

ATOMIC ENERGY IN AFRICA

Twenty-one African countries have become members of the Agency, and throughout the continent much diverse work is in progress to obtain benefits from the peaceful application of atomic energy. Examples, together with possibilities for the future, are given here, with indications of some of the ways in which IAEA is assisting. The activities dealt with are not necessarily all connected with the Agency, but they demonstrate rapidly increasing interest in the application of nuclear techniques. The article is an abbreviated version of a paper prepared for the Eighth Session of the Economic Commission for Africa.

African countries which are members of the Agency are:

Algeria	Mali
Cameroun	Morocco
Congo (Kinshasa)	Nigeria
Ethiopia	Senegal
Gabon	Sierra Leone *
Ghana	South Africa
Ivory Coast	Sudan
Kenya	Tunisia
Liberia	United Arab Republic
Libya	Uganda *
Madagascar	

The IAEA is negotiating an agreement with the Organization of African Unity and expects to collaborate with the appropriate Commission of that Organization in matters of mutual interest.

In practical terms, IAEA's assistance, in agreement with the governments concerned, is related to the implementation of national development plans and to ensuring that the potential of the peaceful uses of atomic energy is taken into account in the preparation of future plans.

NUCLEAR POWER

The great majority of African electric power systems at present in existence are of a relatively small capacity and indeed some large hydro resources

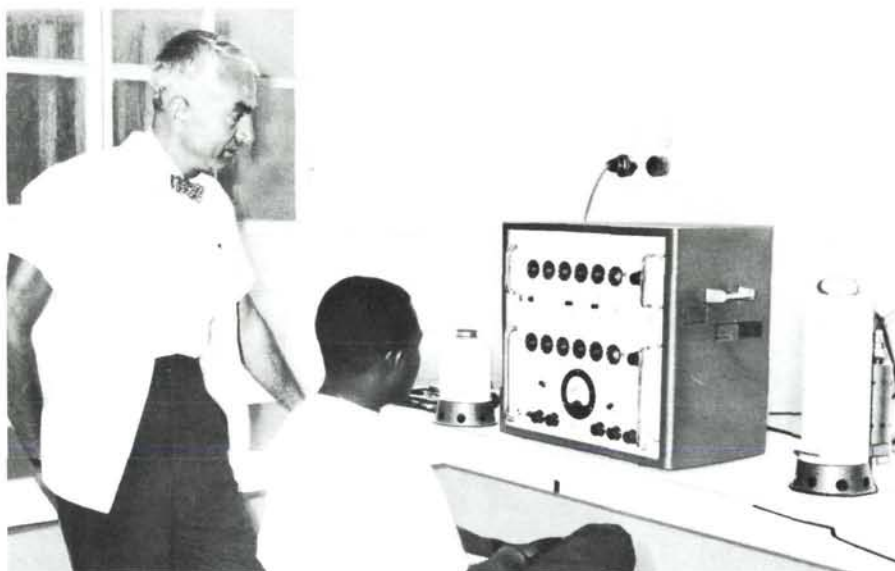
* Accepted for membership subject to deposition of Statutory Instruments.



In the grounds of the Kwabenya Atomic Research Centre, Ghana.

are in many cases untapped. Some time will be required therefore before nuclear units of a competitive size can be envisaged. There are possibilities of achieving an improved load factor in the areas where fresh water requirements will have to be met by plants for the joint production of desalted water and electricity. In Tunisia detailed studies on the feasibility of such a plant for use in the southern area of the country have been made. The UAR has embarked on a nuclear power project calling for a nuclear power station of 150 M(e) which would be integrated into the grid system. In the same country a project for a sea water desalination plant to be used in connection with a pilot agricultural project of 10 000 acres is being considered, the aim being to study the feasibility and economics of the use of desalinated water for agriculture under arid conditions. The Agency is ready to investigate cases of arid areas in Africa for which water de-salting appears to be an important problem.

Reports of the African Electric Power Meetings held under the auspices of the Economic Commissions of Africa and Europe pointed out the desirability for the planning authorities in the Member countries of ECA to keep abreast of technical changes in the nuclear power field. A developing country planning a new power programme should not therefore consider the atomic energy alternative in isolation but together with investigations of conventional means. This should be in the nature of a continuing process particularly when it is borne in mind that at least four years should be allowed for the construction and commission of a nuclear power station and about 2-3 years for the initial survey and studies. The many industrial development proposals now under consideration and particularly the development of an Iron and Steel



IAEA has collaborated in developing medical uses of radioisotopes in Senegal. Dr. J.N. Karamourtzounis, who was assigned under the Technical Assistance programme, is testing equipment used for medical examination with Dr. N'Doye.

