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PREFACE

This report gives a brief review of the Nigerian experience in the field of new and renewable sources of energy. It traces the history of energy development in Nigeria and the state of the arts in the application of the pertinent technologies. The roles of the various sections of the economy are briefly high lighted as are the various constraints limiting the widespread use of new and renewable energy sources, suggestions are made for overcoming these.

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1. INTRODUCTION

With the rapid rate of development going on in Nigeria, the immediate inpact of the energy crisis has begun to strike the Nigerian public at large. Nigeria is slowly but surely reaching that turning point where she will never again be in a position to take her energy supply for granted. The energy crisis has been slow in coming and it will be with us for sometime. The choices are going to be difficult in future and these will affect our way of life in no small measure.

In order that these choices are wisely made and hence all action that will be necessary to implement them, we require not only a sense of determination but also a coherent and realistic plan of action from the standpoint of energy supply and utilisation. A natural pre-requisite to this is a general understanding of Nigeria's energy problem and the various options open to her.

When the role of petroleum in the Nigerian economy since 1973/74 is considered, one is hardly surprised that the issue of petroleum and other energy sources has gained tremendous national interest. In terms of national economic growth, it is generally agreed that there is a definite and strong correlation between the aggregate demand for energy in a society and the Gross Domestic Product (GDP). In Nigeria, the GDP at 1962/63 constant factor cost increased from ₦2,385m ($4186m) in 1960/61 to ₦5,280m ($9267m) in 1973/74. During this same period, the annual demand for electric energy also increased from 360Gwh to 2038 Gwh. These figures represent a 6.3% annual growth of GDP and a 14.3% annual growth of electric energy consumption during the thirteen - year period. These figures should be seen alongside the annual growth of the GDP and electric energy consumption of 4 - 8% in the industrialised countries.

From the above, it is very clear that energy supply is an essential and vital input into national economic growth. Indeed, as the economy takes off from a simple agricultural base and becomes increasingly mechanised and industrialised, the farms and the factories would require increasing amounts of energy.

All the points made hitherto point to the need of a comprehensive policy on energy which would seek to systematically assess the national energy resources and reserves, and to draw up short - term, medium - term and long - term strategies for exploring, exploiting, and utilising the different and various resources for the purposes for which each is best suited in the overall national interest. Since some resources such as petroleum products, coal and uranium are major foreign exchange earners, t role of energy resources as sources of funds for the implementation of nat development programmes must also be considered in drawing up an energy pol Equally important are the uses of some resources in fields of food producti health etc. Thus, an energy policy must be both theoretically saund and practically feasible. It must take into consideration both the socio-econ and political climate of the country in which it is to be operated.

Nigeria is known to be rich in petroleum products, coal and uranium. However, inspite of this fact, it is essential that some diversification be encouraged particularly in view of the fact that the above resources are depletable. For example, it sounds reasonable that water heating and crop drying should employ solar energy where applicable. Other resources also have some part to play in the energy spectrum. Of course, these applicati must be relatively economic, the overall objective being to improve the standard of living of the average Nigerian to a level not too low when compared with that into the industrialised countries.

The main primary sources of energy in Nigeria are:

(i) Firewood and other dead plants
(ii) Coal
(iii) Oil
(iv) Natural Gas
(v) Hydro.

Other sources, which are in the main untapped include nuclear and the various renewable sources.

The above sources are extensive in quantity so that in the context of available resources and their exploitation, the situation in Nigeria is very encouraging. However, a realistic policy is required to ensure that each source is utilised in the most practical and economic manner.

HYDRO POWER

Introduction

Among the fourteen identified New and Renewable Sources of Energy, hydro power is the one most widely used in Nigeria. Hydro sources form the mainstay of electricity supply in Nigeria. The story of the development of electricity supply in Nigeria is thus closely linked with the development of hydro sources.

Fig. 2 shows the historical development of electricity Sales in Nigeria. In the period 1951/52 to 1976/77, the sales grew from 54 GWh to 3,266 GWh, i.e. at an average annual rate of increase of 18%. This phenomenal growth, resulting in a demand doubling almost every four years, was interrupted only during the civil war. In the first years of the post-war period, extraordinarily high growth rates were experienced, due to the backlog demand. In the period 1972/73 - 1976/77, a certain stabilization took place with a growth rate of 17%, i.e. approaching the long-term average.

The very high demand growth resulted from the simultaneous action of two factors. First, the number of consumers grew from approximately 37,000 in 1951/52 to almost 600,000 in 1976/77, i.e. at an annual rate of increase of 12%. Secondly, the average sales per consumer in that 25-year period grew as well, from less than 1,500 kWh to almost 5,500 kWh, i.e. at 5% annually.

In 1976/77, most load centers were connected to the National Grid and only a small number of towns received power from isolated diesel power stations. Maximum demand in the National Grid exceeded 700 MW in that year.

In the first part of 1977/78, the electricity consumption continued growing rapidly. From April to October 1977, an increase of more than 20% over the same period of the previous year was recorded. This development was interrupted in November 1977 when drastic load shedding had to be introduced in the entire power system. The reason was an unfortunate coincidence of an extreme drought period reducing the power output of Kainji and a delay in the implementation of a large thermal power station at Sapele. The situation normalized in September 1978, when additional thermal capacity was commissioned at Afam, Ijora, Sapele and Ughelli. The maximum demand started to grow again and exceeded the 1,000 MW mark in April 1979.

2.2 Load Forecast

Various facts indicate that the electricity consumption in Nigeria is likely to maintain a high growth in the future. The present per capita consumption is very low compared with other West African Countries:

Country	kWh per capita
Nigeria	60
Senegal	110
Ivory Coast	180
Liberia	230
Ghana	390

The bulk of consumption is concentrated in the Lagos area with almost 50% of the total sales and more than 90% of population having access to electricity service. In the rest of the country, the consumption is low. The service coverage for all country is estimated at 20% only. This will improve in the near future as soon as the extensive countrywide electrification programme is completed. Another stimulus for demand growth will stem from the numerous large energy-intensive industrial projects, such as steel mills, cement works, etc., which are either underway or firmly committed.

