NUCLEAR POWER PROSPECTS IN THE PHILIPPINES

A report on nuclear power prospects in the Philippines, recently published by IAEA, analyzes the prospects for installing late in the 1960's a relatively large nuclear power plant in the electric power grid which serves a major part of the Island of Luzon. It concludes that such a plant might be economically competitive over its lifetime with a conventional power plant of the same size. Accordingly, the report recommends steps which the Philippine authorities might take if they wish to pursue the matter further.

The report arose from a request made to the Agency in January 1960 by the Government of the Philippines for assistance in surveying prospects of nuclear power in that country over the next decade. In October 1960 the IAEA Director General sent a three-man mission to the Philippines to gather material for the required analysis. In addition to a reactor engineer and a power economist from the Agency's staff, the mission included an energy resources economist from the Economic and Social Affairs Department of the United Nations.

Need for a Large Thermal Plant on Luzon

The analysis of nuclear power prospects in the Philippines involves consideration of two main questions. The first is: will conditions in the Luzon Grid toward the end of the 1960's be such as to justify installation of a fairly large thermal power plant? The question is put this way since it is felt that during this period large nuclear power plants are more likely to give satisfactory economic performance. The second question, assuming an affirmative answer to the first one, is: should such a thermal plant be nuclear or conventional?

To reach an answer to the first question, concerning the justification for a large thermal plant, the mission considered the growth prospects of the Philippine economy, the effect of such progress on the demand for electric power, the resources available for supplying the needed electricity and the specific plans for expanding electric power production capacity.

A chapter is devoted to the course of recent economic development in the Philippines and the likely trend over the next decade. It is shown that, while the Philippine economy is primarily agricultural, industrialization is proceeding at a relatively swift pace. It is concluded that, despite some problems common among less-developed nations, "the Philippines' economic growth prospects seem generally bright. It should be possible to maintain during the next decade the 6 per cent per year growth rate in real national product which prevailed during the 1949-59 decade (equivalent to about $2\frac{1}{2}$ per cent per year on a per capita basis) and to accelerate the healthy structural changes in the Philippine economy which have been resulting from the diversification and expansion of its industries."

The relationship between economic growth and demand for electricity is well known, and it is borne out by the experience of the Philippines. A chapter on "Electric Power Demand and Supply on Luzon" shows that sales of electricity in the Luzon Grid have been increasing at an annual rate exceeding 15 per cent. Between 1954 and 1960 the peak load of the Manila Electric Company, the chief distributor of electricity in the Grid, more than doubled.

The projections through 1970 made by the Philippine authorities anticipate some slowing down in the rate of growth to an average annual growth rate of 11.7 per cent in sales and 12.4 per cent in peak demand. To meet such increases nevertheless presents a formidable problem for the power suppliers. Moreover, the IAEA report, while accepting the demand projections for use in the subsequent analysis, gives various reasons for believing that they are "decidedly conservative".

To meet expected increases in demand, the Philippine authorities plan additions to capacity during the ten years ending 31 December 1970, of 788 MW. By type of plant, the capacity at the end of 1960 and the planned additions are as follows (in megawatts):

	Hydro	Thermal	Total
Installed as of 31 December 1960	228	219	447
Net additions by 31 December 1970	368	420	788
Total installed as of 31 December 1970	596	639	1 235

The Agency's report concludes that "this supply program is a modest one" since at several times during the decade it would provide inadequate, or barely adequate, reserve capacity to meet projected demand.

The need for a substantial increase in thermal capacity to meet expected increases in demand for electricity during the 1960's is confirmed in a chapter on "Energy Resources of the Philippines". This

chapter indicates several limitations on the ability to meet the additional demands during this period with new hydro plants. One is a lack of river flow data for most rivers, a lack which will require a number of years to remedy. A second is the low plant factors of hydro plants brought about by the marked seasonal variations in rainfall on Luzon and by limited hydro storage facilities. A third is the fact that the multipurpose nature of some hydro plants places a limit on their power output. The remainder of the chapter makes it clear that, because of a paucity of indigenous resources or at least a paucity of information about them, thermal power plants based either on imported petroleum or nuclear fuel provide the only feasible alternatives for supplementing the maximum share which hydro power can supply during this decade.

A chapter entitled "Alternative Power Supply Programs" next analyzes the extent to which the Luzon Grid will be able to absorb a thermal plant, either nuclear or oil fired, in the size range where nuclear power performs advantageously. The basic criteria in this analysis are "whether the plant would be able to operate at a high plant factor without causing other capacity in the system to stand idle unnecessarily and whether minimum acceptable standards of system reserve and reliability would be satisfied". Two alternatives are considered: a plant consisting of one 150 MW unit installed by June 1967 and a plant consisting of two 100 MW units installed by June 1967 and by June 1968 respectively.

On the basis of electric energy balances showing the use pattern of all capacity, it is concluded that, with the assumed load projections, operating the 150 MW plant at base lead (7000 hours per year) would somewhat restrict the utilization of two relatively efficient existing units in 1967 and 1968, and two new thermal units scheduled for 1969 and 1970 would also have to yield part of their load to the 150 MW plant for a year or two. Besides, the 150 MW plant would require about 50 MW more of reserve capacity than is envisaged in current plans. It is then recalled, however, that the assumed load projections seem conservative and it is pointed out that if the projections fall short of actual demand by even 5 per cent starting in 1968, the utilization of all stations in the system would be satisfactory.

