nuclear power and developing countries

The IAEA has begun a world-wide survey of the market for nuclear power in developing countries. Technical, economic and other factors associated with the introduction of nuclear power to such countries were discussed recently in a lecture at Agency Headquarters by Mr. Munir A. Khan, late head of the Reactor Engineering Section of the Division of Nuclear Power and Reactors, who is shortly to take up his appointment as Chairman of the Atomic Energy Commission of Pakistan.

Mr. Khan was among the longest-serving staff members of the IAEA. After engineering training and lecturing in his country he went to the United States in 1951. There, he continued his graduate studies and research, worked in industrial concerns, attended the Argonne International Reactor School and stayed there as a research associate. He joined the IAEA in 1958, and since then his work has touched on practically every aspect of reactor engineering.

He began his lecture by recalling that at present nuclear power stations are in operation in only two developing countries – India and Pakistan. Nuclear power plants are being built in five additional developing countries (Argentina, Brazil, Bulgaria, Korea and Taiwan); eight more (Greece, Hungary, Mexico, the Philippines, Romania, Thailand, Turkey and Yugoslavia) are actively planning to introduce nuclear power and several others are thinking of introducing nuclear power in the long term. Altogether 20 to 25 developing countries are actively interested in nuclear power programmes and are making preparation for its introduction.

Yet a comparison between the overall power programmes of developed and developing countries shows that in 1970 developing countries accounted for only about 12 per cent of total installed electrical generating capacity, which might increase to 15 per cent by 1985. In view of the rapid growth which might be expected in the populations of developing countries the amount of installed capacity available *per capita* would then be actually lower than it is today. Further, at present developing countries account for only about 2 per cent of the world *nuclear* generating capacity, which might rise to about 9 per cent by 1980. By 1985, when 23 per cent of the generating capacity of industrialized countries would be nuclear-powered, the corresponding percentage would be only about half as much in the developing countries. Projections for the year 2000 show that at that time about half of all installed capacity in the

industrialized countries will be nuclear-powered, but in developing countries nuclear power will account for only about 20 per cent.

"It is obvious," said Mr. Khan, "that nuclear power technology, instead of serving to close the gap between the advanced and the developing countries, is in practice only widening this disparity.

"What is the justification for nuclear power in developing countries? Why should they consider nuclear power?

"First, we have heard a number of times the argument that the developing countries want nuclear power for the sake of prestige. There is no doubt that some research reactors in developing countries were built on that basis, and of course any country would be proud to have a power facility if it could afford it. Unfortunately, the days of easy loans and bilateral aid which could facilitate buying nuclear power plants at cut-rate costs are over. Now the prestige factor is no longer important, and developing countries have realised it is too expensive an item to be bought for the sake of prestige.

