In September this year the Pakistan Atomic Energy Commission completed six years of working with nuclear energy. Its expansion in all fields, both in research and practical application, has shown remarkable progress. This outline has been specially written by Mr. Akhtar Mahmud Faruqui, Director, Scientific Information and Public Relations, PAEC.

a review of the aec in pakistan

Applications of atomic energy promise manifold benefits for mankind, and particularly for those who belong to the Third World.

- To the agriculturists, they offer the fascinating prospect of raising, and preserving, plentiful and nourishing crops and fruits.
- Power planners can now rely on a new source – the inexhaustible energy drawn from the heart of the atom – to lift up under-developed areas and to stimulate technological advances in developed countries.
- The medical man has blissfully watched the healing role of the atom and has succeeded in routing out many dreadful diseases like cancer with the use of radioisotopes and radiation sources.
- Dual-purpose nuclear plants, fulfilling the promise of producing electric power and desalting sea water simultaneously, can serve as a boon in places where the familiar twin crushers of economy – the problems of power shortage and water scarcity – co-exist. Nuclear desalination aside, the advent of nuclear science has led to the discovery and subsequent utilisation of hitherto unknown but badly needed underground water reserves.

Such being the vast spectrum of its applications, the atom had a significant role to play in Pakistan – a developing country where the urge to promote agricultural growth is vividly in evidence; where the effort to gear up industry is very pronounced; where modern clinical methods are necessary to combat malignant diseases such as cancer, which take a heavy toll of human lives every year; where water and power in certain regions are so acutely needed that they become a necessity for survival rather than a pre-requisite for development; and where, above all, the desire to ward off centuries-old poverty by taking to modern science and technology is genuine and spontaneous.

How far has this role been fulfilled? The answer is one of hope and satisfaction.

Nuclear power

Like any other country in the world, electric power serves as the prime mover for sustaining agricultural growth and accelerating industrial development in Pakistan. For want of power, the existing industrial units in the country either lie idle or are forced to work under-capacity. Needless to say increased productivity, both in terms of agricultural output and industrial growth, is handicapped by the present meagre level of supply of power.

In more specific terms, the per capita consumption of 130 kWh in the country is among the lowest in the world and makes up less than 2% of that of many advanced countries of the West. The reason: lack of conventional resources of power. The economically exploitable reserves of fossil fuel, mostly in gas, total a dismally low 800 million tons of coal equivalent only! Pakistan thus has no option but to take to nuclear energy to supplement its power resources.

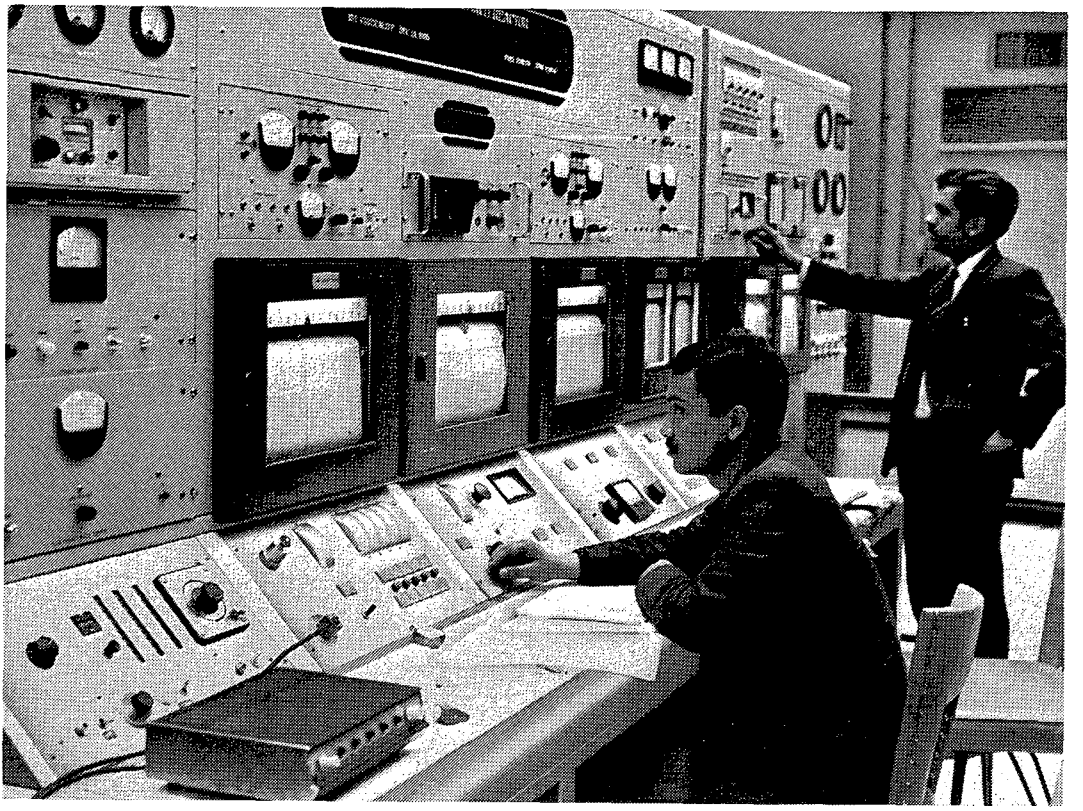
Happily, both the planners and the community of engineers and scientists ungrudgingly accept the role that nuclear power is destined to play in the country in the years to come. This mood has found a vivid expression in the establishment of Pakistan's first atomic power station – the Karachi Nuclear Power Plant (KANUPP). A PHWR, 137MW Canadian designed station, KANUPP is considered to embody the most advanced concept and has been built by the Canadian General Electric Company (CGE) on a turn-key contract. Work on the plant began in September 1966, a year after the first research reactor (a 5MW swimming pool type) attained criticality. Today, the plant is successfully on line and pumps 125MW into the power grid in Karachi, a highly industrialized city with a teeming population of over four million.