The electric energy balances indicate no difficulty whatever in effectively absorbing into the system the plant consisting of two 100 MW units.

The Choice Between Nuclear and Oil-Fired Plants

Having concluded that a thermal plant of substantial size can be justified for installation in the Luzon Grid in the late 1960's, the IAEA report next considers whether such a plant might more advantageously be a nuclear plant or an oil-fired one. A first step in this appraisal is a chapter given over to an analysis of the likely trend of Philippine fuel oil prices "during the 1960's and over the longer run corresponding to the lifetime of the power plant in which the fuel oil would be consumed".

It is concluded that during the 1960's the price now paid by the Manila Electric Company, which, taking into consideration the need for adequate storage, corresponds to an energy cost of 41 cents per million BTU, net of all local taxes and internal transfers, is unlikely to fall, unless oil companies elect to take advantage of the flexibility in their pricing structure for refined products to meet competition from nuclear power by selling fuel oil at less profit or at a loss. For the longer run period, when the thermal plant under consideration would be operating, the report concludes that fuel oil prices in the Philippines are likely to increase because of rising consumption and increased costs of production.

A succeeding chapter reaches a contrary conclusion regarding nuclear fuel costs, that is, that over the lifetime of any plant completed in the late 1960's such costs would be likely to decline because of favorable developments affecting several of the elements involved in the nuclear fuel cycle. Thus, prices for both enriched and natural uranium are expected to come down as a result of a favorable supply situation.* The cost of fabricating uranium into fuel elements is also expected to decline with greater experience and volume production. Higher burn-ups of fuel before withdrawal for reprocessing are thought to be in prospect. Finally, the cost of reprocessing irradiated fuel is expected to decrease.

It is pointed out in addition that guarantees are now available from manufacturers which would provide an assurance as to maximum nuclear fuel cycle costs for any particular type of reactor over the period in question.

Bearing in mind the conclusions reached as to future fuel prices, an overall comparison is then undertaken of the generating costs which alternative oil-fired and nuclear plants might have. A boiling water reactor plant is assumed for the nuclear cost estimates, but it is emphasized that "this should not be construed as a preference for this reactor system" over several other types which are mentioned earlier as being technically suitable for use in the Philippines. The belief is also expressed that "if similar analyses were carried out for other systems mentioned, particularly the more developed systems (gas-cooled and pressurized water), the estimated generating costs for units in the 100-200 MW range would probably not be markedly different from those obtained for the boiling water system".

In the cost comparison both nuclear and oil-fired plants are assumed to operate at 80 per cent load factor over a useful life of 25 years. Capital costs for both are based on the use of United States equipment, although it is pointed out that international competitive bidding might lead in each case to obtaining lower priced equipment from other sources.

* *As noted in an appendix, this forecast was borne out after the main body of the report had been completed by reductions in the prices charged for enriched uranium by the United States Atomic Energy Commission.*

Members of the IAEA nuclear power mission to the Philippines visiting the new 65000 kw thermal generator at the Rockwell Station of the Manila Electric Company. Left to right: Perry D. Teitelbaum (IAEA); Joseph Barnea, Chief of the Natural Resources Development Group of the United Nations; and Munir Khan (IAEA) (Photo USIS)

Capital costs for oil-fired plants are based on estimates obtained from the engineering firm which built the largest thermal plant in the Philippines. Since conclusive evidence on the basis of which long term fuel oil prices could be predicted seemed lacking, a range of prices is assumed, corresponding to energy costs of 35, 40 and 45 cents per million BTU.

Cost estimates for nuclear plants "are based upon information provided to the Agency by Member States as a result of enquiries made specifically for this purpose". It is stipulated, however, that "the final and precise costs to a customer for a nuclear plant can be determined with finality only by receiving fixed-price bids with adequate guarantees on performance and fuel cycle costs". Based on the earlier analysis that nuclear fuel costs will probably decline in the next 30 years, both initial and lifetime average fuel costs are estimated.

Cost comparisons are made for plants of four different generating capacities, namely, plants with single units of 100 MW, 150 MW and 200 MW, and plants comprising two 100 MW units. The comparisons lead to the following conclusions:

"1. A single 100-MW nuclear plant may be competitive only if fuel oil prices average 45¢ per million BTU or more.

2. The prospects of a 2 x 100-MW reactor station to compete favorably appear to be good only if fuel oil prices average 40¢ per million BTU or more.

3. A single 150-MW nuclear plant may be competitive with an oil-fired plant using fuel oil costing about 37¢ per million BTU or more.