The latest load forecast elaborated by the National Electric Power Authority (NEPA) reflects the impressive social and industrial development Nigeria is undergoing. According to this forecast, the maximum demand in the National Grid will grow from 705 MW in 1976/77 to 4,040 MW in 1986/87, i.e. at an annual rate of increase of 19%. Even with such a high growth rate, the average per capita consumption will reach only a relatively modest figure of about 250 kWh at the end of the forecast period which is still substantially below the present consumption level in Ghana. This indicates that the load forecast is by no means exaggerated.

2.3 Large Scale Hydro Plant

The hydro-electric station at Kainji has been the backbone of the generating system. Its installed capacity was extended several times and has reached its final stage of 760 MW now. Recently, additional gas turbines have been installed at Ijora, Afam and Ughelli (Delta) bringing their available capacity to 95 MW, 246 MW and 312 MW respectively. A large steam power plant 696 MW has been constructed at Sapele. All these generating capacity additions will correct the hydro/thermal balance in favour of the latter and thus prevent the power supply from events similar to those experienced in 1977 and 1978. Sufficient thermal capacity will be available for the base-load operation backing up Kainji which - in accordance with its design characteristics - will be used to cover intermediate and peak loads.

With 760 MW at Kainji, 653 MW at the gas turbine stations at Ijora, Afam and Ughelli, and 696 MW at Sapele it will be possible to cope with the growing demand until 1980/81. In that year, a further capacity addition will be required in order to have an adequate reserve. NEPA established the following expansion programme for the early 80's

1980/81	gas turbine plant at Sapele (300 MW)
1982/83 to 1983/84	Shiroro Hydroelectric Plant (600 MW)
1983/84 to 1984/85	Jebba Hydroelectric Plant (540 MW)

A comparison of the capacity of the existing and committed power stations, minus the required reserve, with the forecast maximum demand shows that there would be a reserve capacity deficit of approximately 300 MW in the years 1981/82 through 1983/84. NEPA is at present discussing appropriate measures, such as the installation of additional thermal units, to eliminate that deficit.

From 1984/85 onwards, the current plant programme will no longer be sufficient to cope with the rapidly growing demand (Fig.3.). Major generation system expansion is therefore necessary. The hydroelectric projects under study have too long a lead time to be considered before 1986. Consequently, the only solution is to build a large thermal power plant with an installed capacity in the order of magnitude of 1,000 MW. Preliminary studies indicate that the power plant should be located in the Lagos area where the main load is concentrated, and use gas transported by a pipeline from the oil fields in the Niger Delta.

With this new large thermal power plant it will be possible to meet the incremental demand up to 1985/86. In 1986/87, a further major extension will be required. To this end, NEPA is considering various hydro options including a 1770 MW plant at Lokoja .

2.4 Small Scale Hydro Plant

Much has been written and read at conferences on various sources of energy to help towards solving the energy requirement of the Nation. The development of large hydro-electric schemes, a renewable source of energy, has also been given adequate coverage. Some specific projects, notably Shiroro and Jebba Schemes, have been translated from the drawing board to actual construction with millions of Naira being made available to sustain these projects, while Ikom and Makurdi are yet to be awarded and the Lokoja scheme is being considered in spite of the numerous environmental impact. Small hydropower sites in Nigeria have always been recognised as capable of providing a very useful source of energy, but the development of such schemes has not received the attention it deserves apart from the one harnessed by private enterprise for electricity generation on the escarpment of Jos Plateau.

Hydropower generation on Jos Plateau dates back over half a century when a 2MW Station was commissioned at Kwall Falls on N'Gell River, a tributary of Kaduna River, situated some 28 kilometres west of Jos. Also at Kurra Falls some 60 kilometres South West of Jos a 4MW Station was built using the impounded water at the confluence of Rivers Tenti and Gnar which flows into River Sanga which eventually joins other rivers to flow as tributary of River Benue. The increase in energy demand especially for the Tini Mining Industry on the Plateau led to development of both schemes, at Kwall to 6MW and at Kurra to 19MW. To achieve this increase in generation and to enable generators to operate at increased load factor a number of impounding reservoirs have been created by constructing dams.

The Kurra Scheme utilises Tenti Dam, Ankwil Dam and a small diversion dam at the upper section with two power stations, Kurra Dam at the middle section with one Power Station, and two diversion weirs at the lower section in Jekko area with two power stations. It is interesting to note that through the long dry season during which no rainfall occurs for about five months, the same water impounded at Tenti Dam which passes through the first generator at the first Ankwil Station also passes through the remaining four stations down the line thereby generating electricity at five stations before it finally runs off into Benue River.

As for Kwall Scheme, it utilises Kwall Stream Dam, Gyell Dam and Ouree Dam on Ouree River which is approximately 6 kilometres South of Gyell River. A canal of nearly 11 kilometres in length conveys water from the Ouree Dam to Kwall Stream reservoir. The impounded water permits operation during 4 to 5 months of dry season at an average monthly load factor of 23 per cent.

Apart from the existing schemes described above the Plateau State has other small potential hydro-power sites some of which are Sha Falls which could be developed by N.E.S.Co., and Shemankar as well as Mada rivers which could be developed along with Lower Benue River Basin Development Authority Schemes.

It is estimated that the total electrical energy that can be provided from existing schemes and schemes for which full hydrological investigation has been completed in the Plateau State is some 300 million K.Whrs. per annum. Other sites which have not been investigated will possibly have a further development potential of between 200 and 300 million K.Whrs. per annum. Furthermore the cost per installed KW of capacity in some of the schemes examined is cheaper than the installed cost per KW of the very much larger Hydro-Electric Projects.

Consideration should certainly be given to a reappraisal of Government Policies, which over the last 15 years have inhibited the development of small Hydro-Electric Power Schemes by the Private Sector.

