believe that all this patronage was extended to the oil companies without any "quid pro quo" of their working for their national interests? Now, all the facade is gone and the topic is a matter of high-level political discussions. You might remember Roosevelt declaring that the defence of Saudi Arabia was vital to the defence of America during the Second World War and approve of lend-lease arrangements to Saudi Arabia.

These made precious steel tubes and other strategic materials available to the oil companies to construct the TAPLINE and also extend their production facilities in Dhahran. The extention of full

credit for the taxes they paid to Saudi Arabian government towards their income taxes in U.S.A. enabled the Saudi Arabians to get more without the companies losing anything. It was almost a direct subsidy from the American treasury to Saudi Arabia. For us in Nigeria, in a country exporting energy to light the homes and streets of New York, London, Hamburg and Rotterdam, in a country which is flaring millions of cubit feet of valuable energy in the form of natural gas inevitably produced along with oil, in a country where the non-associated gas occuring at depths are not even investigated for a quick-look evaluation of the total resource base, we are suffering from frequent interruptions of energy (electric power or gasoline or cooking-gas) something has to be wrong somewhere. Any piece-meal approach to the problem would lead only to the shifting of blames from one to the other and mutual recriminations and any amount of newspaper headlines will not solve the problem but only create new ones and get us all into a something-is-wrong-somewhere syndrome.

Power interruptions are not anything new except in very advanced countries, without the resources base, (India often imposes up to 80% electricity cuts even on vital industries in dry years).

However there must be something wrong, besides general underdevelopment, if we have problems in a country like Nigeria with such a readily available resource base. First and foremost, it brings out the integrated nature of the petroleum industry where perfect planning and co-ordination at every stage right from exploration to distribution is necessary.

If we get into the "something is wrong somewhere" syndrome, we will solve no problems and instead become a part of the problem ourselves. Something and somewhere are things which the social scientists can pursue with greater vigour and pinpoint the causes. It is they who can point out the possible deficiencies in technology also even though they may not know how to overcome it.

The topic combining Man, Energy and Society is of particular relevance to Nigeria because this is a land endowed with some amount of the most versatile fossil-fuel (hydrocarbons), a land on the threshold of industrialisation, aided by the external income brought in by the very same fossil-fuel and a society which has to take some crucial decisions on how best the blessings of God are

converted into amenities for man not only in the present generation but in the coming ones. Discussing the points of production versus conservation, there is no special virtue in leaving the soil in the ground for future generations whereas they would much rather prefer our leaving a land sufficiently industrialised and well-provided with all the infrastructure needed for a modern society using the income from the oil to-day. Almost everyone concerned with the oil industry of this country wakes up every morning with a vague fear of some other source of energy - a breakthrough in distant New Zealand or nearer home in Saudi Arabia whose intensive sponsoring of research in solar energy may look like a curious anomaly).

Nigeria with an estimated total reserves of 22 billion barrels of oil is not as rich as Saudi Arabia, Kuwait or Iran or Iraq in the amount of total reserves. Translated into per capita, it is around 200 barrels of oil. However, it is the sixth largest producer in the world and fourth largest exporter. This situation is partly dictated by circumstances the tremendous absorption capacity of the land with its more than 80 million people most of them living out a marginal existence and partly by deliberate choice.

.....Afterall, the era of petroleum may not last for ever and so make the best use of it when the going is good, when the Nigerian oil with its high yield of the more valuable fractions like gasoline is fetching the highest prices in the energy hungry countries of OECD. Many thoughful people are also deeply worried that the country depends on the export of a single commodity at the expenses of all other traditional exports, a commodity the demand for which fluctuates violently and may by some freak of science or technology even altogether cease. When 90 countries of the world are busy combing their off-shore sediments for oil and many of them are coming up with new discoveries, you may very soon find that there is no place to export to. Of course, some of these fears are exaggerated since we are not yet advanced that far that we can carry miniature nuclear plants in our cars as they do for the huge submarines and ships. Anyway, if the transition to nuclear energy takes place at all, the transition period may be as much as 50 years which gives us ample time to make the best use of the export commodity and also prepare for the future, funded by the very same oil.

At the moment, research on the future of petroleum and

petroleum prices is attracting world-wide attention and all research shows the future as a double-edged sword. All I wish to say here is that much more research is needed both by OPEC as an organisation and Nigeria as a nation on the future of petroleum and also on what to do after the Petroleum is exhausted. Would the country have sufficiently developed to reach the famous "take-off" stage to support a sustained growth rate or not? Is it at all desirable or justifiable to multiply the needs of man and spend all the earnings on luxuries for one generation? What kind of a race with time is it? What is the amount of inter-generational give and take that is needed to ensure a desirable and justifiable balance? To some extent, I would go along with those who advocate an "Oil-holiday" a brief span of probably half-a-generation living high on the hog after several centuries of foreign exploitation and endless suffering. However, the danger is that all holidays come to an end and this holiday may come a little bit sooner than expected. All the Peugeots may turn out to be no more than scrap metal and all the transistors burnt out. You can imagine how our successors would find it difficult to find words to curse us for our thoughtless actions and wasting of a precious national asset, without building a better nation. To some extent, I would go along with those who are concentrating on the "time value" of money and a naira earned today can be put to work and start earning dividends - private or social although I would not put too much emphasis on that in the present international context.

There are no comprehensive energy policies in many of the countries. This situation is mainly because there is no use in formulating a policy without the resources to back it up. Even the famous American "Independence before 1980" floundered, even before it started. OECD plans to switch over to coal and nuclear power were not pronounced with so much fanfare as the American Independence plans, but are nevertheless pursued very vigorously. The announcement of 40 nuclear power plants at different sites dotted all over France left people stunned and it was impossible to start even any kind of massive public protest. All they could do was to write some scholarly letters in "Le Monde" and keep quiet about it. The society has a strange but probably right reaction in acquiescing with even things it believes eventually to be to its detriment if it sees no alternative source of energy. As it is, all the industrialised countries will agree to any increase in petroleum

prices because it does not affect them materially. In fact the resources allocated to the procuring of this energy may decrease if they raise the prices of industrial machinery and other products and services sufficiently high. As long as the OPEC countries continue buying even their basic requirements like food from OECD countries, it will be a game of numbers becoming larger and larger on both sides. How else can you absorb the cost of additional energy except this way: just by passing it on to the consumer countries. They may even gain (net) if countries like Iraq, Iran and Nigeria with tremendous needs would rather get rid of their oil at any price than keep it under the ground and starve above the ground.

The threatened energy (Petroleum) crisis of 1973 and the subsequent four fold increase in crude oil prices forced many a country to reappraise their energy policies or to formulate a new one if they had none. Although the oil companies did a supreme job of diverting and rediverting ships on the high-seas to comply with the embago and also to provide their customers with regular supplies, the situation was getting serious enough for even professed free-market societies like West Germany to formulate national energy policies. Many of them are reappraising their energy policies as though that was their whole life etc.

Somewhere along the line if we have taken the wrong path (at least some of us) by using too much energy which is not there, it need not deter us from acknowledging the error and tracing our way back, at least to the point where we took the wrong turn and continue the journey. If the cry of many people calling us all back to earth is something like a whistle calling where and which way to get back, we can heed the cry or at least devote a thought or two to this cry.