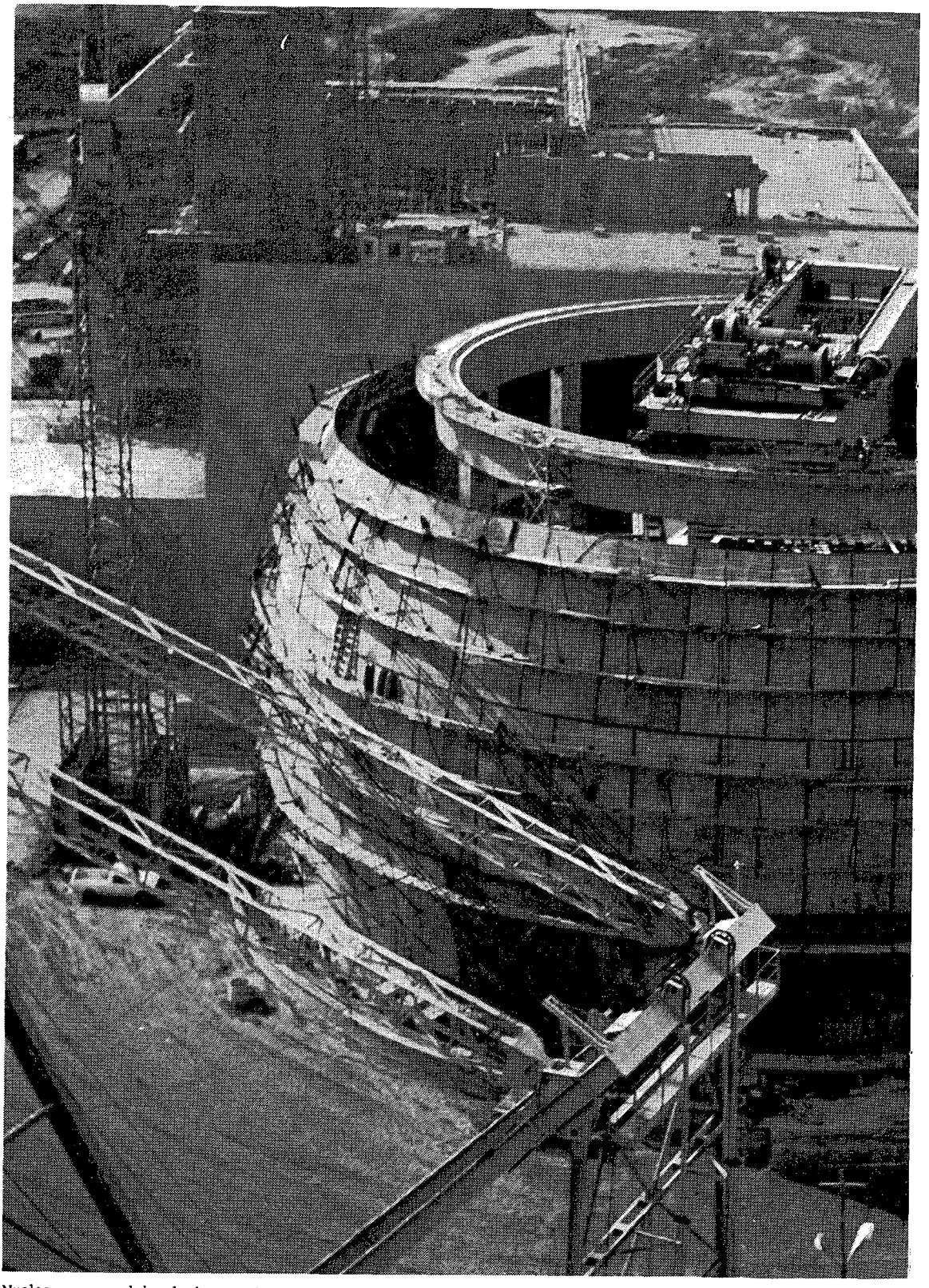
"Secondly, it is said that the developing countries would like to gain experience in nuclear technology, even if the first nuclear power station is not truly economic. This has been happening also in the advanced countries, where large sums of money have been spent for the acquisition of know-how and experience before commercial nuclear power entered the picture. The developing countries cannot afford to spend that much money; however, there is some justification for charging a part of the initial investment in the first nuclear power station towards the acquisition of know-how, training of personnel, developing industry, getting management know-how and so on.

"But the real reason for the introduction of nuclear power in a developing country is economic – because it is only through having adequate and reasonably-priced power that the developing countries can hope to implement their industrialization and development programmes. This applies particularly to those developing countries which are short of indigenous energy resources.