The successful installation of KANUPP and its operation by Pakistani engineers and scientists (the plant will be fully manned by Pakistans when the Canadians leave for home this October) has provided the much-needed expertise and experience for planning and installing nuclear power plants in the country and spurred the men in the Atomic Energy Commission to draw up plans for the second atomic power station – a much bigger unit of 500 MW capacity – in the northern part of the country. Here, the huge Mangla Dam (800 MW) has not adequately bridged the gap between the increasing power demand and the limited available supply, and the proposed Tarbela Dam (2200 MW), the largest of its kind, would not provide a complete solution to the problem, accentuated by the disparity between the growing power demand and the dwindling energy resources. A suitable site for this plant is now being selected and, tentatively, civil construction should begin in 1974. The plant could hopefully feed the northern grids before the present decade is out.

The Pakistan Atomic Energy Commission (PAEC) is also examing the economic feasibility of a dual-purpose nuclear power plant, to generate 400 MW and produce 100 million gallons of fresh water per day, to cope with the inflated demand for power and water in the Karachi area at the end of the present decade or the beginning of the next one. In examining the feasibility of the project, the Commission has sought the advice and guidance of the International Atomic Energy and the Oak Ridge National Laboratory (US). This plant is proposed for completion by 1980.

Beginning with KANUPP, induction of nuclear power in the country's grids would lead to a vastly improved situation in the year 2000 when about 1/3rd of the total generating capacity is expected to be nuclear, thus wiping out the deficit due to the inadequacy of the conventional resources. The bulk of this energy will be consumed by the growing industrial sector but agriculture too will get an additional slice to improve the irrigation system.

With Sind and Punjab, two of the larger provinces whose economy is largely dependent on agriculture, sitting on a big salt water lake and faced with the bleak prospects of filling its water requirements, the possibility of installing "Irrigation reactors" for pumping out saline water and desalting it later need critical evaluation. The PAEC proposes to actively pursue a



The control room of the Pakistan Research Reactor (Parr I) at the Pakistan Institute of Nuclear Science and Technology. All the photographs illustrating this story are by courtesy of the Pakistan AEC.

programme employing nuclear energy for the utilisation of the untapped underground reserves of saline water in Sind and Punjab.

The coastal belt of Mekran in the province of Baluchistan stretches over several hundred miles and provides an ideal location for nuclear power agro-industrial complexes. The fisheries industry, now in its nascent stage of growth, shows a tremendous potential for development with the availability of cheap power and water. What is more, preliminary studies conducted by the PAEC confirm that food processing industries, steel and aluminium production, fertilizers, chemicals and mineral processing, have great promise of sustaining themselves as profit making pursuits if based upon a large nuclear plant for the supply of two basic raw materials: Water and power.