This would be better than proceeding in the wrong path straight ahead or taking circuitous routes to the same point where we branched off. But, who is going to decide whether we have blundered into the wrong path or going the right way? To the technologist anything showing improved efficiences of his machines is progress and it is always linear. If the technologist himself feels that most technological advances during the last century of growth have involved the heavy subsidy and application of hidden, indirect additional forms of energy and many of these technological advantages will evaporate with the disappearance of

all these subsidies, he would plan (in fact he alone can plan) for an orderly transition to a society consuming less energy. Instead of viewing technology as a battle to combat Nature, technology should go along with Nature as much as possible. Afterall, all our ancestors were neither idiots nor ignoramuses when they laid more value on man living in harmony with Nature instead of swimming upstream all the time. Whatever semantics you use, you will find that the world energy demand is itself a product of the type of society and the factors encouraged or instituted by the society in energy consumption.

Notwithstanding, the present division of the world into developed and underdeveloped nations, technological changes in one part of the world do not fail to reach another part of the world, even if by trickles. If Brazilian meat is consumed fresh by the Nigerians, flown in by the Brazilian planes every other day, if Canadian wheat is consumed by the Arabs for their "Kubz" carried by ships, these are all touched by modern technology of cargo planes, bulk carriers etc. all dependent on energy for their functioning, particularly easily transportable energy like petroleum and petroleum products.

World energy demand can be created by very necessary factors like improving the standard of living of the poorer two-thirds of the world population by improved agriculture, industrialisation etc. and also by creation of useless things like aluminum foil (which costs enormous amounts of energy for conversion from primary ore to usable metal) for wrapping cream, jam and butter or TV dinner - and aimless transportation by gas - guzzling cars. The type of demand created and the type of consumption encouraged will depend on the very basis of society - whether a society encourages private greed and profit-motive irrespective of the consequences to the rest of the economy and the rest of the world or plan for the common good of everyone concerned encouraging optimum utilisation of existing resources and facilities.

The Club of Rome studies have clearly indicated that an indefinite increase in energy demand and an insatiable demand for consumption of resources cannot go on. The consequences of a doubling of the demand every ten years for energy alone will create a ten-fold increase, in less than 100 years, putting an enormous amount of strain on the resource base as well as the environment. The second club of Rome studies realised the need for dividing the

world into different types of societies at different stages of development whose needs are totally different and vary in character from very essential to absolutely useless.

After showing you the close connection between, MAN, ENERGY AND SOCIETY let me examine this problem in the perspective of space and time. My invoking the dimensions of space and time is not to belittle the importance of man but to show the directions which can yield fruitful results for the continued existence of mankind and perhaps even multiply itself without all the predicted catastrophes of mass starvation, total deaths etc.

However, the technologist can only show the way. It is the society which ultimately makes the choice, if it is left with a choice and if it has not driven itself into a choiceless predicament by thoughtless and precipitate action.

COSMIC FLOW OF ENERGY

The most predominant form of energy permeating the cosmos is the gravitational energy. Heat, light and nuclear energy are also present in the cosmos. Chemical energy, the kind of energy locked up in fossil-fuels, counts for very little in the Universe. The sun is going through stage 2 in its life-history when hydrogen, when it is compressed "burns" to form helium. The thermonuclear burning releases energy and the hydrogen at huge temperatures opposes any further compression and this thermonuclear burning has now been on for nearly 4.5 million years and will take another 5 billion years before all the hydrogen is used up. After that, gravitational contraction can be resumed. At the moment, the energy released by sun is given in amounts of solar luminosity which is $= 2 \times 10^{33}$ ergs per second. The details can be left to the astronomers but this puts our own problems in the right perspective in space. Let us not forget that we are all walking on the thin crust of a big planet and in the long run "we are all dead". We do not matter too much to the Universe and we are all dead long before we are even born from the Universal time point of view.

When we are talking about Nuclear Energy from controlled fusion reactions we really have to imitate nature in a smaller form and bring about this "thermonuclear hang-up" going on in the sun's interior, on a smaller scale.

However, the amount of input of energy we need to bring about

this "hang-up" which occurs as a matter of course in nature may eventually be more than the energy we will release by fusion reactions. As yet, controlled fusion reactions are not yet a reality and we have not yet reached the stage where we can make cold economic calculations before even the technical feasibility has been proved. May be, after all we are proceeding in the right direction when we are trying to imitate Nature on a smaller scale and our dreams of 'backstop' technology to solve energy problems once and for all may come true. As it is, it is too early to say anything assertive and your guess is as good as mine, regarding the possible outcome of experiments.

The only way we have learnt to harness gravitational energy directly is in hydroelectricity where the gravitational energy of water stored up in the dam is converted into electrical energy. This is the reason why hydroelectric plants have close to 100% efficiency in their conversion process which no chemical or nuclear power station can approach. Apart from the original energy input in the form of building the dam and the installation, the rest of the energy input for continuous running is supplied by nature through hydrology in the form of rainfall and riverflow.

TIME PERSPECTIVE:

From the geological time point-of-view, man should roam this planet for at least another 15 to 20 million years without any serious mishaps like a nuclear holocaust before geology even cares to preserve the fossils of an extinct mankind. Otherwise it would consider mankind as a temporary aberration in the evolution of the vertebrates and concentrate on the regular line of vertebrates which have managed to survive and evolve further.

Mankind itself has lived on earth for close to several million years without any commercial energy. Hubbert shows the importance of commercial energy even on a smaller time scale of 5000 years, before and after the present to be insignificant. Taken individually for the major sources of fossil-fuel energies like coal, hydrocarbons etc., this time span is even further reduced. However, what does this signify? If the problem is negligible compared to others both in time and space perspective, why make a fuss about it all? There is a point in showing the time and space dimensions of the problems of human energy and this is the direction of evolution.

TERRESTRIAL FLOW OF ENERGY:

The idea behind outlining the terrestrial flow of energy is not to draw you into a numbers game or to make you believe that there are unlimited quantities of energy available just by uttering the words "open sesame", but to show the practicability of tapping many of these sources of energy and making them do work. Terrestrial heat radiated back to space, has very little capacity for work.

The chemical energy which plays such an important part in our lives is primarily due to a freak process by which a small part of the solar energy incident upon the earth during the last 600 million years has been stored.

Photosynthesis is the process by which the chlorophyll of plant leaves convert the inorganic materials $C0_2$ and H_20 into organic carbohydrates with an accompanying chemical storage of energy - the storehouse for all the biological energy requirements of the entire plant and animal kingdoms.

Photosynthetically stored energy is released by the reverse reaction of oxidation oxygen + organic materials H_2 + $C0_2$ + Heat. On the average, the rate of decay and oxidation of plant and animal materials is approximately equal to the rate of photo-synthesis. However, a small portion escaped this reverse process due to oxygen deficient environments and this today is available to us in the form of fossil-fuels. Looking at things quantitatively, this source of energy will be at the bottom of the scale. There is approximately 10% of the solar energy available in the force of winds, waves, connection currents, (If you want numbers it is about 40×10^{12} watts out of a total of $173,000 \times 10^{12}$ watts of solar radiation). Taking one last glance at photo-synthesis, the insignificance of this source must not be forgotten. Going up the ladder, we get to wind power.

I am myself watching with a lot of interest and curiosity about the new experiment that is being done by a Wisconsin power-plant operator. Instead of worrying about the concentration of solar energy, with mirrors, lenses etc., he plans on growing shrubs and other useless vegetation (vegetation useless except for burning purposes) which can grow very fast and use this vegetation in a dired state for burning and boiling the water to steam. After all, all power generation by thermo-mechanical means implies practically

boiling the water, no matter whether it is done by burning the shrubs or by moderating a super modern atomic reactor. This experiment is in harmony with nature aided by all the scientific advances in agriculture but used to cultivate useless shrubs. The efficiency of utilisation of solar energy in this indirect way is an age-old practice but in this case, it is aided by modern management and conversion to electricity.