Potential small hydro-power resources are not peculiar to Plateau escarpments in Jos or Mambila but such resources include:-

(i) River sites - with or without dams where sufficient Specific hydraulic capacity exist and where power - houses and related structures can be built.

(ii) River sites where small dams are built for flood control, navigation, irrigation or recreational purposes.

(iii) Existing structures on irrigation or water supply canals (with particular reference to the installation of Bulb-type turbines on the outlet valves of such canals and Dams).

There is no area of Nigeria which does not have at least one of the above resources judging from various irrigation schemes, but we have hitherto failed to harness them for hydro-power generation. Small low-head or high-head hydro-power facilities are available and turbines could be designed to match various water-flow conditions.

There are few constraints to the implementation of small hydro-power generation in Nigeria which may be summarised thus:-

(i) Lack of co-ordinating bodies for water resources (A new Water Resources Body was inaugurated recently).

(ii) Lack of Technical Man Power to carry out feasibility studies and to design, construct, and operate small hydro-power stations.

(iii) Economic constraints.

It is hoped that the recent establishment of a National Council on Water Resources will go a long way to removing the constraints to the implementation of hydro-power generation. It will be necessary to seek international co-operation to provide technical assistance, the development of manpower and finance in the form of long-term direct loans to finance development.

3. SOLAR ENERGY

3.1 Inroduction

Of the various New and Renewable sources of energy perhaps Solar Energy is the most promising for wide - spread application in Nigeria. Lying approximately between latitudes $4^{o}N$ and $13^{o}N$ as she does, there is hardly anywhere in Nigeria where the length of day is less than 11 hours. Although it is recognised that the lengths of actual sunshine hours are less on account of closed cover, there is definitely sufficient time all the year round for solar devices of some type or the other to be put to use anywhere in Nigeria. On the average, the yearly total solar energy falling on a horizontal surface in Nigeria is about 2,300 kWh/m^2 with an average of over 2,000 hours of sunshine per year with relatively little seasonal variation particularly in those areas which are remote from the coastal areas. Nigeria is thus in a geographically favourable zone for use of solar energy.

It should be mentioned that there has been a number of traditional uses of solar energy in Nigeria. Such application include:

(i) crop-drying by direct exprosure to the sun e.g. cocoa beans from which chocolate is manufactured;

(ii) drying of clothes and other wet materials;

(iii) drying of mud-blocks used in building construction.

The above list is by no means exhaustive but they are all attended by the same problem - efficiency of operation. In order to improve the efficiency of utilisation of solar energy more modern methods will have to be employed.

3.2 Current Work on Solar Energy Development in Nigeria

Most of the work on Solar Energy utilisation in Nigeria has been undertaken. by individuals in the universities and polytechnics, and such research and development agencies as the Federal Institute of Industrial Research in Lagos and the Project Development Agency in Enugu. A number of experimental units has been built and tested but it is necessary to state that thus far the stage of commercial production of Solar Energy devices has not been reached in Nigeria. A few items have been imported and are working but only as demonstration models. It is expected that the on-going developmental work and the attendant publicity will soon lead to some local manufacture on commercial scale.

It is worth noting here that a Solar Energy Society of Nigeria has recently been formed. Such a body will increasingly provide a forum for sharing of experiences among workers in the field of Solar Energy application.

3.3 Prospects for Solar Energy Application in Nigeria

It is necessary to identify solar energy applications suitable for Nigeria. In exploring these prospects the following direct uses are relevant:

(i) heating of water for domestic and industrial uses;
(ii) space heating;
(iii) cooking;
(iv) drying of agricultural and animal products;
(v) refrigeration
(vi) space cooling;
(vii) desalinisation and
(viii) electricity generation - thermal and photo-voltaic.

The items in the above list have not been arranged in any particular order. An attempt will be made to expand on the above topics.

(i) Water Heating

Solar water heating is perhaps one of the oldest and most developed of all applications. Hot water is widely used in homes for bathing and for washing clothes and dishes. There is little definitive data on the extent to which homes in Nigeria actually need hot water but it is safe to say that given the hot climate in Nigeria, hot water requirements for bathing will be minimal although it is noted that modern homes, particularly in the urban areas, are frequently equipped with electric water heaters for this purpose. It is thus conceivable to expect a good market for solar water heaters in these areas if only to reduce the pressure on the use of fossil fuels.

Perhaps a better use may be found for solar water heaters in Nigeria if the hot water is used for cooking and for washing and other sanitary functions. These duties will be particularly appreciated in rural areas where conventional forms of energy are not easily come by.

Large scale uses of solar water heaters can also be envisaged for hospitals, hotels, schools, industries etc. Industrial applications can extend to use of solar - generated hot water for processes or as feed - water for process water heaters.

The technology of solar water heaters is already well developed and the prime need in the Nigerian scene is for local adaptation which takes account of such constraints as inadequancies in the range of material available for construction, limitations in practicable fabrication techniques and the ready acceptability of such devices. Considering the fact that conventional fuels are at present relatively cheap in Nigeria, the aim must be to produce solar water heaters that are demonstrably economically competitive with the present conventional alternatives.

ii. Drying of Agricultural Products

The aim in crop drying is to achieve a low level of moisture content so that the crop remains stable in storage and is easier to handle. The use of the sun to dry crops is an ancient practice and is widespread. Thus, in Nigeria, such crops as cocoa, groundnuts (peanuts), corn, yams, lumber, etc. are dried by simply spreading them out in the sun. The technique is simple, cheap to use and, to a large extent, effective. However, it has some serious limitation. When crops are directly exposed to the sun, they are liable to infestation by insects, dust and vermin. They are also exposed to elements other than the sun e.g. rain.

The use of solar dryers ensures that the material drying takes place in protected surrounding and under controlled conditions. which will generally result in enhanced quality of the dried product. Solar drying can be extended to protein products such as meat and fish which would otherwise deteorate rapidly in storage if they have been attacked by flies during the 'exposed' drying stage.