4. A 200-MW nuclear plant may be competitive with an oil-fired plant using fuel oil costing 35¢ per million BTU or more.

"Subject to the assumptions stated earlier, it appears that in the Luzon Grid, nuclear power plants of the 2 x 100-MW or 150-MW sizes may be competitive with oil-fired plants having an average lifetime-fuel-cost of 40¢ per million BTU, or $2.40 per barrel. When oil prices go above this figure the area of competitiveness for nuclear power is greatly enlarged. Therefore, considering that the present price of fuel oil is approximately 38¢ per million BTU, one can conclude that the use of nuclear power in the Luzon Grid towards the end of the 1960's deserves serious consideration."

Three additional advantages of nuclear power are then adduced to reinforce this conclusion. The first is that it would enable the Philippines to escape a total dependence on a single fuel source, namely, oil, for its thermal electricity supply. The second is that nuclear power costs may prove to be more stable in the future than those of oil-fired plants, which are subject to fluctuations in oil prices. Finally, "the building of a nuclear power plant, by offering a source of competition, can serve as a useful check on upward fluctuations in the price of oil."

Steps Toward Nuclear Power

The concluding chapter in the report sets forth "the successive steps which it might be desirable to take in giving further consideration to nuclear power and, in case an affirmative decision is made, in the actual installation of a nuclear plant". Various preparatory steps on the public policy side are suggested, including the enactment of legislation regarding such matters as third party liability and reactor safety. More detailed and intensive investigations of some of the subjects considered in IAEA's report would also be desirable, particularly future power needs, programs necessary to meet them, further comparisons of the merits of oil-fired and nuclear plants, and procedures for obtaining nuclear fuel. Administrative and financial arrangements for building a nuclear plant would have to be made, one or more sites selected, and specifications prepared as a basis for bids for both oil-fired and nuclear plants. Then would come the important step of issuing invitations for fixed price bids accompanied by suitable performance guarantees. It is suggested that, since evaluation of the bids would be a complex matter, the assistance of an international panel of experts might be sought.

The roles which might be played by the Philippine Atomic Energy Commission, the principal utilities, and other interested groups are then discussed. The need for co-ordinated operation of hydro and thermal power plants in the Luzon Grid is emphasized.

Suggestions are made regarding the training of personnel to operate a nuclear plant. Finally, the types of assistance which might be obtained from the IAEA are listed as follows:

(a) detailed analysis of alternative reactor systems suitable for the conditions in the Philippines; (b) health and safety measures; (c) preparation of atomic legislation and regulations; (d) preparation of specifications for the nuclear plant; (e) evaluation of bids; (f) site selection; (g) training of personnel; and (h) obtaining fuel and outside financing.

FAST REACTOR PROGRAMS

Scientists from 22 countries and two international organizations discussed the physics of fast and intermediate reactors at a seminar held by IAEA in Vienna last August.

Fast reactors are those in which the neutrons emitted in the fission process are not "moderated" or slowed down, while in intermediate reactors they are moderated to a limited extent. When the neutrons are not slowed down, they are particularly effective in converting the abundant uranium isotope, U-238, which accounts for more than 99 per cent of natural uranium but which itself is not fissionable, into plutonium-239, which is readily fissionable, like uranium-235. It is, therefore, possible to "breed" fresh nuclear fuel in a fast reactor even in larger quantities than the fuel consumed.

This advantage of fast reactors, which may become the ultimate means of economic power generation from nuclear fission, has led to large programs of research and development in many countries. Some of these national programs were reviewed during the closing stages of the IAEA seminar. (The main part of the meeting, however, was concerned with the physics aspects of such reactors.) The highlights of this review are presented in the following paragraphs.

France

Dr. G. Vendryes (France) said that his country's program was initiated four years ago in the hope that within the decade 1970-1980 fast breeder reactors would become competitive as a source of cheap nuclear power, the more so as conditions in France lend themselves particularly to this development. The construction of graphite reactors by Electricité de France would provide France with ample supplies of plutonium.

The first step taken by the French Atomic Energy Commissariat was to begin construction of the experimental reactor "Rapsodie" at Cadarache. Plutonium, probably in the form of a plutonium-uranium-molybdenum alloy, will be used in the very first loading of "Rapsodie". When the reactor becomes operational by the end of 1964, one of its main purposes will be the carrying out of experiments on irradiation of fuel elements.

A laboratory complex has been built at Cadarache and at present various items of equipment are being installed there. A team to measure nuclear constants will also be transferred to Cadarache, which now has all the facilities and means for research and development in the fast reactor field.

As a second step in the French program it is planned to design and build a 250 MW (thermal) reactor towards the end of the present decade, which would help in designing a true electrical plant prototype.

Stress will continue to be laid on plutonium fuel studies and on solving problems in such fields as physics, electronics, control and safety, mechanics and engineering.

The larger part of the French fast reactor program will be carried out in close co-operation with EURATOM.

Soviet Union

Describing the program of the USSR, Dr. Ivan Bondarenko said that the problem of basing the production of electrical power on nuclear energy was not acute in his country, in view of its large reserves of fossil fuels. Nevertheless, power needs constantly grow, making it necessary to open up new sources of energy. Interest in fast reactors, Dr. Bondarenko pointed out, was linked to the hope of obtaining cheap electrical power in the relatively near future.

The USSR program in the fast reactor field, which started in 1948, might be divided into a theoretical and a practical stage. During the first stage, research on various physical aspects was carried out,