Industry in West, East, and Central Africa, in so far as they require regional supplies of electricity are relevant to the production of future power. The ECA at its 1965 session also endorsed a suggested study on the possible role of nuclear power as an integrated power project for the Western sub-region. In preliminary investigations so far carried out by the IAEA in nine countries in Africa it has been suggested that the role of nuclear power should be the subject of separate studies during the next 3-5 years.

NUCLEAR RAW MATERIALS

In 1965 Africa produced about 17 percent of the world's uranium output mainly from South Africa, Madagascar and Gabon. In addition Madagascar produced about 1000 tons of monazite containing about 140 tons of thorium oxide as well as small tonnages of beryl. This does not represent production potential since South African production has been deliberately cut down from its production capacity of 5700 tons per year to less than 3000 tons in 1965. \$5 per pound of contained uranium oxide in concentrates is regarded as an economic price for uranium although many long-term contracts still exist in which the price is in the order of \$8 to \$10 per pound. However, contracts for small tonnages have been made in earlier years at prices as low as \$3.42 per pound, but it is unlikely that this would be representative of the prices which will prevail when the demand and supply position become more in balance. For example, the average price per pound paid for U_3O_8 in the U.S.A. in 1965 was \$8 per pound and the Canadian stockpile price is fixed

at \$4.9 per pound. When in later years demand exceeds supply and assuming that reserves of what are at present regarded as economic ores are not substantially increased in relation to rapidly increasing consumption, it will become economically necessary to mine deposits which are at present regarded as sub-grade.

The most up-to-date information (mid 1966) on the future supply and demand of uranium indicates that, on present evidence and at present prices, the Western world resources of uranium in 1970 at a production cost of \$5-10 per pound U_3O_8 , is about 600 000 tons, but larger amounts can be expected in higher recovery cost ranges. In the period 1971/80 cumulative consumption is expected to reach at least 270 000 tons and subsequent annual demand will rise to 55 000 tons. Deposits of uranium already known and developed in Africa represent the results of limited search and there seems little doubt that a more intensive prospecting, particularly in areas not as yet surveyed, will result in discoveries of new deposits of uranium ores as well as deposits of other minerals of potential atomic energy significance such as beryllium and thorium. Investigations of such areas are currently being carried out in Senegal, Tunisia, United Arab Republic, Upper Volta, Niger, Central African Republic, etc. In addition, the possibility of economic recovery of uranium as a by-product in fertilizer production from phosphate rock is being studied in Senegal and Tunisia and has previously received some attention in Morocco and UAR. Although the cost of production is not attractive on current prices of uranium, this situation would change with the development of new reactor systems such as breeder reactors and any change in the supply and demand position which will surely arise within the next two decades.

These facts are important for Africa since the development of nuclear power is likely to reach significant proportions only in the latter part of the century when the maximum world demand will face rapidly diminishing resources unless new deposits of ore are found or new reactor systems are developed which would permit utilization of higher cost uranium produced from low-grade deposits. The continent's vast potential of mineral wealth might well be organized to take advantage of this anticipated new demand which could be an important source of foreign exchange.

APPLICATION OF RADIOISOTOPES IN AGRICULTURAL DEVELOPMENT

Atomic energy in the form of radioisotopes and radiation plays an important part in the investigations essential to increase agricultural production. Endeavours to increase production require an understanding of the factors which affect yields. For example, fertilizers that are rendered radioactive are extremely useful in determining the best methods of fertilizing a crop in different soils, thus showing how to get the greatest yield for a given amount of fertilizer through the correct placement. The Agency is actively organizing world-wide projects designed to increase the efficient use of fertilizer on rice and maize. Madagascar and the UAR are carrying out research in the rice project; the

UAR is participating in the maize project, but interest has been expressed by Ghana and projects could be developed elsewhere in the main maize-producing countries such as Congo (Kinshasa). The use of portable instruments (neutron moisture probes) for soil moisture determination is invaluable in studies on the wise conservation and use of water in crop production. These methods have been in use for some time in Algeria, Ghana, Ivory Coast, Kenya, Madagascar, Morocco, Senegal, and the UAR.

Nuclear techniques are being used in plant production and protection studies, particularly in cocoa, peanut and rubber research in Ghana, in groundnuts and sorghum in Senegal and on olives in Tunisia. In 1966 the IAEA organized a world-wide co-ordinated programme for tree-crops such as cocoa, coconut, oil-palm olives and rubber, to determine the most efficient means of fertilizer application leading to increased yields. It is hoped that several African countries will participate, and a start has been made on olives in Tunisia.