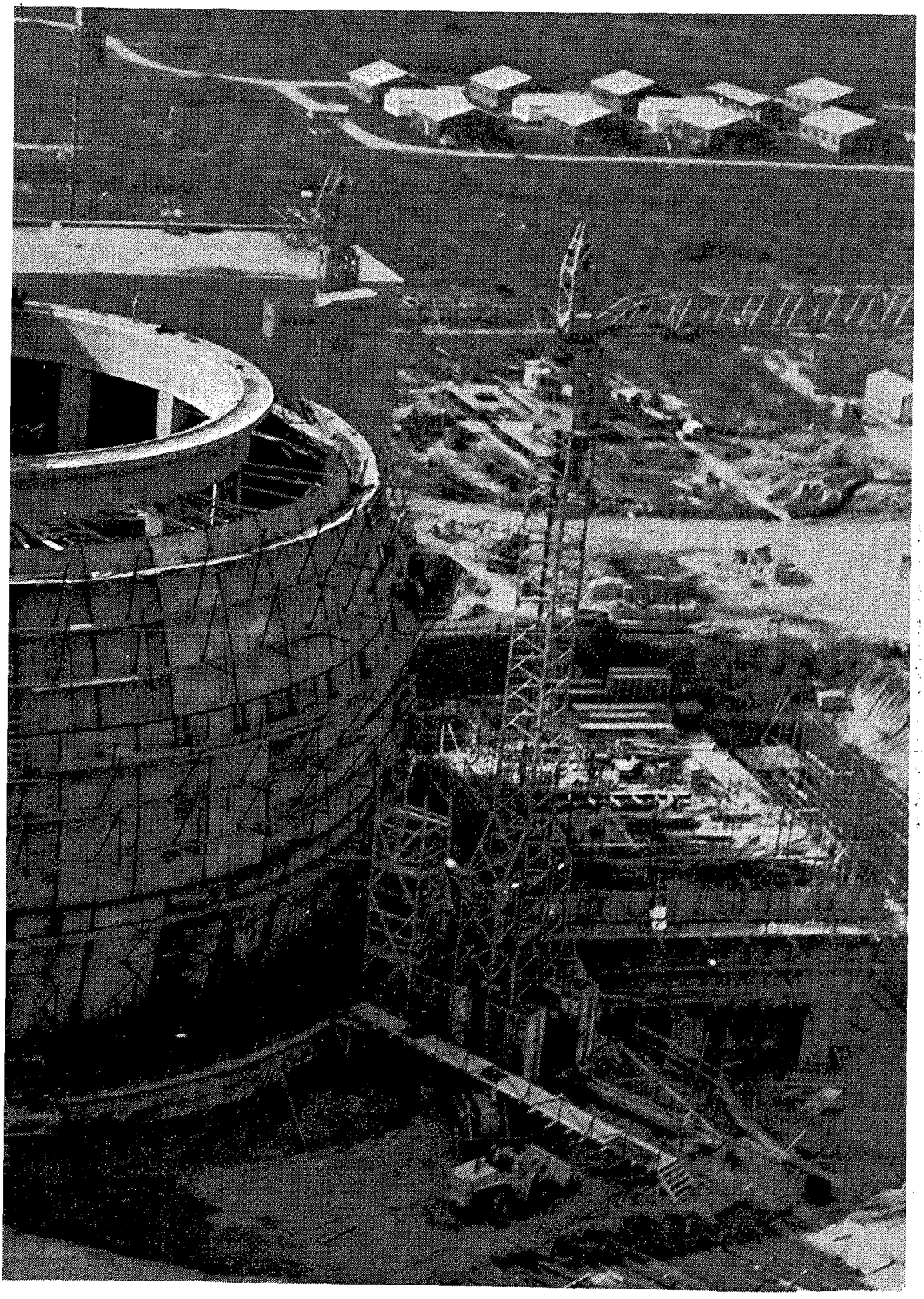
"The developing countries of the world represent nearly three-quarters of the world's population, and are largely poor in fossil fuel resources. The Middle Eastern countries are rich in oil, but they represent only a small fraction of the population. Total *per capita* consumption of electricity in developing countries, excluding Mainland China, is only one-thirtieth of that in North America, and one-fifteenth of that in Western Europe. It is evident that if the developing countries are ever to advance industrially they must find ways of meeting their sharply increasing energy requirements at minimum cost.

"Recently the price of oil has been increasing very sharply. In fact, in the last four years there have been increases ranging from 50 to 100 per cent in different parts of the world. It appears that the days of low-cost fuel oil at 20 to 30 ¢ per million BTU [$8 - $10 a ton] are over. The going rates are double – 40 to 60 ¢ per million BTU – and the trend established by the recent Teheran agreement with OPEC [the Organization of Petroleum Exporting Countries] shows that from now on there will be continuing increases in the price of oil. This development is hurting the developing countries most. The advanced countries can afford to pay more for oil; they can pass on the cost of more expensive power in the form of increases in the prices of manufactured products for consumption at home, and, of course, for export abroad. But the developing countries are unable to do so.

