NUCLEAR POWER PROSPECTS IN PAKISTAN

As part of its programme to assist the development of nuclear power, IAEA undertakes, on request, reviews of the prospects for nuclear power in individual Member States. The first such review was done in Finland and resulted in the issue in December 1960 of a report on "Prospects of Nuclear Power in Finland". Subsequently in August 1961, a similar report was issued on "Prospects of Nuclear Power in the Philippines". A third report on "Prospects of Nuclear Power in Pakistan" was issued in June 1962.

The Pakistan report arose from a request received by the Agency from the Government of Pakistan early in 1961. After a preliminary visit by the Agency's Deputy Director General for Technical Operations and the Director of its Division of Reactors in December 1961, the Agency dispatched to Pakistan in January 1962 a mission consisting of three staff members from the Department of Technical Operations.

The Mission remained in Pakistan for two weeks conferring with appropriate officials and personally inspecting some of the principal power supply sites and installations. Their report is based on the information obtained in these conferences and visits. It also leans heavily on factual data accumulated in several previous reports prepared by private consultants for the Government of Pakistan on various aspects of its power supply situation.

A general finding of the Pakistan report is that nuclear power should be considered "a leading contender for the supply of future energy needs". A principal reason for this is that the conventional energy resources available, both of hydroelectric energy and of fossil fuels, appear insufficient by themselves to give in the long run "the high per capita consumption of electricity which is characteristic of a developed country". Thus, an alternative source of energy to supplement the existing resources appears desirable.

Since nuclear power appears to be necessary for the development of Pakistan's power economy in the long run, the report notes that early undertaking of a nuclear power project would have certain advantages, even though "economic considerations may not, in the initial years of the first nuclear power station, be entirely favourable in comparison with a conventional power station producing the same amount of electricity". Among the advantages would be a beneficial effect on the reliability and stability of prices for alternative fuels which generally results from diversification of fuels. It is noted further that "construction of the first nuclear power station in Pakistan will provide the country with the necessary first-hand experience in such matters as operation and maintenance, nuclear safety, third-party liability and insurance, fuel management, and training of technical staff. On the basis of actual experience gained as a result of this undertaking, Pakistan will be in a position to decide upon how rapidly or how slowly it wishes to proceed with its nuclear power programme."

In making an economic comparison between nuclear and alternative sources of power over the near term, the mission was confronted with numerous and important uncertainties affecting both power demand and power supply, which made the comparison more than usually difficult. As to power demand, the report states: "Industrial development planning leads to the preparation of a great variety of projects whose implementation and timing are understandably subject to revisions and changes, so that forecasts of power consumption vary within much wider limits than in the case of highly industrialized countries." As to power supply, the report states that "intense efforts at surveying the country may lead to discoveries of new sources of fuel which would affect greatly the short term energy picture". It is also not clear to what extent certain power supply projects now in the planning stage may be carried out.

The analysis comparing nuclear power economics with those of conventional alternatives is performed separately for the Karachi area, for West Pakistan and for East Pakistan, since the power supply systems serving these regions are not now, nor in the near future likely to be, interconnected.

The Karachi Region

Uncertainties about future power needs and resources are stated to be less great for the isolated power system serving Karachi and its environs than for the other major power supply areas of Pakistan. It is indicated further that the area presents the most suitable near term characteristics insofar as nuclear power is concerned.

The Karachi area has been suffering from a serious shortage of power, and prospects of continued rapid increase in peak load make it clear that important additions to generating capacity must be made. Two gas-fired 66 MW units have been scheduled for installation in 1965, and further thermal units in this or a greater size range appear to be needed shortly thereafter. With respect to these later plants, consideration is given to the comparative costs of nuclear and conventional alternatives. This analysis indicates that a 132 MW nuclear plant installed in 1967 would be competitive with a gas-fired plant of equivalent size, under the assumptions of a four per cent interest rate and of declines in

nuclear fuel costs over the lifetime of the plants. Further comparisons indicate that a nuclear plant of 66 MW capacity installed in 1967 would have power costs slightly higher than those of an equivalent gas-fired plant installed at the same time, but that, if the installations were delayed another three years under the favourable assumptions mentioned above regarding interest rates and nuclear fuel costs, the nuclear plant of 66 MW might be virtually competitive.