Perhaps the main constraint in the use of solar dryers are socio-economic in nature. Specifically, solar dryers are relatively expensive. Prices can only be brought down by the use of locally - available materials of construction and the development of local fabrication expertise. Also, there is need for public education as regards the capabilities of solar dryers and, most importantly an assurance that the quality of the dried product is not inferior to that obtained from traditional drying techniques. This is particularly necessary for cash crops such as socoa and groundnuts. The farmer must be assured that the products are good and the end - users must also be assured that the finished products e.g. chocolates, are in no way inferior to those obtained from the traditional drying techniques.

(iii) Distillation of Salt and Brackish Water

Although there is hardly any inland brine lakes in Nigeria, distillation of water can be useful in the coastal rural areas of Nigeria. These areas, particularly in the riverine areas of Southern Nigeria are not readily accessible and hence are mostly devoid of basic infrastructural facilities. Family or village - size solar stills can prove to be quite cost - effective. This is also true of several remote areas of Nigeria where dirty water is available.

Perhaps some by-products of solar desalianation may just be profitable. Notable among these is the production of distilled water for batteries. In Nigeria, in recent times, the cost of distilled water has risen sharply coupled with a sharp decline in quality. Another by product, common salt may also be feasible although more work needs to be done on this.

(iv) Space Heating

Although the weather in Nigeria is generally hot, some areas do require some space heating particularly in the Harmattan season. Some areas like Jos Plateau, are generally cool throughout the year. While there may be little active heating requirements, it will be most appropriate to develop techniques of Passive Heating for these areas.

Perhaps the constraints to the use of Passive Space Heating have to do with the lack of the required technology. This will have to be overcome. Also builders and architects will need to be fully informed as to how to integrate this system into modern as well as traditional architecture.

(v) Space Cooling

There is a need for cheap cooling methods all over Nigeria. The popular vapour compression air conditioners are either too expensive or there is no electricity supply to drive them. As attractive as mechanical solar air-conditioning appears to be, it is unlikely to gain much favour in a developing country like Nigeria. Thermal systems are so capital - intensive as to make them rather unattractive in economic terms.

Short of a drastic break-through, perhaps further developments in photo-voltaic devices may put solar air-conditioning within the reach of the rural dwellers. This is still several years hence.

However, Passive Cooling systems may go a long way to improving the comfort of Nigerians. The technology should be further developed locally.

(vi) Solar Refrigeration

Solar refrigerations are attrative for large-scale applications in long-term food preservation and for storage of various items such as biological and medical materials. Considering the costs of solar refrigeration systems, farmers and other rural dwellers may have to form co-operative units for use of central refrigeration facilities.

(vii) Cooking with Solar Energy

Sociological considerations are likely to limit the widespread use of Solar Cookers in Nigeria.

(viii) Electric Power Generation

The technologies for electric power generation from Solar Energy are fairly well established. However, Solar power plants are capital intensive and it may be many years hence before higher final costs and improvements in the pertinent Solar technologies will make Solar power generation economically viable.

In Nigeria, electrical energy sells for about 6k (about 10 cents) per kwh. Any viable Solar system will have to match this figure. Such system will necessarily include storage devices and distribution system.

However, there are several isolated areas of Nigeria which are not served by the grid system. Such places may profitably use solar system based on photovoltaic conversion. Other uses in remote areas include railway signalling system, telecommunication systems etc.

(ix) Industrial Applications

Although industrialisation is in its infancy in Nigeria some thought is already being given to the conservation of her depletable energy sources. To this end, and apart from the use of Solar generated heated water for washing and other domestic chores, hot water can be generated for process work or as the feed water for process water heaters.

(x) Water Pumping

Perhaps the most noble use of any form of energy is for the provision of water for drinking and for irrigation. Large tracts ofland are now not arable because water is not available. Governments have continued to spend large sums of money through the establishment of River Basin Authorities and other means mainly for the purpose of providing portable water for the teeming millions and irrigation water for the farmlands. As laudable as these ventures are, they are not really sufficient because of the vast expense involved. Solar energy is being thought of as a means of providing this essential service to the rural dwellers. While thermal systems may be rather expensive now, it is quite conceivable that system based on photovoltaic conversion can be cost-effective. Some experimental pumping units have been installed in various parts of Nigeria with reasonable results. More work needs to be done in this all important application.

4. BIOMASS

In the context of this energy source, consideration is given to fuelwood, charcoal and the organic fluids - ethyl alcohol and biogas. Each will be considered separately.

4.1 Fuelwood

Fuelwood is not only the most popular biomass fuel in Nigeria, it is also the most widely-used of all fuels accounting for over 40% of the total energy consumed. Annual consumption figures are not easily come by but an estimate of about 70 million cubic metres (about 38 x 10^9 kg of wet wood) is thought to be a minimum. It's use is not only confined to the rural areas but also extends to the highly urbanised centres such as Lagos, Ibadan, Kano, Kaduna, Enugu etc. It is without any doubt, the major fuel for large - scale domestic cooking and several small-scale industries (e.g. bakeries) which utilise fuelwood as their major energy source.

To supply the fuel requirements, fuelwood plantation have continued oto be established in Nigeria since about 1912. These are now supplimenting the wood obtained from the free forests and at the same time assisting in fighting the consequent environmental problems of deforestation and desertification. Unfortunately, however, the pressure on land utilisation has tended to reduce these fuel plantation.

Perhaps the main problem associated with the use of fuelwood is the fact that the fuelwood energy recovery appliances - stoves and combustion chambers - have remained as crude as they were several years ago. Conversion efficiencies are low (less than 8%) and pollution is intense. In spite of all these drawbacks, fuelwood is still the cheapest and naturally the most popular. Figures for Ibadan, a large town in Nigeria, indicate that fuelwood energy cost about 10.6k/MJ while the corresponding figures for charcoal, bottled gas and kerosine are 29.73k, 30.0k and 49.0k per MJ respectively.