Exotic or Quixotic as it may sound, when we visualize only windmills when we think of windpower, mankind has utilised windpower to a far greater extent than it cares to remember or even admit. From very ancient times sailing ships propelled by windpower have been the means of transportation in the high seas, inland canals and waterways supplying a considerable amount of energy used up in transportation of men and goods by modern technological man. Admittedly, the control of man over the forces of nature was practically zero, but properly understood and used, windpower has been a major source of energy in at least one major field. The trade between ancient China, India, Mesopotamia, Rome, Phonecia was all powered by wind-powered sailing ships. Winds have one big advantage that they are a renewable form of energy and the other big disadvantage that they are periodic. Ancient Persia (Iran) used windpower in an organised way for generating work as early as the 7th century and transmitted this art to China around 1200 A.D. Apart from this, we have the familiar windmills, at least from the middle ages, producing mechanical power for such tasks as grinding grain or pumping water for irrigation. Since the first wind-powered electric generator was built in Denmark in 1890, wind-powered generators have been built off and on in isolated places. Studies at Oklahoma State University indicate that by building wind-energy conversion systems inland and off-shore, the U.S. alone could generate an estimated 1.54×10^{12} kilowatt-hours of electric energy annually, now supplying nearly 5 to 10% of the country's projected power-needs.

Serious research is going on optimum ways of constructing propellers, wind turbines etc. At the moment, they are just a speculative energy source and it is too early to work out their economics. Let us be just satisfied with our plane rides with tail winds helping us reach our long-distance destinations an hour or two earlier. Once we get over our obsession with huge power plants with their economies of scale, there is really nothing

preventing us from building small 5 to 10 megawatt generators based on windpower. Indeed we may be forced to do it in relatively under-developed regions without extensive electricity grids with centralised plants and planning. The limiting factors are the intermittent nature of the winds and the resulting needs for storage and the availability of accessible sites.

OECD does not place too much of an importance on the wind-power potential citing "difficult engineering problems involved, the high capital costs and the limited availability of accessible sites" for the large scale generation of power needed by the highly industrialised nations with their insatiable need for power...

I am not going into direct concentration of solar energy although it is the highest up in the ladder. My thesis is that the lower down the scale we stay, the better off we will be in terms of net energy, using nature to do as much of the work as possible. Nature definitely has more resources at her disposal and she is definitely not worried about the rate of return. Although the sun shines for all, the job of concentrating the diffuse solar energy and its conversion to usable electricity etc., is a matter of technology and organisation. It inevitably costs money and there is already talk of who is going to work the solar derby. Even from the fundamental stand point, some people like Odum and Odum consider that by the time sunlight is concentrated, it does relatively little work where net energy is concerned. According to them, systems of vegetation have already developed ways of maximizing the concentration of solar energy from its dilute sources to organic matter, and the chain of biochemical machinery in plant photosynthesis has already been selected for maximum power after many million of years of natural selection.

Many of the new propositions made for converting solar energy more directly into higher-grade energy as in generating electricity or manufacturing chemicals would be impractical and would not yield any net energy. According to them, using more land in agriculture is about the only way of using more solar energy. This would mean a shifting of the agriculture, at present based on fossil-fuels using relatively little land and even less of solar energy to a more labour-intensive agriculture.

On the other hand there are people who see in solar energy the ultimate source of energy on an ever growing - a back-stop

technology - a technology which would put an end to all our worries about the availability of energy on an unlimited scale for unchecked growth everywhere. Arthur D. Little predicts a market of close to $3 billion for installations using solar energy, for heating, cooking and hotwater alone. I am not going into anything as controversial and as distant as solar energy right now except to say that there are places and times where solar energy would come in handy, particularly with the development of new 'silicon wafers etc.", for concentrating solar energy. However, direct concentration of solar energy for industrial power generation etc., is going to involve much more energy input than in indirect uses of solar energy where nature has already done part of the work. Simpler uses of solar energy for drying crops etc., are already being made use of to the maximum extent where solar energy is available freely. Use of solar energy for space heating is not a necessity in places where the climate is already bright and warm enough. As regards cooling, it is much easier for human beings to get used to the heat to some extent and to design clothes etc, to suit the warm or hot weather.

Both are being done already. A few firms specialising in solar energy concentration devices will promote them very aggressively. Just as it happened with the vigorous and aggresive marketing of the oil companies, the seams will burst an all sides within a short time. Fundamentally, I do not see a day when solar energy will really be economical without involving heavy subsidies.

ENERGY AVAILABLE TO MANKIND

The big five of the world energy are five. They are in increasing order of importance the NUCLEAR, HYDROELECTRIC, COAL, NATURAL GAS, PETROLEUM. The more or less sneaky way in which the importance of petroleum fuels has grown in the total percentage of the world commercial energy demand is easily seen when we review the energy mixes, over several decades. I deliberately use the word "sneaky" because the European coal industry (outside of U.K) was practically killed by the oil industry, the way they dumped heat for space heating and industrial uses. It was an uphill battle because the coal-miners after all constituted a large part of any politician's constituency but finally oil won the battle both because of its technical superiority and the extremely

aggressive marketing. I don't want to bore you with too many statistical figures for more than one reason. The first being, as I shall mention elsewehere, making up huge figures is next to useless except as a rough guideline. Secondly, the energy industry is in such a state of flux that one can't see more than one hundred yards at a time in the thick fog surrounding the energy industries and the tremendous complexity of the picture. There are at least twenty different projections based on different scenarios for U.S. alone and none of them is reliable in the words of Senator Jackson.

"NUCLEAR POWER"

NUCLEAR ENERGY: While in a distant way even the solar energy is energy released by nuclear fusion going on on a gigantic scale, all our current talk on nuclear energy is about the energy stored in atomic nuclei of some of the earth's natural constituents. The simplest and probably the most inefficient way of using this tremendous source of energy is by converting it into thermal energy to boil the water to steam which will run the turbines and generate electricity. We have been fairly successful in this "boiling water" use of nuclear energy. Some attempts have been made to use theermal energy released from the nuclei directly as process heat to some extent finding one new way of using nuclear energy and also avoiding the essentially inefficient use in electricity generation.

Although the scientists have understood the theory of nuclear fission for almost half a century, nuclear energy has come of age very quickly. It is only 33 years since the experimental nuclear pile at the University of Chicago demonstrated that controlled nuclear fission was possible and it is only 18 years since the first commercial nuclear power plant - the Shipping port station near Pittsburgh - went into operation. Since mankind's first acquaintance with atomic power was in the form of destruction and holocaust with atomic bombs, there is a residual fear about nuclear energy, its potential and limitations even in the minds of very well-informed people. Probably, the first acquaintance of man with fire energy release by combustion - was also in the form of some holocaust or at least a fire in the kitchen.