Two important developments to be expected during the lifetime of power plants completed late in the 1960's are cited as strengthening the case for nuclear power in the Karachi grid. One is the possibility that interconnections may be made between the Karachi area and the present West Pakistan power grid. Such interconnections might be expected to make possible operation of thermal power stations at the higher load factors relatively favourable to nuclear power costs. The second expectation is that the building of a nuclear power plant instead of one fired by natural gas might produce savings by delaying the date when a new pipeline would be needed to carry into the Karachi area increased requirements of natural gas for various industrial purposes. It is noted further that Karachi, "being an important seaport and also the largest industrial centre in Pakistan, has the necessary facilities for receiving and handling all the heavy and specialized equipment for the construction of a nuclear power plant".

West Pakistan

The electric power grid serving a large area of northern and central West Pakistan is at present served primarily by hydro plants. The report states, however, that future expansion to meet expected load growth must include substantial additions to thermal capacity, since hydro resources are limited in total and have the further disadvantage of having low capacity in winter when the peak load occurs.

It is difficult to draw a picture of future capacity additions at this time because of several major uncertainties. The first concerns the extent to which a ten year programme for reclaiming some 29 million acres of waterlogged land will actually be carried out. If it is carried out in full, the power demand for tubewells and pumping plants would amount to about 800 MW.

A second uncertainty relates to the amount of hydro capacity which may be installed in a major hydro project (Mangla) expected to be completed in 1968. One proposal is to install 300 MW there; an alternative proposal is for 900 MW. If the lower alternative is adopted, larger amounts of thermal capacity will be needed during the 1960's. It is estimated by one of the Pakistan Government's consultants, moreover, that under these conditions the thermal plants would be capable of operating at load factors high enough to make nuclear power plants economically competitive. One reason is that investment costs for gas-fired plants in this area may be considered to have a substantial component for the construction of natural gas pipelines. Consequently the usual relationship whereby nuclear plants have substantially higher investment costs than alternative conventional plants does not apply.

If the larger amount of capacity is installed at Mangla, the report indicates that thermal plants would then be used for a few years primarily to carry peak load. Accordingly, they would operate at low load factors. Since investment costs of nuclear and gas-fired (including pipelines) alternatives would be roughly comparable, and since operating costs at low usage factors would be relatively insignificant, some weight in choosing between the alternatives might be given to technical performance factors. In this connection the report states: "Experience with the Shippingport (USA) Nuclear Power Station, when used as a peak load facility, shows that a reactor can follow all system load change demands in its power range. It also can be shut down and started up under controlled conditions at a faster rate than any conventional modern station."

Turning to the situation in the West Pakistan grid area over the longer term, the report points out that, if a reasonable share of available natural gas is conserved for industrial uses other than the production of electricity, the limited amount remaining and the lack of hydro potential would force the area to use imported fuels within 25 to 40 years. Nuclear plants would under those circumstances be likely to compete favourably. The report accordingly concludes: "Cost analyses indicate that nuclear power might be of interest at present to fill the need of part of the thermal power in West Pakistan. Its prospects are expected to be even more favourable in the future. Hence it might be desirable to initiate a very modest nuclear power programme, even at some economic penalty, so as to insure against uncertainties in the future."

East Pakistan

This most populous region of the country is divided roughly in half by two large rivers. There is at present no electrical interconnection between the two halves but such an undertaking is considered feasible. Accordingly, the Agency's report gives separate consideration to the eastern and western zones of East Pakistan, assuming no interconnection, and also considers the situation which might exist following interconnection.

Present capacity in the eastern zone is mainly hydro, but further hydro potential is very limited. Demand estimates indicate that a power gap requiring the construction of one and perhaps two 40 MW thermal units is likely to appear by 1967, with a further 40 MW being required within two years thereafter. The report estimates that a 50 MW nuclear unit constructed to fill this second gap might operate at load factors of 80 per cent after 1970 and that it would be economically competitive if present high fuel oil prices in East Pakistan are maintained and if natural gas prices are aligned with these oil prices. The

comparison would have to be reviewed, however, if gas rates were set at a lower level reflecting gas production, transmission and distribution costs.