4.2 Charchoal

Charcoal burning is a rural art although its use is confirmed to the more urbanised areas mainly because, in its best form, it is essentially smokeless. While its use is mostly confined to small-scale domestic cooking some special charcoals are used by local blacksmiths and goldsmiths. Charcoal production is effected in earth kilns in the forests (particularly in the denied savanaahs) where they often constitute a fire hazard. Recovery is very poor and some work in a Nigerian University has obtained only 11% of the over-dry weight of wood instead of the anticipated value of about 30%

Unless these is some most work in this line, it is unlikely that charcoal will contribute much to the energy growth of Nigeria.

4.3 Production of Ethyl Alcohol

This source of biomass energy has not been investigated thoroughly in Nigeria although she is rich in molasses, cereals and palm products from which it is frequently derived For example in 1972, over 2 million cubic metres of raphia palmwine was produced in the delra area of Nigeria alone. It is quite concervable that this figure would have increased now. Some of this could easily be proceased and converted to alcohol although tremendous competition should be expected from the numerous palmwine drinkers.

4.4 Bio-Methane

Some laboratory work has been reported in the area of anaerobic bacterial digestion of organic wastes for biogas production. Several plant and animal wastes and manures have been screened for their ability to generate methane gas and some prototype plants have been built on a laboratory scale. A notable raw material for Biogas production in Nigeria is siam weed (Eupatroium Odoratum) a powerful and ubiquitous weed which often threatens valuable vegetation because of its high competitive capacity. For example, siam weed has been found to generate about three times the amount of biogas produced from water hyacinth per kilogram dry weight per day.

4.5 Pros. ·cts and Problems for the Development of Biomass Energy Forms for Nigeria

These are discussed under tne different energy utilisation sectors. There are four such sectors: Domestic, Agricultural, Industrial and Commercial.

(i) Contribution to the Agricultural Sector

Fuelwood is already being used in crop processing. There is however an immediate need to develop biogas for the same purpose, particularly in the areas where livestock are available.

The development of the production of ethyl alcohol in rural areas and later methanol production is quite feasible. These would then be readily available to fuel some cultivation equipment. The use of alcohols, blended or unblended, may not now be economical, but, with the rising cost of oil it may eventually become so. It will also confer independence in fuel resources to the rural areas and agricultural operations in particular.

(ii) Contribution to Domestic Energy Utilization Sector

Domestic energy requirements can be almost fully served by biomass products especially in the rural areas. Already, firewood is being used for cooking. Biogas can satisfy basically all domestic energy needs. Liquid fuels such as pyrolytic oil and alcohols can also run various prime movers. There are mobile pyrolysis plants for wood and lignocelluloses.

(iii) Industrial and Commercial Sector

This is a heavy energy demanding area, and petroleum products will for long remain the main source. Supplements would however be available from several sources including biomass. Refuse derived-fuels (RDF) is an essential development that will not only help to improve the urban environment, but also provide energy especially for generating electricity or gas. In the long run this is likely to remain the only viable method of waste disposal.

In agro based industries, the utilisation of hogged fuel of wood wastes and agricultural residues has a good potential to raise process steam and steam for powering mobile plants.

The greatest contribution will be on the liquid fuels particularly the alcohols.

As a future alternative, the crude alcohol distilling technologies now practised need to be refined to supplement energy needs particularly to rural industries.

4.6 Associated Problems and Methods of Containing Them

Deforestation is a great danger in uncontrolled utilisation of wood as fuel. This leads to desertification and soil erosion in the sahel and rain forest areas respectively. The only national solution is to ensure a sustained reforestation programme to supply not only fuelwood requirements (now standing at about 90% of total removal) but also other industrial wood requirements. Special efforts are required on raising the more potential tree species including the Euphorbia species which may be a basic raw material for liquid fuel production from biomass in the future.

The wood-burning stoves in use for domestic purposes are very inefficient and pollution-ridden. The level of technology required to improve on these is well within the reach of the country's human and material resources.

Large scale production of methanol and Ethyl alcohol may require the use of some basic food crops - Cassava, Cereals etc. - as raw materials. This is likely to make these scarce food crops more expensive. This therefore should be preceeded by greater efforts at production of these crops. Efforts could also be directed towards the utilisation of other forest products that are not popular food crops as raw materials.

Most of the appliances available are imported and are not specialised to utilise fuels other than petroleum products. It is however known that for several products, modifications can be made on the fuel injection/carburration systems of existing appliances to run on novel fuels.

4.7 GENERAL RECOMMENDATIONS:

Biogas technology should be immediately introduced and appliances to utilise these should be produced locally. This should be a viable commercial proposition.

Improvements in all wood-burning stoves should be effected and commercialised.

Charcoal burning kilns should be designed and commercialised. These should be capable of improving percentage charcoal recovery and the possible recovery of other fuels - gas and oil. The design should also contain the current serious forest fire risks in existing earth charcoal kilns.

The existing methods of fermentation and distilling of alcohols should be upgraded and newer raw materials should be examined.

RDF should be introduced, especially into the urban areas.

Afforestation is very essential. Forest lands should not be unduly reduced. Plantation of special tree species and shrubs (e.g. Euphorbia spp.) should be undertaken. Work should also commence on the technology of extracting liquid fuels from this and similar plants.

5. WAVE AND TIDAL ENERGY

Although vast quantities of exploitable energy in the form of waves and tides abound along the coastal areas of Nigeria, no attempt has been made to harness it for useful purposes. The situation is likely to remain so for the foreseeable future.

The constraints are generally as detailed for the other renewable sources of energy viz:

(i) lack of detailed studies of waves and and tides and hence practically no data on basic parameters;

(ii) lack of information on the potentialities of waves and tides as viable sources of energy;

(iii) high cost of power plants based on waves and tides.

The future use of wave and tidal energy in Nigeria will depend to a large extent on the formulation of an energy policy for Nigeria and the building up of a suitable data bank. Also, concerted efforts will have to be made at building up the technological manpower to design, build and operate the relevant systems and items of equipment and machinery. In this regard, the universities, colleges of technology and various research institutions will need to be properly funded to take on this assignment with local and international participation.