However, the origins are lost in antiquity and we do not know how long man hesitated before making use of fire in a controlled,

systematic way. If an old Chinese story is to be believed, the man who lost his house in the fire came back to see his pig roasted nicely and tasting better than in the raw state. At any rate, nuclear power generation is not any more a scientific curiosity on a futuristic concept or an episode in a science fiction story, but a major factor in the energy picture. Even the operating plants and those on order in U.S.A. alone will generate over their lifetime a quantity of electricity that would require almost twice the proven oil reserves in the U.S. and Alaska if oil-fired plants were used. Nuclear energy will play a very dominant role in the French energy picture where the government announces over forty nuclear power plants distributed all over the country in one stroke, thus avoiding a lot of environmentalists' court suits etc., so common in the U.S. programme. Even oil-rich countries like Iran are going in for nuclear power-generation, may be, for a variety of reasons but ostensibly to prepare themselves for the day when oil will run out and also to save the "noble substance" for its more valuable uses.

Looking at nuclear energy from a new materials point of view, we have to confine ourselves to the presently operating fission type reactors. There are several varieties of fisssion type reactors and all of them have one thing in common, that is they use less than 5% of the total weight of fissile and fertile material in the core before the core is removed from the reactor. We have pressurized boiling-water and gas-cooled reactors and all of them use uranium 235 isotope as fuel. There is less than 1% of this isotope in naturally occurring Uranium and the remainder is Uranium - 238. While 235-U is fissile material, 238-U is considered "fertile" material - fissile being those fissionable and fertile those which can be converted to fissionable materials.

The process of converting a fertile isotope into a fissile one is known as "breeding" and the breeding principle employed in suitable reactors alone can enable us to make use of essentially all the nuclear fuel in the future. Breeding in an efficient way is possible only the "fast breeder" reactors (i.e.) those reactors employing more energetic neutrons (i.e.) neutrons that are not slowed down tremendously by moderators like graphite, water gas, etc. Some of the light-water reactors offered by the Americans use enriched uranium fuel (enriched from less than 1% 235U) where a part of the fertile Uraninum 238U is converted to Plutonium 239, A part of the Plutonium is also consumed by fission. The breeding

can proceed in two different ways (1) By thermal breeders using slow neutrons working best on 232 Th - 235U cycle (Thorium cycle) and (2) Fast breeders working on the Uranium cycle 238, - 239U. The rest of the reactors are more difficult than the thermal variety and they are still in the development stage. Only by establishing safe and reliable fast breeder power systems can we be sure of enough quantities of Uranium and Thorium reserves for thousands of years. Otherwise we will exhaust the presently explored and proved reserves of Uranium reserves. Almost all the proved recoverable reserves in all parts of the world have already been committed for sale to the nuclear power stations in operation or in the construction stages. Any new nuclear power station should already move to new sources.

FUSION

Unlike fission which has proved itself useful for commercial power-generation, fusion is still in the experimental stages. It may take at least another two decades before controlled fusion reactors are possible and are ready for commercial application, if at all. Fusion has many advantages over fission reactors if the initial problems can be overcome.

One may be tempted, in fact, bound to ask "what is holding up the rapid expansion of nuclear power generation if the vistas are so bright both from the economic and technical aspects?" The answer to this question is: There is continuous expansion in the nuclear power generation industry. However, the expansion is not as fast as it can be or should be. Apart from a lot of fears about the dangers of nuclear radiation and consequent troubles with communities, the real bottle-neck is financing. Nuclear industry can never be so self-financing as the oil industry has been, because power generation is subject to community control as utilities and they will never be left with enough money to finance their projects. However, with national backing and firm leadership at the political level, as in France, there is no reason why nuclear power generation cannot completely take over from the oil and gas industries all their power generation work. Oil companies are already turning their attention to nuclear industry and are getting associated in a big way with nuclear raw materials, reactor manufacturers, extensive research etc. They may also have the

necessary capital readily available if they let their oil and gas enterprises be nationalized for substantial compensation payments. COAL POWER:- Coal, the dethroned king makes a comeback. In fact, if the planned American "Project Independence" has to make some sort of headway and realise its objectives, coal has to give the most powerful helping hand. Coal as a fuel has played a vital part in the development of the industry during the past few centuries. The industrial might of countries like U.K., Germany and other European countries was made possible by the availability of large reserves of coal within their borders and the development of technological skill. Coal was the king as late as the 1960's in Western Europe and even today plays a vital role in the energy-mix of countries like Soviet Union, China, India etc. Coal was dethroned by oil because coal is basically a dirty fuel, dangerous to mine underground, expensive to transport and awkward to handle. Technically, it is only an indirect energy source unlike the oil which can be burning in the internal-combustion engine. The energy released by the combustion of coal has to be used in the form of steam or after conversion to electricity. Its use as an energy source reduces to one of "Boiling Water". On the positive side, we have to include the comparatively wide-spread location of coal deposits, easy exploration and the relative abundance of coal deposits. Coal is not as elusive as oil.

In a way this situation is ironical. The formation of coal is a more complex sedimentological and geological problem. Most of the coal deposits are "autoch thonous". formed "in situ". The basis for all coal deposits is a special climate and vegetational conditions conducive to the growth of dense forests and vegetation. Unlike oil, which is really ubiquitous, coal is confined to specific geological ages like Bermo-carboniferous, Tertiary etc. Nevertheless, in view of their massive nature, coal deposits are easily located. Accidental discoveries of shallow coal or lignite deposits is made much easier by frequent drilling or digging for water. The inventory of coal resources of the worlds is much more comprehensive and much of the exploration work can be carried out in the course of normal geological mapping and investigational work of the government departments within limited budgets. The introduction of geophysical methods makes life easier and even without sophisticated methods, coal is easier to locate. Coal deposits are being continuously discovered, like the vast deposits of Indonesia

discovered only in 1973. More than anything else, by an accident of history, we have more coal deposits proved than oil deposits.

Project Independence calls for an increase in coal production from 602 million tons in 1973 to 962 million tons per year in 1980 in U.S.A. Fortunately a lot of the coal in U.S. is mineable by strip-mining methods and technology is sufficiently sophisticated to do the job efficiently. Much of the opposition to expansion of strip-mining in U.S.A. is directed more at the social irresponsibility of the mining companies rather than at technology. The oustanding example of the very large open-cast mines for lignite in Rhineland, West Germany and East Germany have not in any way ruined the environment. In fact with sufficient social responsibility and care, the land used up in open-cast or strip mines can be rehabilitated (of course, at a cost) and probably restored with even more grace and beauty laid according to more modern ideas. Even the *New York Herald Tribune* acclaimed the rehabilitation measures of the Rhineland lignite mining industry.

Technological improvements in the use of coal desulphurization for removal of sulphur can emeliorate some of the adverse effects from using coal. Coal has been used after all, till recently, in the railway locomotives, domestic heating where diesel or fuel oil is used now. With all its advantages, oil can be a serious drain on the foreign exchange reserves of a country which has to import it. All those people who fought for the protection and retention of the coal-mining industry, suffering from the onslaughts of oil industry, were not all with vested interests in coal or politicians trying to catch the coal-mining votes. If only international economic relations were governed according to text-book principles of "relative advantage" etc., it would have made sense to switch over to imported oil, in preference to more expensive local coal. However in energy-intensive industries, almost all industrial countries have to follow the lead of some country which has reduced its manufacturing costs. This is the only way they can stand international competition, particularly when countries like Germany, Japan, etc. are dependent on external trade. This compelling necessity to be competitive, the aggressive pushing by the oil companies of oil products (some times even at dumping prices) were the reasons why Europe switched over to oil and planned on increasing it more and more until the oil-prices shot up beyond everyone's imagination. In a way, it was a classic case of

short-sightedness and vague thoretical principles gaining ascendancy over robust common-sense which reduced the European countries to complete impotence when OPEC started using oil as a political and economic weapon.