Atoms in agriculture

Agriculture is the mainstay of the country's economy, driving more than 80% of the total population to the fields and earning the major portion – 50% – of the Gross National Product (GNP).

Both in terms of its contribution to the GNP and as the only means of subsistance to an overwhelming majority of the population, agriculture is by far the most important sector in the country's economy. This calls for intelligent research investigations aimed at achieving better results in agricultural pursuits — by evolving improved varieties of crops and fruits, by preserving the surplus harvest for either long-term utilisation or export, and by combating outstanding problems, including that of salinity.

Work on these lines was initiated at two agricultural research centres established by the Commission at Tandojam and Lyallpur, ideally suited for agricultural research, by employing radiation and radioisotope techniques. Considering the short life of the two establishments, the Atomic Energy Agricultural Research Centre (Tandojam) having been set up in 1963, and the Radiation Genetics Institute (Lyallpur) in 1969, the research advances in some directions, even modestly speaking, can be described as encouraging.

Promising mutants of wheat, cotton and rice, for instance, have been evolved and are under extensive field trials. A high-yielding mutant of wheat developed at Lyallpur gives a higher protein content of 19% compared to 12% in the parent variety. A short-culm mutant of a local variety of rice (called banaspati) has been evolved. It matures one month earlier than the mother variety and retains all the desirable characteristics. Several early maturing mutants of cotton which show marked resistance to insects, and bear a larger number of bolls, have been isolated and are being put under extensive field trials.

It has also been demonstrated that wheat and rice can be safely and effectively disinfested by gamma irradiation and the shelf-life of some fruits can be appreciably extended by gamma rays. Citrus fruits, for instance, can be preserved for over a month without refrigeration, long enough for their shipment to neighbouring countries. Considering the fact that about 20% - 40% of the total produce is lost to rodents and insects, the development of inexpensive and effective methods of food preservation could contribute to the national effort of obtaining self-sufficiency in food production. The export of delicious fruits grown in abundence in the North West Frontier Province could also be possible to lift up the economy of the province.

Salinity has posed a serious threat to the agricultural scientist in Pakistan. Large stretches of saline soil extend for miles and, according to one estimate, one acre of fertile land is lost to salinity every five minutes. The magnitude of the damage is collossal. Indeed it finds no parallel in any other part of the world. Happily, the efforts of the Commission's scientists in combating this problem have yielded encouraging results. At Lyallpur a biological approach has been developed, and has led to the production of good crops from highly saline fields with the normal input of fertilizer and water. The successful application of this method on a large scale could usher in revolutionary changes in the life of the country's farmer.

The healing atom

The numerous benefits of radiation treatment have led the PAEC to initiate an extensive programme of collaboration with the premier medical institutions of the country, whereby selected hospitals are provided with radioisotopes and other nuclear facilities for medical use. The need for such facilities is pressing and imminent, as the incidence of some of the most malignant diseases is very high in the country. For instance, goitre due to iodine deficiency is very common in Pakistan. In Karachi 30% of school children have enlarged thyroids, in Multan the incidence is still higher, whereas in the upper regions of Gilgit, Chitral and Hazara, lying at the foot-hills of the Himalyas, almost every villager is a goitre patient. For the physician and surgeon working in government hospitals or private clinics, diagnosis of thyroid diseases with the help of conventional methods is no easy task. This task is simplified at the PAEC medical centres.

At present, four medical centres are in operation at Karachi, Lahore, Jamshoro and Multan and two more are planned for Peshawar and Quetta. These centres are fully equipped with modern nucleonic instruments and other laboratory facilities for carrying out work on medical problems such as cancer, heart diseases, kidney and liver diseases, anaemia, goitre, nutritional deciciency states, etc. The Commission has also provided the services of highly qualified physicians, who are trained in handling radiation work, to look after these radiomedical units.