6. GEOTHERMAL ENERGY

Thus far, very little thought is being given to the development of geothermal energy in Nigeria. This is in spite of positive indications of several potential sources particularly at Ikogosi in Ondo State, the Kerri Kerri Formation near Maiduguri in Borno State, Abakaliki in Anambra State and in the Niger Delta subsurface. In some of these sources, the surface temperature of the warm springs is up to 15°C higher than for other surface waters in the relevant area while temperature of over 80°C have been recorded in some shallow boreholes. Nigeria's geothermal energy resource base is particularly large when one considers the existence of several thick highly-pressurised aquifers with temperatures in excess of 120°C in the Niger Delta subsurface (this is comparable to the setting in the Gulf Coast of America).

The successful exploitation of Nigeria's geothermal resource will have to await detailed studies aimed at providing the necessary data base as well as full feasibility studies of possible applications. Decision on the exploitation will have to await a comprehensive energy policy for Nigeria although in the meantime preliminary work must be done in obtaining these much-needed information.

7. WIND ENERGY

Nigeria is well-suited to the use of wind energy. However very little work has been done in this line although isolated wind mill-driven water pumping stations have been installed in some coastal areas of the south and in the northern parts of the country. Some of these installations, like in Badagry and some other coastal areas near Lagos were installed over twenty five years ago. With the introduction of conventional electricity supplies, these units have gone into disuse and are now more of museum pieces.

Data on wind properties abound with the Meteorological Department. Hence all that is needed is a collation and analysis of these data for engineering purposes. Specific applications will be for water pumping for domestic, agricultural and industrial use and for electricity generation.

Some work has been done in some of the universities on wind mills particularly the Savonius Rotor using the normal oil drums.

8. CONSTRAINTS LIMITING THE DEVELOPMENT AND WIDESPREAD USE OF NEW AND RENEWABLE SOURCES OF ENERGY IN NIGERIA

8.1 Institutional and Policy

In order to obtain a practical development of New and Renewable Sources of Energy (NRSE), appropriate uses must be identified in the total energy consumption pattern. This implies that an over-all energy policy for the country must be drawn up and within such a policy, one for NRSE. Such a policy will necessarily include the provision of a good institutional frame-work whereby the provisions of the policy can be vigorously pursued.

8.2 Inadequate NRSE Data Base

There is a significant lack of data on all NRSE. Such information is essential for the take-off of NRSE applications. Such data, when available should be standardised.

8.3 Financing

Perhaps the most important constraint to the extensive utilisation of NRSE in Nigeria are the high initial costs which can be several times more than for conventional sources.

8.4 Research and Development

Research and Development efforts on NRSE are essentially in their formative years in Nigeria. Those that exist are not co-ordinated. Furthermore, the R&D efforts are mostly limited to the laboratories and hafdly ever take into consideration the end uses.

8.5 Information Flow

There is a serious lack of data, literature and other items of information for all categories of people who may be interested in the application of NRSE. The public at large is not fully aware of the need for the utilization of NRSE, their limitations and economic advantages. Planners and decision makers need to have technical and feasibility reports on the various applications and have to be informed not only on the successful applications but also the failures. Specialists must have access to all items of information pertaining to NRSE. In order to generate total awareness on the nature and application of NRSE, school, college and university curricula need to include topics on NRSE.

8.6 Education and Training

Nigeria is desperately short of trained manpower at all levels. This is particularly true of technical manpower at all levels. This situation must improve in order to effect whatever policy is advanced for NRSE applications.

8.9 Transfer of Technology

Nigeria depends largely on imported technology in the areas of plant, equipment and machinery as well as 'know how'. The importation of these technologies is further favoured by the extreme shortage of local technical expertise for research and development, project planning and management, indigenous contracting companies and the various supportive industries - heavy engineering, metallurgical and chemical. The net result is that the technologies available are those designed for use elsewhere. There is hardly any effort to encourage the adaptation of these technologies to local conditions and certainly more to encourage original local ones. Furthermore, there is hardly any attempt to appraise these imported technologies. The end result is that very little technology is transferred.

9. MEASURES TO OVERCOME THE CONSTRAINTS

9.1 Institutional and Policy

Nigeria needs to define a comprehensive national energy policy which will include a policy on NRSE. To this end the Federal Government of Nigeria has recently instituted an Energy Commission of Nigeria which shall be responsible for the strategic planning and coordination of national policies in the field of energy in all its ramifications and without prejudice to the generality of the foregoing, shall -

(i) serve as a centre for gathering and dissemination of information relating to national policy in the field of energy development;

(ii) serve as a centre for solving any inter-related technical problems that may arise in the implementation of any policy relating to the field of energy;

(iii) advise the Government of the Federation or a State on questions relating to such aspects of energy as the Government of the Federation or a State may from time to time refer to it;

(iv) prepare after consultation with such agencies of government whose functions relate to the field of energy development or supply as the Commission considers appropriate, periodic master plans for the balanced and co-ordinated development of energy in Nigeria and such plans shall include recommendations for the exploitation of new sources of energy as and when considered necessary, and - such other recommendations to the Government of the Federation relating to its function.

(v) lay down guidelines on the utilisation of energy types for special purposes and in a prescribed sequence;

(vi) inquire into and advise the Government of the Federation or of a State on the financial needs of energy research and to ensure that adequate provision is made for this in relevant energy departments of the Commission;

(vii) advise the Government of the Federation or of a State as to grants and other financial disbursements to authorities charged with production and distribution of energy and other similar institutions in Nigeria;

(viii) collate, analyse and publish information relating to the field of energy from all sources, where such information is relevant to the discharge of its functions;

(ix) carry out such other activities as are conducive to the discharge of its functions.

As can be inferred from the above, the Commission is all-embracing and very high-powered. When it becomes fully functional it is expected that most of the constraints listed would be adequately tackled.

It is pertinent here to mention other governmental institutions whose functions relate to the field of energy:

(i) Federal Ministry of Mines and Power - this ministry is charged with the overall policy aspects of solid fuel recovery and power generation.