Cool can make a "come back" displacing oil in all uses, where it is not absolutely necessary. There is nothing preventing this "come back" particularly where the conversion to coal-firing is not going to involve major new investments. Since the railroads have anyway been electrified, it matters very little whether the electricity comes from coal or fuel oil. A project independence that way is even easier for Europe since it is (1) not in anyway so energy intensive as the U.S. one and (2) the transportation segment consuming a major share of oil products in U.S.A., is not that totally dependent on oil products and for so large a quantity. As we have seen in the case of nuclear power, if the 'have-not" countries tackle the problem on a war-footing, there is nothing to stop coal displacing oil in most of its uses and gaining its former dominance. The situation will be totally different if all the industrial countries can simply pass on their added costs on account of the higher oil-prices back to countries importing their industrial products in the form of higher prices. Then, there is no incentive for tackling the problem on a "war-footing". If the problem can be solved by raising the prices of manufactured products and by recycling of petrodollars back into their own industrialised economies, there is no necessity to tackle it on a war-footing and start paying higher costs before it is absolutely necessary.

furthermore, it is now so that coal and products from coal can compete with oil and oil products even on an economic basis. Much of the inconvenience in handling coal can be easily overcome by more mechanisation and mechanised handling, coal liquefaction and coal gasification. Some of the new processes being developed now, called COED and COGAS can convert one ton of coal into 10,000 cubic feet of quantity synthetic natural gas and one to 1.4 barrels of high-quality low sulphur crude oil.

In the COED process, the crushed and dried coal begins transformation in a multi-stage process called pyrolysis-heating in the absence of air. Heated at successively higher temperatures (up to 1600 degrees F in a series of 20-foot tall, 6 foot diameter, reactors,) the coal is turned into two volatiles-heavy oil and a gas.

What remains of the coal is char, a finely crushed by-product that resembles coal in colour and appearance.

The heavy oil is filtered to remove its solids and is treated with hydrogen under pressure to make low-sulphur synthetic crude oil. The synthetic crude oil can be subjected to the same refinery processes as the natural crude oil and converted into standard petroleum products like gasoline, jet fuels, kerosine, diesel fuel and other fuel oils essentially similar to those derived from natural crude oil.

Instead of Pyrolysis, coal can be hydrogenated also to yield liquid hydrocarbon products. In the Fischer-Tropsch process, a coal-derived gas consisting of carbon monoxide and hydrogen is passed through a catalytic reactor, yielding liquid hydrocarbon products.

COAL GASIFICATION

This is the chemical transformation of solid coal into fuel gas. Two pricinpal types of coal-gasification processes are now under development. One type yields a gas with a high-heating value called "substitute Natural Gas" or "pipe-line quality gas". The second type yields a gas with a low-heating value called low-Btu gas. There are at least half-a-dozen methods being tested now. Lurgi, Winkler and Koppers-Totset processes use first generation technology largely developed in Europe. New processes are being developed by Exxon, General Electric, Hygas (Institute of Gas Technology, in Illinois) BIGAS (Bituminous Coal Search) and CO_2 Acceptor (Consolidated Coal Company).

The economics of these processes are very favourable. A plant processing 25,000 tons of coal a day would need an investment of $300 to $500 million. Its output would be 250 million cubic feet of high quality gas and 25,000 barrels of oil.

UNDERGROUND GASIFICATION OF COAL

So far, only the the Soviet Union has practiced under-ground gasification of coal on a commercial basis although extensive research has been carried out in several European countries even nearly twenty-years before. The advent of low-cost oil stopped the research. The underground gasification will be very similar to "in-situ" combustion of heavy oils and this may be the most practical way to obtain energy from coal in very deep seams and other seams where easy mining methods are impracticable.

Looking at all the possibilities, we can only agree with Dr. Karl-Heinz Bund, Chairman of Ruhrkoble A.G., that "Coal is the sleeping giant in the world energy picture."

COAL RESERVES

Current estimates for world coal deposits are around nine trillion tons. Of the total, 76% is hard coal and 24% browncoal and lignite. U.S.S.R., U.S.A. and China have very large deposits and between them account for 88% total reserves. U.K., West Germany, Australia, India, Canada, Poland and South Africa all have significant reserves and account for another eight percent of world reserves. More detailed exploration and geological investigations are likely to result in more coal discoveries as the Indonesian deposits. Although coal reserves are about 15 times, as a global average, larger than oil reserves, the vast geographical differences in coal reserves, the relative cost of mining coal etc., make the "come-back" of coal as king different in the different parts of the world.

The problem in making coal the king is much more in Western Europe than in U.S.A. purely because of the technical conditions of mining and relative inabundance of coal. Several interesting variations on the theme of using coal have been proposed. In the use of coal for transportation purposes, the answer is to make use of coal for synthesizing hydrocarbons, but not the usual syncrude etc. The promising fuel is held out to be Mathonol, whose heat content is 170.9 kilocalories per mole compared to 94 kilocalories per mole of carbon. The value of carbon as a fuel can be multiplied by the factor of 1.8 if the difference in chemical binding energy is supplied by a nonfossil fuel source like nuclear process heat. Methane produced from coal with nuclear heat increases the fuel value of the carbon by a factor of 2.2.

In Europe, all the components to master the energy problems are available: light water reactors, high temperature gas-cooled reactors, the fast breeder, a little bit of coal, the technology for handling process heat as chemical binding energy, and the technology of pipelines and chemical engineering. It is only a question of organisation and putting them all together.

In U.S.A., the problems are not technological but man-made. Labour problems, uncertainty about environmetal laws and their enforcement and lack of research can inhibit the rapid production

of coal and its use.

To quite a large extent, only the Soviets have given equal importance to coal as to oil and developed technologies for coal utilisation. Their energy-mix is also not so heavily weighted in favour of oil. The very vastness of the country and the early difficulties in the transportation systems and the severe bottlenecks in almost everything connected with transportation of energy in any form (transmission lines, pipe-lines, railway-cars) led to the development of local energy sources for local consumption, to the extent of trying to make even regions, within a country, self-sufficient. Moreover, the Soviets were unwilling to gamble on risky exploration ventures for oil, in the early stages.

Economics of Coal:- A number of coal based complexes have been proposed. These complexes produce synthetic crude, SNG, coke and a variety of other products including sulphur, coal tar etc. The economics in such a case will depend on by-product credits. It is possible to supply synthetic crude at $6-8 per barrel and SNG at around $1/1000 Btu based on a coal cost of about $8 per ton. If we look into the investment needs of the oil industry on a world-wide basis, the substitution or a simple "come-back" of coal is well within the possibilities. The world-wide need for OPEC oil may get reduced considerably long before the oil deposits get exhausted.

STRATEGY:- More than all the economics involved, the relentless onward march of technology is not going to stop and the prospects for oil in the long run may not be all that rosy. Furthermore, there are very few countries with real exportable surplus of oil over and above their immediate and foreseeable needs.

We may even conclude that the end of oil-era is almost within our sight.

NIGERIAN COAL RESERVES:

Coal reserves of Nigeria, of all varieties, have been estimated to be 353 million imperial tons distributed in nine different localities in the former eastern and northern regions of Nigeria. Nigerian coal should not be considered as a source of energy but reserved for metallurgical purposes. In a total world reserves of over nine trillion tons of coal, these meagre reserves can at best be of only local

importance. For power generation and other similar purposes, the amount of associated gas flared alone should be enough to cover the needs of Nigeria.