Regarding the western zone of East Pakistan, the report notes that a power gap of 90 MW is to be expected by 1970, which might provide an opportunity for nuclear power in view of the particularly high fossil fuel costs prevailing in the region. Much would depend, however, on whether additional transmission and distribution facilities are built to make it possible to serve a wide area from a single plant.

The most favourable opportunity for nuclear power in East Pakistan is stated to be that which would arise if the eastern and western zones are interconnected. That would provide a total demand of over 400 MW in 1970 and make possible a 100 MW nuclear unit whose economic advantages would be particularly attractive.

Moving Ahead

It is stated as "the view of the IAEA Mission that the Pakistan Atomic Energy Commission, together with the national power authorities should pursue the matter (of nuclear power) further". The report concludes by indicating some of the steps which Pakistan might take "once a decision of principle is taken to go ahead with a nuclear power plant project". It is suggested that consideration be given to forming a project group to gather information and provide continuity. Continued training of nuclear engineers and technologists, in which a research reactor now under construction in Pakistan might be useful, is also emphasized. An invitation for bids is recommended as a way of obtaining precise cost data.

Aspects of the project in which IAEA can offer assistance are then enumerated. These include preparation of the specifications, selection of a site, evaluating reactor safety, preparing health and safety regulations, evaluating bids, training personnel, obtaining fuel, and seeking outside financing.

ATOMIC ENERGY IN YUGOSLAV AGRICULTURE

With the assistance of the United Nations Special Fund, a major project for extending atomic energy applications in agriculture is to be undertaken in Yugoslavia. IAEA will act as the Executing Agency for the project, which will be carried out over a period of three years and will include a number of activities to develop nuclear research and training for the improvement of overall agricultural production, especially in respect of grain and livestock. Among the principal aims are improvement in the use of fertilizers, improved irrigation and drainage, better breeding and selection of crop plants, and better livestock management.

Improvements in these fields can be hastened through research involving the practical application of nuclear techniques. It is therefore planned to expand the research and training facilities of the Institute for Application of Nuclear Research in Agriculture, Forestry and Veterinary Sciences at Zemun, near Belgrade, which deals with practical problems in all phases of plant culture and animal husbandry. The object is to make it the central institution in the country for the application of nuclear research in the field of agriculture.

Under the Special Fund project, which was approved in May 1962, the Fund will contribute US $546 400 to cover the cost of equipment, training and expert services, while the Yugoslav Government will contribute the equivalent of $1 206 000 in the form of land, buildings, equipment, staff and other services. The execution of the project will start early next year at the Institute at Zemun, which at present has two buildings and 50 hectares of arable land. The project calls for an expansion of buildings, additional equipment and a larger scientific staff. It is anticipated that by 1965 the number of resident scientists at the Institute will increase to 90. The Special Fund will provide experts, fellowships and equipment through the Executing Agency, and the programme includes in-service training of counterpart personnel to be provided by the Yugoslav Government.

The Institute's work in connection with this project will be on the following main subjects:

(a) Soil fertility and plant nutrition, including methods for laboratory assessment of the fertility status of the soil, and methods of application of fertilizers; studies of leaching of plant nutrients; studies of soil moisture in connection with irrigation and drainage; and studies on the absorption of nutrients by plants from the soil and on nutrient translocation and accumulation within the plant;

(b) Plant breeding, using irradiation to produce mutants of agricultural crops and forest trees as a supplement to conventional breeding methods;

(c) Animal husbandry, including protein nutrition studies of poultry and animal health protection.

Soil Fertility and Plant Nutrition

Half of the soils in Yugoslavia are acid and have a low productive capacity. High yields, therefore, cannot be achieved without proper application of fertilizers, the effects of which depend on the type of soil, properties of plants and the manner of application. At present about 700 000 tons of superphosphate are