Since their inaugration, several thousands of patients from goitre, leukaemia, cancer, congestic cardiac failure, angina pectoris, renal calculi, hepatitis, etc. have been referred to the Atomic Energy Medical Centres, and diagnostic investigations have been carried out. Of these, a few hundred patients were considered suitable for radiation therapy and regular and intensive treatment was administered to them. The results in most cases have been extremely encouraging and, in many cases, the treatment proved to be life-saving. With other patients, much better results were obtained by radiation than by the conventional therapeutic procedures. Many persons were saved the risk of surgical operations, and cured by much simpler treatment with radioisotopes.

Studies in Hydrology

The problems of hydrology, peculiar to the conditions in Pakistan, have led the Commission to undertak several sub-soil studies with the help of radioisotopes. The Commission has collaborated with the Karachi Port Trust in a project aimed at tracing the movement of sand and silt near the Karachi harbour. The Commission has also conducted a similar study for finding the direction of flow of underground water near Quetta, capital of Baluchistan, and for the selection of a suitable site for a dam proposed in the area.

Such studies can be broad-based and be held more frequently in Baluchistan, where water scarcity has forced people to live under sub-human conditions, and where economic development has been retarded solely because of this impediment.

Industrial applications

The industrial applications of atomic energy are destined to play an important role in the country. Scientists of PAEC have done considerable developmental work on introducing radiography to the local industries, and over the years have arranged a number of courses for them. The response from business circles has been steadily on the increase, confirming that the industrial applications of atomic energy would make a mark on the country's economy in the not-too-distant future.

Search for nuclear minerals

The importance of having a reliable indigenous supply of nuclear minerals for the development of atomic energy, cannot be over-stressed. Realising this basic necessity, the Commission has initiated a systematic programme of exploration and exploitation of such minerals. Over the years, this activity has been intensified and extended to a number of promising regions.

Preliminary studies have indicated that there are promising deposits of uranium in the Dera Ghazi Khan District and detailed investigations are now being made with the financial and

Clinical investigation being carried out at the Atomic Energy Medical Centre at Multan.

technical backing of the United Nations Development Programme. In view of this initial success, the prospects of planning a self-reliant nuclear power programme can certainly not be regarded as a "far cry" in Pakistan.

Training of personnel

One basic consideration in the successful development of any sophisticated technology, such as atomic energy, is the availability of sufficiently trained manpower at all levels. Thanks to its far-sighted policy of local and overseas training, the Commission now has on its rolls nearly three hundred qualified scientists, engineers and other technical personnel. All of them are specialists in their own fields and most of them have received nuclear orientation.

To meet its future requirements of highly trained personnel, a Reactor School providing training in nuclear technology is also being run in the country, at the Pakistan Institute of Nuclear Science and Technology (PINSTECH), the premier research establishment of the Commission, which is assured of playing the role of the mother institute. The course is jointly organized by the Commission and the University of Islamabad which is in close proximity to PINSTECH, and successful candidates are awarded a M. S. degree in Nuclear Technology. The standard of the School compares favourably with that of similar institutions in foreign countries and its facilities are becoming increasingly accessible to scientists from friendly countries.

PINSTECH

Concevied as a national centre for advanced scientific research, PINSTECH is rapidly developing into a laboratory of international stature. It houses the country's first research reactor, PARRI of 5 MW capacity, which became critical in December 1965, and provides excellent facilities for research in nuclear physics, engineering, chemistry, materials, electronics and isotope applications.

Situated in the village of Nilore on the south-eastern periphery of Islamabad, the federal capital of Pakistan, the Institute stands as a symbol of the aspirations of the country's scientific community. Blending utility with elegance, PINSTECH provides modern facilities in classical surroundings, and owes the aesthetics of its layout to world famous architect, Edward Durrell Stone.

In October 1967, barely two years after the reactor became critical, the first batch of radioactive isotopes – Sodium 24 – was produced at PINSTECH and air-freighted to Dacca for use at the Cholera Research Institute. Since then, a number of other isotopes have been successfully produced for use in the Commission's own laboratories and its radioisotope medical centres. By providing the technical support for the country's nuclear power programme, PINSTECH is destined to play an important role in the activities of the PAEC.

By adopting nuclear science and technology, even though on a modest scale, Pakistan has demonstrated to the under-developed countries the immense potential of the atom for supplementing developing economies, to the ultimate advantage of the teeming millions of the Third World who will benefit from it.