Our study of coal as an energy resource is not so much for Nigerian needs as to find out the repercussions for Nigerian crude oil export trade if the major consuming/importing countries switch over to coal.

geothermal energy.

Living on the thin crust of a planet packed with molten liquid at high temperatures within a very short (relatively speaking) depth, it is in a way ironic that we are considering geothermal heat energy as a distant alternative to solar power, tidal power etc. Geothermal energy has been described as the earth's primordial energy.

The annual outward heat flow to the earth's surface is about equal to the heating value of 170 billion barrels of petroleum. The influx of heat by conduction from the earth's interior has been determined from measurements of the geothermal gradient and the thermal conductivities of the rocks involved. The average rate of flow of heat from the interior of the earth has been found to be about 0.063 watt per square meter. For the earth's surface area of 510×10^{12} square meters, the influx amounts to some 32×10^{12} watts. The rate of heat convection by hot springs and volcanoes is estimated to be about 1% of the rate of conduction or about 0.3×10^{12} watts. The major portion of the geothermal energy in the form of dry hot rocks has not been put to use nor are thoughts directed towards that end. Only local hot spots in this tremendous heat supply in the form of reservoirs of steam or hot water can be exploited. All our talk about geothermal energy is confined to this very small portion of the total geothermal energy available. The reasons are obvious. Geothermal energy in the form of steam or hotwater is already one step in our conventional power generation schemes. Instead of our boiling the water nature has already done it for us.

A geothermal reservoir which is deep and well insulated is hard to find and the exploration process is closely akin to the exploration for oil. The production practices are also close to petroleum reservoir engineering practices. In fact, it spans the entire gamut of sciences and engineering which the petroleum industry is now using. The oil companies are in an ideal position to spread their

wings in this field. Some companies like Phillips exploring in Phillipines for geothermal energy have met with considerable success. However, there seem to be a lot of misunderstandings between the government and the company even at this very early stage.

The company wants to reserve the right to change for geothermal energy at the same rate as for energy from oil, even if the cost of production of geothermal energy is much less.

There is no ready way of locating the deposits deep down except in regions of "surface thermal display". (i.e.) areas with hot springs and geysers. Only drilling can reveal the presence of steam or hotwater. Generally in the volcanic areas, high temperatures are reached at comparatively shallow depths.

Geothermal fields are of two major types (1) "Dry steam" "and" wet steam or "hot water" type. Steam or very-hot water reservoirs have temperatures ranging from 400 to 700 and they provide sufficient concentrated thermal energy for power production. Lower temperature water reservoirs have temperatures from about 150^{o} to 200^{o}F and can be of value in various heating jobs.

The economics of geothermal power is very favourable both from investment and operational costs point of view. The cost of electricity produced from geothermal steam was about $0.0053 per kwh from a nuclear plant and $0.01 per kwh from an oil-fired thermal generating plant in California.

Geothermal energy in any form has not been tapped on a large scale for a long time. There is no established industry or tradition to make definitive statements. However since the quantity of thermal energy at a temperature of about 100^{o}C within depths of 10km. from the surface of the ground is enormous, the potential can indeed be great. However, much more research is needed to make geothermal power a reality. The present estimates of geothermal potential range all the way from 1900 MW to 132,000 MW by 1985.

Geothermal energy is of importance to every energy importing country. The experiences gained in the oil industry and sub-surface hydrology are the building blocks for the geothermal energy industry. Italy, Japan, U.S., Russia, New Zealand, Iceland all have established some operating geothermal power stations and used geothermal energy for space heating.

Predictions for geothermal energy range from the ability to generate from 1 to 100% of the total U.S. electrical supply for

hundreds to thousands of years. There's even talk of geothermal energy satisfying most of the total energy requirements of entire communities including transportation indefinitely.

A rock-melting drill being developed at the Atomic Energy Commission's Los Alamos scientific laboratory could bring geothermal energy to virtually every community in the world simply by drilling holes nearby deep enough to reach hot rocks. Because the normal geothermal gradient is 20 deg C/km, rocks at temperatures of at least 300 deg C could be reached by holes about 15 km (9 miles) deep drilled almost anywhere. And, unlike conventional drilling, the Los Alamos drill is more efficient as it drills deeper because heat is the drilling medium. Under the Los Alamos plan, two holes would be drilled into hot rock, with water driven down the deeper hole for circulation through fractures and withdrawal at high temperature via the other hole.

Meanwhile, currently practical geothermal activity in the U.S. is limited to the Western states, although it has been used for some time in other areas of the world, Italy and New Zealand in particular and a Russian scientist claims the geothermal energy potential of his country is greater than all of its other energy sources put together.

A number of oil companies currently are interested in geothermal energy (Shell, Signal, Phillips, Getty, Union, Gulf, Chevron, to name a few) and virtually every electric utility company in the West has done some geothermal research, as have the U.S. National Science Foundation, U.S. Geological Survey, U.S. Bureau of Mines, U.S. Bureau of Land Management, and U.S. Bureau of Reclamation. In addition, U.S. federal legislation currently in the works would set up a Geothermal Resources Development Fund.

After placing the problem in the right perspective both in space and time, I may be permitted to sing the panegyrics of petroleum as a versatile fuel and raw material. At the last count, close to 64,000 organic chemicals could be manufactured out of petroleum feedstock. As a fuel, it has an energy density more than 1½ times that of coal, its nearest competitor. Its liquid nature is its asset. The fuel can be applied, directly at the point of application like in I.C. engines without going through intermediate stages of conversion. Even though the whole industry might have a life span of less than 200 years (in fact it would be even less if we omit both the first and the last ten percent of the consumption period) but it would be a

glorious century with one achievement after the other. It is a growth industry "par excellence"

The advantages of using Petroleum fuel instead of the conventional coal was first recognised by the Navy people, particularly Lord Fisher, the first Lord of the British Admiralty at the turn of the century. The French Premier Clemenceau in asking for American aid in petroleum supplies during the first world war characterised each drop of petroleum as a drop of blood. American President Wilson gloated over the allied victory in the first world war as, "the Allies floated to victory in a sea of oil."

In the words of Peter Odell; "A description of the world's oil industry demands the use of a many superlatives. By any standards, it is the world's leading industry in size, it is probably the only international industry that concerns every country in the world and, as a result of the geographical separation of regions of major production and regions of high consumption, it is first in importance in its contribution to the world's tonnage of international trade and shipping. Because of these and other attributes, a day rarely passes without oil being in the news." I may add that nearly half the shipping tonnage afloat today is carrying crude petroleum or the petroleum products over the high seas. Over two million miles of pipelines are doing the same job in other areas. Very soon external (international) trade in crude oil promises to be nearly one-quarter of the entire trade, in dollar value, in all commodities-raw materials and finished products.

The technical achievements of the oil industry, to understate the case, are fantastic. From exploration in the swamps, jungles and caves of the tropics to the permafrost of Canadian North and U.S.S.R., to the ocean depths of several thousand metres, oil industry has always devised its own ingenious ways of approach to the problem. Today we have the capability to drill in waters up to 3000 feet in depth and produce from fields situated in waters up to 750-1000 feet in depth as a matter of course. This is one field which has never hesitated to use any available scientific and engineering knowledge from any field besides creating new ones by constant research. The Chairman of Burmah Oil Co., when describing his team of engineers in Equador remarked "Between them they know everything that is to know under the sun." It draws the best talent available, gives thorough training lest there be any mistake whose cost may run into millions of dollars, pays and treats them well, but

at the same time demands almost marital attention (in fact, even more) to work. Unfortunately, the technical achievements of the industry are not matched by its attention to other things that enrich life and make life more livable.