(ii) Federal Ministry of Science & Technology - this is the ministry that overseas general research and development works in Science and Technology. One of the five divisions of the ministry looks after Industrial and Energy Issues.

(iii) Nigerian National Petroleum Co. Ltd. - A public company charged with the exploration, exploitation and marketing of petroleum resources. The company also refines crude petroleum for domestic consumption.

(iv) National Electric Power Authority - A public corporation and the sole authority for the generation, transmission and distribution of electrical power.

(v) Ministry of Water Resources - a ministry charged with policy aspects of water resources utilisation.

(vi) Nigerian Electricity Supply Co. - an old private company located in the Jos Plateau. This company has a history of efficient electricity supply using small-scale hydro-electric plants.

(vii) In addition to the above, most of the nineteen states have institutions charged with energy responsibilities.

9. 2. Inadequate Data Base

One of the early activities of the Energy Commission will be establishment of Data Banks on NRSE. Such data should include the energy demands of the people, the available energy sources and their distribution, and the social and economic acceptability of the resultant applications.

9.3. Financing

Government should commission feasibility studies on NRSE applications. Thereafter, Government should consider various financial incentives such as tax rebates, tax exemptions etc. which would make NRSE devices competitive with conventional means. Such incentives will induce the private sector into entering the new field.

Banks and other financial institutions should initiate new methodologies for financing NRSE projects. In this wise, the fiscal policy should be reassessed.

In view of the fact that applications of NRSE sources are particularly suited to the rural areas, government should, as a matter of course, finance integrated NRSE schemes for rural communities. This way, the potentialities of the schemes can be demonstrated at grass-root level while also generating the required technology for constructing and operating the various devices.

9.4. Research and Development

Research and Development efforts need to be stepped up and adequately financed. Efforts should be directed at organising well-coordinated research and development as well as demonstration programmes.

9.5. Information Flow

The flow of relevant information needs to be improved considerably. There should be massive educational programmes aimed at creating public awareness and employing all facets of the mass media. Information leaflets, pamphlets and brochures describing in non-technical language the stories of NRSE appliances and plants should be freely distributed. To augment this, carefully planned and selected demonstration projects should be mounted all over the country care being taken to ensure the suitability of each project to the area where it is being mounted.

The relevant organs of government should prepare, for easy reference, technical feasibility and economically viability reports of various NRSE applications. These should be made available to planners and decision makers.

Government should encourage the organisation of conferences, seminars, workshops etc. as a means of creating avenues for discussion among specialists in the field and between these specialists and non-specialists.

Educational institutions should include energy studies in their respective curricula.

9.6. Education and Training

Training programmes should be organised for managers, decision makers, architects, engineers, technicians and artisans. Special emphasis should be given to training in Materials Sciences and Technology.

9.7. Transfer of Technology

Emphasis should now be placed on co-operation rather than pure transfer of technology. Efforts should be directed at adaptive technology and the building up of the necessary design competence and fabrication infrastructure. Generally, very little technology is ever transferred . On the other hand it can be acquired and adapted to suit local conditions.

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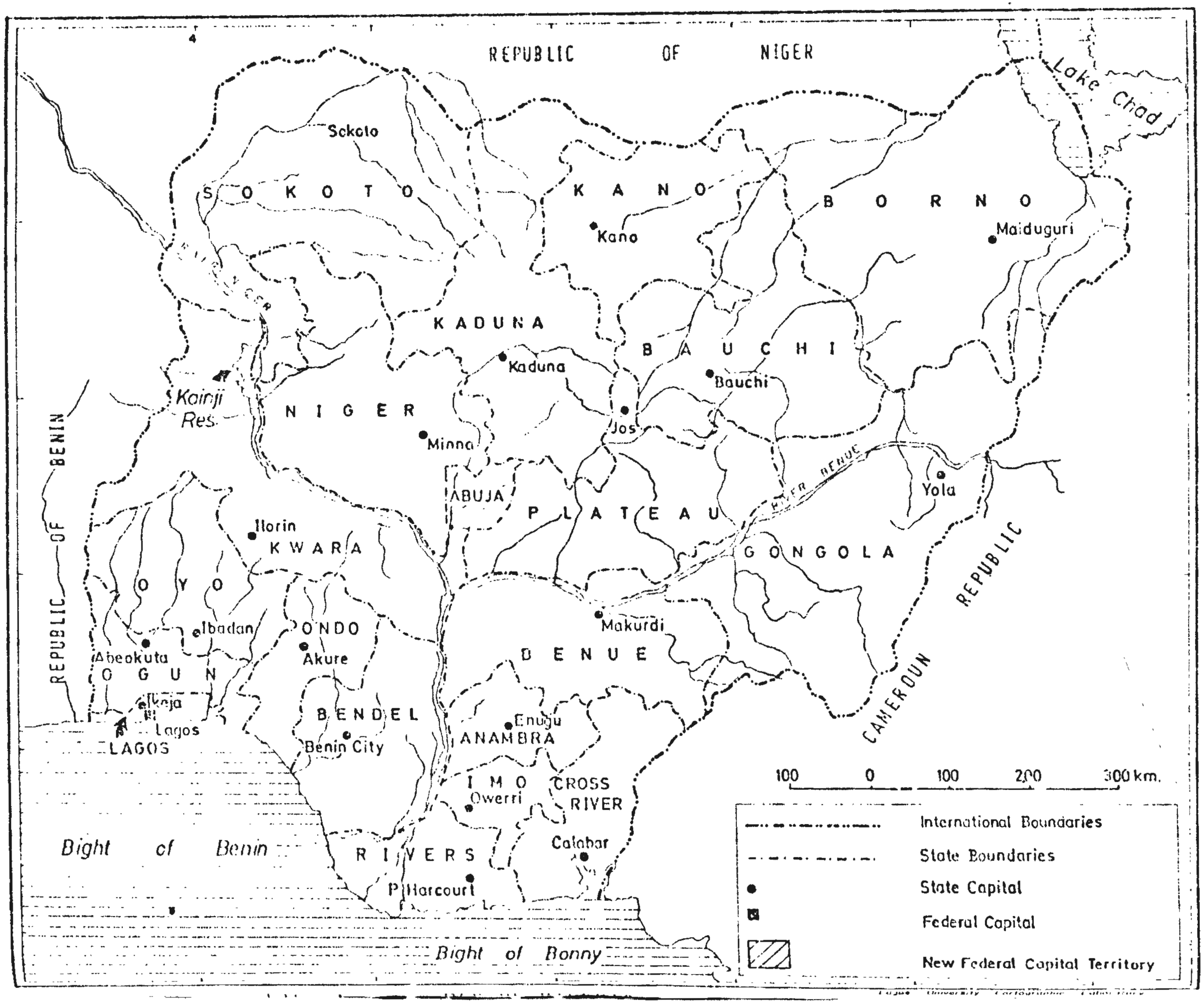
REPUBLIC OF NIGER
Lake Chad
SOKOTO
Sokoto
KANO
Kano
BORNO
Maiduguri
KADUNA
Kaduna
BAUCHI
Bauchi
Jos
Kainji Res.
NIGER
Minna
ABUJA
PLATEAU
RIVER BENUE
Yola
GONGOLA
REPUBLIC OF BENIN
Ilorin
KWARA
OYO
Ibadan
Abeokuta
OGUN
ONDO
Akure
Makurdi
BENUE
Ikeja
Lagos
LAGOS
BENDEL
Benin City
Enugu
ANAMBRA
IMO
Owerri
CROSS RIVER
Calabar
RIVERS
P Harcourt
Bight of Benin
Bight of Bonny
REPUBLIC CAMEROUN
100 0 100 200 300 km.
International Boundaries
State Boundaries
State Capital
Federal Capital
New Federal Capital Territory