"One could ask 'why should the oil producing countries get away with these price increases?' But their argument is very simple – most of the oil producing countries are developing countries, and rely solely upon oil revenues to finance *their* development programmes. If the price of oil does not increase to meet the cost of importation of capital equipment they cannot keep up their development and industrial expansion programmes – so they also have a tremendous problem. In these circumstances one can see why the developing countries are forced to



Nuclear power and developing countries: in Argentina, the 319 MW(e) Atucha installation in the course of construction ...
Photo: Comisión Nacional de Energía Atómica Argentina



think in terms of the nuclear power alternative, to supplement their available, limited energy resources with the prospect of cheaper nuclear power in the future.

"A comparison of the costs of conventional and nuclear fuels shows that there is a decided advantage in going towards nuclear power. Increases in the price of uranium (which account for only 20 per cent of the total nuclear fuel cycle costs in a typical light-water reactor) are not going to make a great difference with regard to the overall fuel cycle cost within a nuclear power programme; most of the cost, i.e. 80 per cent, is for industrial operations such as enrichment, fabrication, reprocessing and so on. These costs are subject to continuing technological improvements, and very intense competition between a number of countries, so these costs will be kept down and are not likely to escalate as sharply as the cost of oil. On the other hand, oil prices *are* escalating sharply, from year to year; any country which bases its programme on oil-fired stations is taking the chance that their fuel oil bill may rise sharply without much notice."

Mr. Khan considered next technological problems in the introduction of nuclear power in developing countries – first, that of grid size. In developing countries the electrical supply network is generally small, and such countries are therefore not able to absorb large standardized units such as those being developed in the industrialized countries. "At present the 'standard' power reactor in industrialized countries ranges from 750 to 1300 MW(e)," he said. "Perhaps in the next five years this will rise to 1500 to 2000 MW(e). The smaller countries will be unable to use such 'standard' plants; for them, the most interesting sizes are 300 to 600 MW(e), which are unfortunately not of much interest to the nuclear industry in the advanced countries.

"'Know-how' with respect to smaller reactors is in fact available," he continued. "There are now about 250 power reactors under construction or in operation. Of these two-thirds are of under 600 MW(e). Of the 112 reactors which are actually in operation 102 are below 600 MW(e), and those 102 reactors have accumulated more than 800 years of operating experience. It is in fact experience with these reactors that has given the nuclear industry the facts and know-how to increase the size and to build larger and larger units. From a technological standpoint therefore reactors in the 300 to 600 MW(e) range are fully developed; they are on a strong technological footing, and there should be no technical problems in building them.

"The second objection is that the developing countries may not be able to operate these plants successfully. If one looks at the history of some of the plants built in the developing countries, or less-industrialized countries, one finds that in fact the experience has been very good, and the speed at which nuclear power projects are being implemented also shows that with proper preparation and management developing countries can indeed build and operate these plants. This cannot, of course, be generalized; it applies only to selected developing countries – the 20 or so developing countries I mentioned earlier."

With respect to the competitive status of nuclear *versus* conventionally-fuelled power stations, Mr. Khan refrained from giving absolute figures. Capital costs varied widely; and had increased sharply for both types of plant in recent years.

"What is really important is the differential in costs between the two alternative types of programme," he said. Conventionally-fuelled power stations cost less to build initially; but this was offset by savings in fuel costs during the first few years of operation so that a break-even point was reached fairly quickly. Even with respect to capital costs, "if the manufacturers' designs were optimized and the small- and medium sizes of reactor were standardized and built in multiple units, and if there were greater international competition between the various manufacturers, we would certainly see significant capital cost reductions. One could further improve matters by making better use of local labour and materials available in the developing countries, thus making savings in foreign exchange and in total expenditure; and, additionally, by adopting similar safety criteria in more countries so that variations between

individual plants to meet local design requirements could be reduced." Savings which might be achieved as a result of the lower fuel costs of nuclear power stations could eventually be ploughed back to finance further expansion of the power programmes of developing countries; and so on.