Even if it lasts over a brief period of just over a century, it is a very dynamic industry with continuous improvements in its methods of exploration, production, transportation, refining and even final distribution . It has supported innovation and decreased costs at every stage. Even today in its declining days, it is coming up with new innovations in exploration as the "bright spot techniques" for direct detection of hydrocarbons, building off-shore concrete production platforms which can serve also storage tanks for up to a million barrels of crude oil, building super-ships of more than half-a-million ton capacity, reducing the transportation costs, inventing new processes to use every bit of the crude oil (one of the Foster-Wheeler advertisements shows a pig being cut into pieces and every piece being made use of and the caption says "We leave nothing but the squeal." Even if it is over a brief period, oil industry has reigned supreme, enjoyed a glorious rule over the world, participated in our major world wars and a number of other minor wars and upheavals and has been a glamour industry for nearly half-a-century.

The role of Petroleum as a source of primary energy is very well brought out in the very highly industrialised countries like U.S.A., U.S.S.R., etc., who are also endowed with enormous resources of petroleum. The role of petroleum as a basic chemical raw material is coming into prominence only slowly now all over the world, although early beginnings were made as early as 1918 in U.S.A. Lastly, petroleum as a major export resource in many underdeveloped countries is almost the only hope of salvation and development for these countries. It is almost like capital accumulated over millions of years by nature and like all other forms of capital can be converted into production, to ensure a higher standard of living for the people.

In this respect, "sombrero el petroleo" - sowing the petroleum - for national development, the watch-word of the Venezuelan oil nationalists is worthy of consideration by every country and is in fact being followed by many of them.

Petroleum industry is really a succession of industries which if integrated can roughly be divided into four stages: (1) The search

for and production of crude oil (2) The transportation of crude oil and products (3) The processing or manufacture of petroleum products as in refining and (4) finally the distribution to the consumer. Many companies are involved in all the four pnases of the industry and there are others who specialise in one or the other phase. The companies involved in all the stages are giant companies called the majors and others in one phase or the other are the so called independents. The transportation of crude oil and production is handled by tanker companies and pipeline companies. The tanker industry is only partially handled by the oil companies while nearly 65 per cent of this industry is in the hands of the shipping magnates. Petroleum is an industry which requires the highest degree of technical skill and right management since so many different factors have to mesh into one another to ensure smooth supply and a profitable business.

Secondly, let me say the oil industry is like a giant elephant with too many types of people from different disciplines talking from their own points of view. A technologist or engineer like myself is more likely to wonder and praise the technological ingenuity of the industry, the readiness with which imaginative and creative ideas are encouraged and backed up with enormous amounts of money until we start thinking about the social implications of what we are doing - aiding or abetting in doing.

A Marshallian economist like Adelman of M.I.T. is more likely to look at the industry from the pure supply and demand point of view with constant reference to the competition model and talk about factors which will ultimately lead to a state of equilibrium and reduction in oil-prices. Incidentally, every prediction from Adelman has been proved wrong and he blames it wholly on the activities of the U.S. State Department acting on its own, completely ignorant of the subject and intricacies of Mineral Economics. At the other extreme, we will find semi-politician-philosophers like Bertrand Russell who will always find political motive such as the control of mineral resources, particularly oil, behind every war, including the Vietnam war and the Biafran war. There are geographers like Peter Odell who will find the resources of the North Sea deliberately underestimated by the oil companies and assign much higher figures to the total discoverable resources in their models. Each one may be right and uttering some truth, but describing a completely different animal, like the six blind men who were

describing the elephant. All are facts, the large sizes of the firms engaged in oil business, their global nature, the politico-economic role they play and the technological ingenuity of the industry.

HYDROCARBONS AND NIGERIA:

Modern Oil industry may be deemed to have started in 1857 in Rumania and 1859 in America. However, until the turn of the century it was largely an American industry supplying "kerosene" for the lamps of the rest of the world.

The first attempts to find oil in Nigeria were made in 1908 by the Nigerian Bitumen Co., (a German company) who drilled about 14 wells sixty miles southwest of Lagos. However, the British ordinance, of 1914, precluded anybody else other than a British subject prospecting, exploring for or exploiting oil in any of the British possessions.

This applied to India as well where only one company, the Burmah Oil Co., a British company was allowed to operate and they were quite content to sit on the one field they had discovered by chance through the oil soaked legs of an elephant trekking through the forests. After all, they needed a market for the oil in the rich oil fields of Burmah which they were exploiting and there was no sense in proliferating the sources of supply. After 1909, that is after the discovery of the rich oil fields of Iran by BP, which Burmah oil financed in the beginning finally ending up with a 25% share-holding, the incentive to prevent further exploration in India was pretty strong. Although I have worked for the very same Burmah Oil Co., in a semi-nationalised form and as an employee received much better treatment from them than from my own government, I have no hesitation in condemning the company's dog-in-the manger policy of not doing it themselves and not allowing others to do it either.

The West African market was too small for the different companies operating as sellers here even to attempt to build separate installations or even send separate shipments. It went by rotation, one company sending the shipment each time and everyone else sharing it after arrival here to market under different brand-names.

It was the imminence of war in Europe and the probability of its becoming a World War which prompted the first serious

exploration for oil by BP-Shell in Nigeria in 1937. After all, there was an urgent need to build up vast supplies of this vital liquid at strategic points and Nigeria was a natural choice for the control of the South Atlantic. However, the war broke out earlier than anticipated and the exploration attempts had to be abandoned only to be resumed in 1951.

You will see that in the oil industry, it is not technical competence or financial capability or anything like that, which decides the direction of attempts, but the goals of society, in this case, the British Empire and the preservation of the Empire both by direct occupation and indirect commercial gains. Nigeria was the last place where this ordinance went into effect, although the Sheikhdoms like Bahrain were to be forced by treaties to adopt a similar stance towards non-British subjects, individual or corporate. Even such a powerful company like California Standard Oil Co., had to open up a Canadian subsidiary (1929) and operate in Bahrain as a British subject. Only Saudi Arabia was independent. Even such powerful figures in the oil history like Henry Deterding, of Royal Dutch, had to become British citizens before they could start their depredations all over the globe.

Until the arrival of the internal-combustion engine and the assembly-line manufacture of motor-cars and aeroplanes, there was only one major use for petroleum products and that was kerosene. Even then, people had to be persuaded to buy kerosene abandoning their traditional animal or vegetable fat for lighting.

Nigeria has a reserve base of 22 billion bbls. which when translated into reserves per capita works out to only around 200bbls. per person. Compare this with Venezuela which has 2100, Iraq with 4500, Iran with 1700, Libya with 11,100 and Saudi Arabia with 24,100 bbls. Norway even at this undeveloped state of its oil resources already has 5200 bbls per capita. Additional reserves may be coming forth in course of time, but compared with her population, Nigeria will never become rich by oil alone as Iran, Iraq and Saudi Arabia. In other words, oil will not give Nigeria enough surplus funds for investment and an investment income comfortable for generations. The race with time which I referred to earlier is especially acute here. Algeria with three times as much reserves per capita as Nigeria is doing so much to industrialise herself and be economically independent.