FIG. 2

HISTORICAL GROWTH OF ENERGY SALES

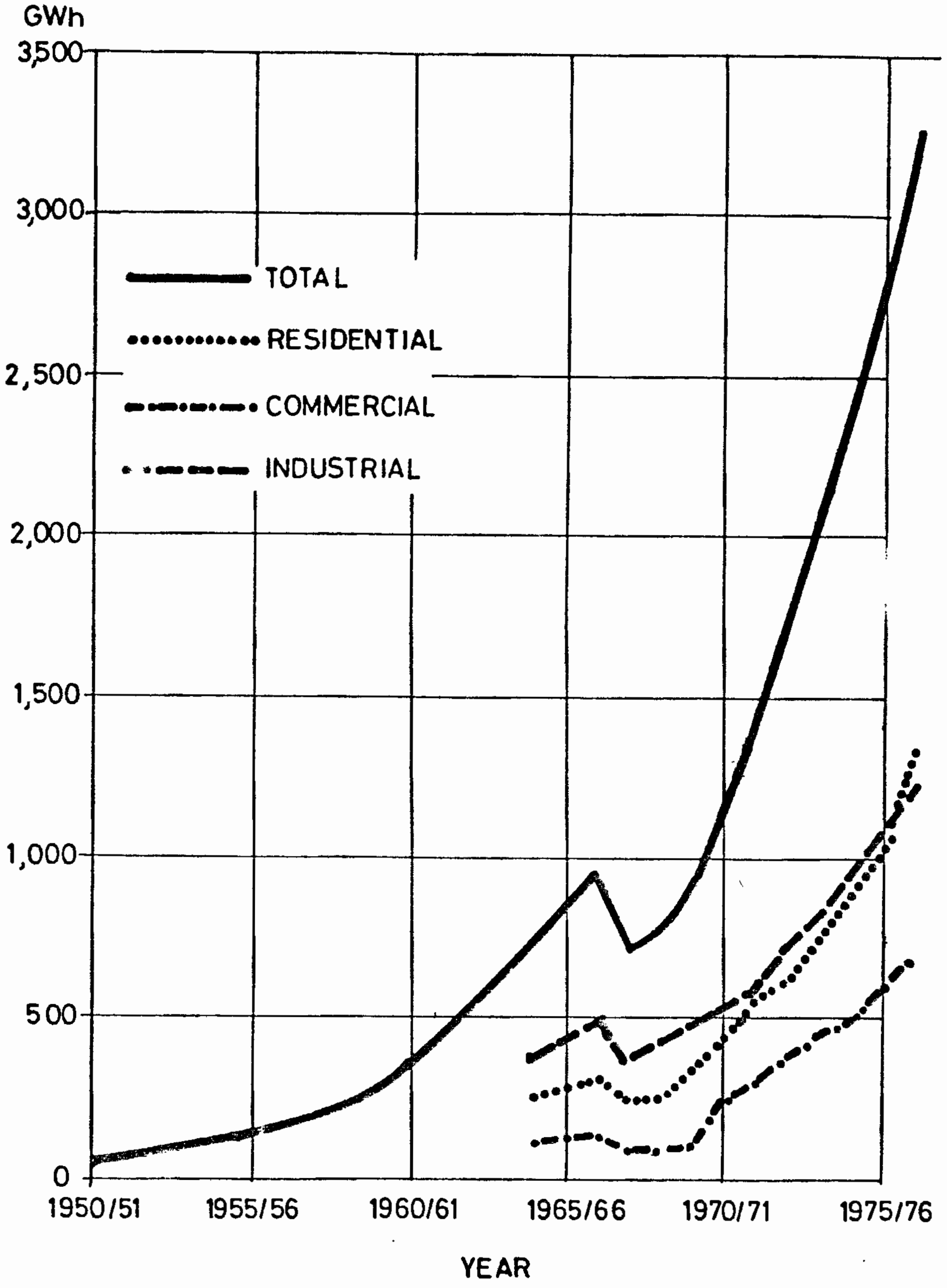

FIG. 3

ELECTRICITY GENERATING PLANT PROGRAMME
1978/79 - 1987/88