Wheat strains developed through radiation have recently been shown, in trials in Libya, Tunisia and the UAR, to be superior to local and common strains. On present evidence it would be desirable to introduce these strains into Algeria, Ethiopia, Kenya, Morocco, Somalia, and Sudan.

Entomological research is being undertaken on a considerable scale and much attention is being given to the possibilities of eradication of the Mediterranean fruitfly in studies in Tunisia and Morocco and research into the eradication of the tsetse fly is being actively supported by the IAEA in Uganda.

Trainees at work in the Middle Eastern Regional Isotope Centre for Arab countries, UAR. (Photo: IAEA/Goldberg)



More intensive research is contemplated utilizing all the tsetse fly research facilities in Africa. Preliminary studies are being undertaken on mealybugs in cocoa in **Ghana**.

The introduction of radioisotopes in animal science is likely to be essential, particularly where research will help to elucidate those problems interfering with animal productivity; in **Senegal** it is proposed to establish an animal biochemistry laboratory with radioisotope facilities in an existing veterinary institute.

In the campaign to increase agricultural production both by the efficiency of production and by avoidance of losses from insect pests, etc., the use of radioisotope techniques is considered by research workers as an additional useful tool in their hands. For this reason the IAEA has been actively encouraging the establishment of small radioisotope units within the existing agricultural research units or, where none exist, in the faculties of agriculture of the national universities. It is not intended that the laboratory should be continuously in use but should be available if and when the need arises to solve particular problems. Many such laboratories exist and more recently new ones have been or will be established in Sudan, Nigeria, Cameroun, Uganda, Ivory Coast, and Rwanda.

FOOD PRESERVATION

The application of atomic radiation for the preservation and disinfection of food is under continuous consideration and research in some of the technically advanced countries. At this stage of development it would seem to offer distinct possibilities of interest to many African countries both in the dry and wet zones. In an environment where refrigeration is virtually absent, preservation of foodstuffs must be undertaken using other methods; irradiation causes the least change in general terms, from the raw product as compared to canning. For this reason the Agency is interested in carrying out studies in the appropriate African environment. Such irradiated products as potatoes, onions, wheat, bacon have already been cleared in one or more advanced countries for human consumption. Other products are under consideration for similar clearance. When this stage is reached pilot trials should be undertaken.

GRAIN, FRUIT, AND VEGETABLES

Destruction of insect pests in grain by irradiation and for sprout inhibition of potatoes and onions appears to be biologically and technically possible. Much work has also been done on the prolongation of the useful shelf life of fruits and vegetables, mostly based on the control of microbes. Delay of ripening of some tropical fruit, particularly bananas, mangos and papaya could be achieved by atomic radiation and the radiation preservation of fruit juices may be practical after further research. Whilst research is taking place in developed countries where facilities, resources and trained personnel are available, experts have recently advised that some of the work should be carried out in countries

where the raw materials are produced and where the processes would be applied eventually even if such countries now have no adequate facilities for such work. Initially in Africa it might be desirable to concentrate research in one centre on behalf of many countries which have the same problems. The proposed Ford Foundation Institute for Research into Tropical Foodstuffs Other Than Rice in Ibadan, Nigeria, might be a suitable site.

FISH

Losses of fish both in inland and maritime waters due to insect spoilage are well known in Africa. Considerable research is being undertaken utilizing conventional means in Mali, Niger and other countries and the possibilities of the prevention of these losses by radiation are being actively considered. The major problem is one of finding an inexpensive insect-proof package to prevent re-infestation. Since dried and smoked fish products are easily transportable, it has been recently recommended that studies on insect destruction be carried out under practical conditions by transporting materials to existing research establishments for irradiation. This may well be another problem which could be studied at the Ford Foundation Institute. Under the European Development Fund, pilot studies, combining irradiation and refrigeration, are being carried out in Europe designed to permit transport of fish from Abidjan to the interior of the Ivory Coast while ensuring it is fit for human consumption. The second stage will be carried out in Abidjan.

MEAT AND MEAT PRODUCTS

Radiation decontamination of commodities such as meat, bone, and blood meals, would substantially increase the markets for such products in Europe and elsewhere. Some laboratory tests (similar to the fish studies) in respect of meat preservation are being undertaken in Europe as the first phase of a pilot irradiation scheme in Chad designed for the export of meat to neighbouring countries.

Food irradiation is a complex subject and the IAEA, whilst actively co-operating in the necessary research before it is warranted to introduce the technique in a wider scale into developing countries, is actively supporting a limited programme of research in Nsukka (Nigeria), and Tunisia and in training programmes designed to provide knowledge on the potential and limitations of food irradiation. A training course on the subject will be held in cooperation with the United States Government in the summer of 1967.