Mr. Khan took as an example a 500 MW(e) power station. In the initial capital cost there was a differential of about $125 per kilowatt of rated output in favour of a conventional installation. Taking a fuel oil price of 50 ¢ per million BTU increasing at 2½ per cent a year, and a discount rate of 10 per cent, the point at which such a station would break even with a comparable nuclear power station would occur after nine years. If the initial oil price were 60 ¢ per million BTU the cross-over point would occur at about 5½ years; if the discount rate for fixed charges were 15 per cent the cross-over point would occur at about 9 years, and so on. Assuming that a certain developing country had an electrical supply network (grid) of 3000 MW and that it doubled in 7 years by using either nuclear or conventional plant, then the fuel bill for the additional 3000 MW if it were to choose a conventional installation would be of the order of $92 million a year, at 60 ¢/million BTU. For a nuclear installation of comparable size the fuel bill would be about $33 million a year – a differential in favour of the nuclear plant of the order of $59 million. "The point is that the fuel savings are so substantial – and they may be more substantial if the fuel oil price escalates in the future – that countries faced with such a decision must give serious consideration to nuclear power."

Perhaps the most crucial problem in the introduction of nuclear power in developing countries was financial – nuclear plants are capital intensive, and require not only more money in absolute terms but more foreign exchange, which is scarce in developing countries. Ten to 15 years from now developing countries could well be in great difficulty, unable to run oil-fired stations because of the very high cost of oil, and unable to finance future expansion programmes. In Mr. Khan's view the loaning organizations must take a long-range view when considering the optimum means of helping developing countries. If they were to take a short-range view not only were the developing countries likely to suffer, debt servicing was likely to become a major problem.

"But the developing countries cannot just expect low-cost money and low-cost reactors from the industrialized countries, depending entirely on outside help and resources," he went on. "I think it is necessary, first of all, that they should clearly elaborate their power expansion programme and identify the unit sizes which are required at various times. They must improve the organization and management of the power industry. They must adopt suitable safety standards and licensing requirements, so that nuclear power stations can be built in an orderly fashion. And they must train adequate manpower to plan and build these plants, and operate them safely ...

"What can be done to help these countries? The advanced countries could take a greater interest in helping the developing countries to implement their nuclear power programmes, and could supply technical and financial aid in this regard. The nuclear industry in the industrialized countries should play an important rôle in developing and optimizing power reactors in sizes suitable for application in developing countries. The loaning agencies should change their attitude and view with greater sympathy the use of power reactors in such countries, and finance viable projects. The IAEA has been showing very keen interest in helping developing countries in the introduction of nuclear power; during the past 10 years we have taken several important steps in this direction. We have surveyed the requirements of these countries, by sending nuclear power survey missions to a number of developing countries in the Far East, in South East Asia, in Latin America and Africa. We have made studies to judge the technical and economic merit of specific nuclear power projects proposed in these countries. Then, we have made internal studies of technical and economic aspects of small- and medium-sized reactors; and we have completed a co-ordinated programme to

assess the technical aspects and the costs of smaller reactors, in which industrial concerns from several countries have taken part. And we have held a number of scientific meetings.

"But I think the most important development is the recent launching of the market survey by the IAEA. Last October [1971] the Agency convened a working group on power reactors of interest to developing countries. This group recommended that the Agency, in co-operation with the advanced and the developing countries and with other international organizations, should launch a survey to determine more accurately the requirements for nuclear power plants in developing countries during the next ten years. The object would be to help the developing countries in defining their programmes more accurately; to assist the nuclear industry in the advanced countries to see the size of the potential market and the requirements for plants of various sizes so that they might standardize such projects and lower their costs. The survey would also help the loaning agencies in financing the projects by giving a better idea of the loaning requirement.

"At the present time 12 developing countries have responded to the Agency's invitation to take part in this survey. Some more countries may join later. It will take about a year and a half to complete the survey. We may received support from several advanced countries, including the United States, the United Kingdom, France and Canada; and we hope for assistance from other advanced countries including the Federal Republic of Germany and Japan.

"We also have the co-operation of the World Bank [International Bank for Reconstruction and Development], and they will contribute to the survey both by giving money and by supplying expert advice. We feel that this market survey will not only give us a better idea of the real situation in the developing countries, but will also enable us to have a better understanding of their problems. The co-operation between the World Bank, other loaning organizations and advanced countries and the IAEA should help to facilitate the introduction of nuclear power into the developing countries."