In Nigeria, we should not forget that the oil industry is handled

by the most-experienced international firms and therefore the technology employed is of the highest standards, subject, of course, to political constraints. Right now, they are sure of being here for a long time to come and therefore they are using the latest technology in their own long-term interests. Furthermore, some of the companies involved are themselves state companies like Elf, Agip, etc., and they are especially interested in preserving long-term political friendship and advantages therefrom rather than short-term gains of exploiting a reservoir hastily or any such thing.

There can be no such thing as a definite conclusion in a matter in such a state of flux, but we can always have recommendations for the immediate future and also give expression to some of the nagging worries. Even these recommendations have only limited validity since the people in charge of these affairs, some of the best brains in this country, are already seized by the problem. What they are looking for are some quick solutions to these problems and worries and not just an enunciation of the problems. The only conclusion I can come to is that we should not be hasty in arriving at any conclusions until more research has been done and the results of the presently commissioned research contracts by OPEC, OAPEC and this government are ready. All we can do is to hasten this work and do our bit here as conscientiously in as best a manner as possible and for this we should all really get together; in all seriousness.

My biggest worry about the Nigerian oil industry is the manpower needed for its development. Nigerian reservoirs are one of the most difficult to engineer and Nigeria needs technical manpower on an enormous scale not only to carry on things as they are but also to be creative in solving new problems that arise. However, all our efforts to train manpower should be based on self-help to the maximum. When you look at the Nigerian fields, it looks as though God made one field and in a fit of anger threw it down to pieces for you to pick up the pieces from wherever they are scattered. I have elsewhere touched upon the problems of the Nigerian oil industry right from the exploration through swamps to the production from scattered pieces of oil accumulations. This is not just a question of opening or closing valves but requires engineering skill and sophistication of the first order. Bad engineering will simply leave too much oil in the ground. Nigeria is

almost the only OPEC country (forget about the small Emirates) where manpower development is lagging far behind the need and not receiving the importance that should be attached to it. OAPEC countries meet periodically at ministerial level to discuss manpower development. Iraq has undertaken the gigantic task of building up a Technological University at a cost of over 1 billion dollars. The contract for the buildings alone is for over 200 million pounds. Here we are having problems at every stage. Even the efforts made at Warri based at a cost of about 25 million dollars is running into difficulties. The department of Petroleum engineering at Benin, once closed down by COREN is limping again but just limping. Here only at Ibadan have we been able to maintain a Petroleum Engineering department and graduate two sets of engineers. Ibadan, do not forget, is 300 miles away from the nearest oil field and so far, Ibadan has been helped by CIDA to a considerable extent.

In the absence of local manpower, will Nigeria be able to take up a challenge from the oil companies? After all, the oil companies very silently acqueisced when Kuwait and Saudi Arabia nationalised their oil resources and they were even willing to work for Venezuela and Saudi Arabia on a fee per ton basis. They found it more profitable to do that than worry about the concession terms and taxes etc.. In fact, they were quite happy that they did not have to worry about finding the market and that they would get their money for production. Will Nigeria be able to take up the challenge and develop her resources with her own manpower like Iran, Iraq or go into one of those contracts like Saudi Arabia, due to lack of developed manpower? Will it negotiate with all the 17 companies and if so from what posotion - a position of strength or weakness? As I have told you earlier, Nigeria is one of the most difficult places for oil production and you meet with problems at every stage right from the stage of exploration through swamps, mangroves and tropical forests to the stage of production where oil is distributed over 10,12 different sands of varying thicknesses, ranging over a depth of 3000 feet. This requires frequent completions and recompletions, which require real expertise. Will Nigeria be able to develop all this expertise very quickly? In my opinion, the development of manpower programmes are not going according to schedule even though plans have been devised and enough money spent to do something about it. May be,

something more concrete should be done about it at a very high level not stopping with indigenization decrees and watching the returns from the oil companies for the degree of indigenisation. There are ways of circumventing these decrees.

The training of manpower locally is only one of the aspects of development of manpower. In addition to sending plane loads of students for Ph.D. and higher degrees, plane-loads of people who actually have to do the work when they come back-in short, the actual workers-have to be sent abroad to learn the techniques. In addition to training technical manpower, the management must also receive fresh training as managers of the resources of an independent nation and forget their old training as custodians of law and order for the colonial master. The effects of colonialism cannot be shaken off so quickly but every effort should be made in that direction. Japan realised this very early in its history of industrialisation and sent batches of people to get trained abroad. They were not standing on prestige that only the bosses should go abroad and try to learn something. One more point, communications are an important aspect of training. Japan realised the importance of communications at a very early stage and went ahead with mass education programmes. Of course, there are problems in communication. As Peter Drucker remarks, the more we talk about communication and the need for proper Communication, the less we seem to be able to communicate to each other However, Drucker was referring to the problem at a different level - a much more sophisticated level. I am referring to the need for easy accessibility of bosses to the individual worker, the need for interchange of ideas, the need for an industrial democracy where speaking out one's mind without fear of being put down or ridiculed should prevail. I know efforts are being made in every direction I have indicated, but in the fast race we are running, the pace seems to be almost snail's pace. This country is receiving a fair deal from the oil companies who come here to work in so far as the training of people is concerned. Somehow I am surprised that there are very few offers from the various governments in the world with offers of scholarships and training facilities. When I was in Iraq, we used to be deluged with offers of scholarships and training programmes etc.

My second worry about Nigerian oil is this: Is Nigeria doing enough to create a security of demand for its crude oil? No doubt

Nigeria has been quite active in disposing of its participation oil through its own channels, but as far as I can see, this had been left to chance and the vagaries of world economic situation. Is Nigeria trying to tie its crude oil to certain refineries even in distant places as the Shah of Iran is doing by building refineries in India, Senegal etc. Is Nigeria simply going to let the oil sell itself? If as happened last year there is a world economic recession and the demand goes down, the tied crude oil will be sold first and others will not find a market. Here was the big advantage of the major oil companies. They were transferring their crude oil to their own affiliates and everything was planned in one central office. If the crude is left unsold, there is an automatic drop in the money available and this would have serious repercussions throughout the economy of the country. Is Nigeria trying to win friends and build up business contacts on a long-term basis? If the oil companies foresee the end of the oil era before the turn of the century, is Nigeria doing enough to industrialise herself and use the oil herself? There are quite a few long term problems and the earlier we start thinking about them the better.

My third worry about Nigerian oil is this: Is Nigeria investing something at least of its oil revenues in friendship with neighbouring countries and other African countries? Africa, as I have mentioned before, is still rich in untapped hydroelectric energy. Neighbouring Niger is already a major uranium country and Togo is showing potential as a major Uranium country. Nigeria may have its moment of pride when it gets oil revenues beyond all their dreams but an industrialised Nigeria, an energy-hungry Nigeria would need the friendship of other energy-carriers for its own needs. Untold riches suddenly obtained may lead to some arrogance and greed but foresight certainly will prevent the appearance of these evils. As the nation with the largest black African people, Nigeria has a special place in leading Black Africa. As one in four of the entire population of Africa, Nigeria has a special place of pride.

You may retort by saying that charity begins at home, but the investment in friendship I am advocating is only in Nigeria's own long-term interest. I can envisage a day when there is an All-African electric gridwork based on hydroelectricity supported by a few base-load thermal power stations based on fossil fuels.

As one in every four the Nigerian already has a place of pride in

the geography of the continent and corresponding responsibilities. Whether they will have the same place of pride in the history of the continent (for someone looking back in the year 2500 A.D.) will depend, to quite an extent, on what this generation does, how it handles its affairs and money and how it wins the friendship of other Africans and helps them in every way.