ATOMIC ENERGY IN HYDROLOGY

Recent studies have proved that data of great economic significance with regard to the availability of ground water in arid zones and for the investigations of water resources can be obtained with comparatively small effort and at a lower cost through the use of isotope techniques. Isotope techniques

may be used to locate the sources of recharge and to determine the direction and velocity of ground water movement as an additional tool in the effective utilization of the available water resources. These techniques are currently used in Kenya, the UAR, and Tunisia and are proving valuable in initial exploration. At present this is the position in, for example, Niger and Chad, and other zones in the Savannah and Sahel regions. In arid and semi-arid regions ground water must be developed to maintain viable pastoral and nomadic economics. Isotope techniques can be used to good advantage in the evaluation of long-term potential for sustained ground water production. Another use of these techniques has been in tracing the availability of ground water for municipal purposes and has been most successful in Lusaka (Zambia). A regional adviser on the applications of atomic energy in hydrology will serve, under IAEA auspices, many countries in the arid and semi-arid zones in 1967.

INDUSTRIAL APPLICATIONS

Industrialization projects are prominent features in many development plans of African countries. In a modern industry the use of radioisotope techniques (nucleonic gauging, radiography, tracing) is an integral part of direct importance to many African countries. They are now standard practice in prospecting for oil and mineral deposits, giving information in a manner not obtainable by any other method. Recent work performed in the UAR with IAEA assistance has demonstrated clearly the range of useful applications of radioisotopes in different industries. Tracer experiments were performed in oil fields, steel plants, the glass industry and fertilizer factories. Non-destructive testing of ingots by means of gamma radiography was also successfully introduced. With the proposed steel industries there will be a marked increase in the utilization of radioisotope techniques. Tracer applications are in moisture measurements in construction of highroads and in ore dressing. Consideration of the use of these techniques in industrial development schemes now being planned or undertaken in various regions of Africa is being given in Ghana and should be given by planners as well as industrialists and contractors elsewhere.

MEDICAL APPLICATIONS

Improvements in health services and facilities have been assisted in recent years by advances in nuclear medicine in particular in diagnosis and therapeutics. National development plans provide for considerable hospital building programmes as well as national health schemes. Radioisotope laboratories for diagnostic purposes are already in operation, many as a result of IAEA assistance, in Algeria, Congo (Kinshasa), Kenya, Morocco, Nigeria, Senegal, South Africa, Sudan, Tunisia, the UAR and Uganda. Medical research into the causes of tropical diseases such as liver cancer, sickle cell anaemia and various types of malnutrition is being undertaken in all countries with the necessary radioisotope facilities. Some of it is being supported by the IAEA through research contracts in Congo (Kinshasa), Kenya, South Africa and the UAR.



In the University of Lagos Medical School, Nigeria, where radioactive techniques are used for research and diagnosis.

This work requires trained personnel and specialized equipment and adequate health and safety measures have to be observed. The increased availability of radioisotope facilities in Africa to tackle medical and biological problems must allow time for training personnel and the introduction of appropriate legislation.

RESEARCH REACTORS AND TRAINING

In 1966 there were three research reactors operating in Africa, in Congo (Kinshasa), South Africa and the UAR. One is under construction in Ghana and one or two other countries have plans to introduce one.

With the development of the utilization of atomic energy throughout Africa, more qualified personnel are needed. The nuclear sciences figure in the curricula of the national universities in:

Algeria	Rhodesia
Congo (Kinshasa)	Senegal
Ethiopia	Tunisia
Ghana	United Arab Republic
Kenya	Uganda
Nigeria	Zambia

Plans exist for their introduction in the Ivory Coast. Visiting lecturers and equipment have been provided by IAEA, for example, to the universities in Tunisia and Uganda and will be sent to the University of Khartoum and the Royal College, Nairobi, in 1967.

The IAEA also provides training to all candidates or personnel from the level of technicians to middle-grade scientific personnel to highly specialized scientists and engineers in the various branches of nuclear science and technology. In collaboration with the IAEA a regional radioisotope training centre for Arab countries is maintained in the UAR, primarily for training and reactor studies. Regional training courses, with IAEA assistance, have been held in Congo (Kinshasa), Uganda, the UAR, and a regional course for African participants in the repair and maintenance of nuclear instrumentation will be held, probably in Sierra Leone, in 1968.

It is recognized that training in the more specialized aspects of atomic energy cannot be obtained at present in Africa, but the IAEA Fellowship Programme can be used to enable Africans to study overseas and meet this gap. To date 225 Africans have received training under this programme. In addition, grants to cover scientific visits for qualified personnel to study special aspects of atomic energy are also available. Nationals from Senegal and Tunisia have benefited from this latter programme.