SITING EVALUATION OF A NUCLEAR POWER PLANT IN SOUTHERN ISRAEL*

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Abstract

An investigation of the feasibility of building a nuclear power plant before 1980 along the southern Israel seashore was carried out. The various engineering, economic, ecological and public aspects of the problem were analyzed. The feasibility of a nuclear power plant depends upon economic and environmental factors as well as the need for diversification of the power production sources. Israeli power production capacity at present is relatively small. However, with the expected increase in total generating capacity and constantly rising oil prices, a nuclear power plant of about 400-500 MW capacity (or a somewhat larger one in the event of a combination of power production and desalination) could be included in the conventional network. Other factors that may influence the decision are as follows: scarcity of potential sites along the seashore, the level of various pollutants in the air, and the sensitivity of the Israeli public toward the installation of conventional and nuclear power plants. The relative importance of the various factors was weighed and analyzed. Local ecology experts are all in agreement that a nuclear power plant is environmentally preferable. It would be regrettable to miss the "break-even point" which, because of the specific Israeli conditions, may have already been reached.

Introduction

Israeli interest in nuclear power plants goes back to the early sixties. In 1962, a special committee made the following recommendations: to reserve several sites along the Mediterranean coast for construction of nuclear power plants (n.p.p.); to study the feasibility of installing at the end of the sixties, the first n.p.p.; and to maintain a continuous follow-up of technical developments in this field.[1]

Due to the relatively small size of the Israeli power supply system, the largest power unit operated until now by the Israeli Electrical Corporation(IEC) is 230 MW(e). Under these circumstances, n.p.p.'s could not compete economically with conventional power plants (c.p.p.). Recently, the question of determining when to install the first n.p.p. has been discussed quite frequently at symposia and technical meetings[2,3]. Various bodies have become interested in the subject and participated in those meetings.

The municipality of Ashdod, one of the communities near two potential sites for the first n.p.p., commissioned the Technion, Israel Institute of Technology, to investigate the ecological and environmental aspects of the

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installation of such a plant in the vicinity of the city.[4] It should be noted that, as a result of the "ecological scare" that has recently swept Israel, local authorities often insist upon carrying out their own investigations. The present work is a result of such a study.

Capacity of Existing Conventional Power Plants

Electric power is produced, transmitted and distributed to Israeli customers by a single company, the IEC. Its power generating capacity grew from 3.0 MW(e) in 1930 to 570 MW(e) in 1962 and 1525 MW(e) in 1972. This rapid development compels the IEC to cope with a yearly growth rate that is one of the highest in the world. Only 6 years are required to double power production in Israel. Out of 42 countries listed in a recent survey[5], Israel has the highest yearly load factor (0.68 versus 0.30-0.50 in most other countries).

Israel's power generation in 1974 will total 1920 MW(e). The power plants are located in Ashdod - 780 MW(e), Tel Aviv - 620 MW(e) and Haifa - 520 MW(e). In addition, a few gas turbines having a capacity of up to 40 MW(e) each are being installed, mainly to meet peak power demands.

Factors Influencing the Decision Making

The criteria for evaluating the feasibility of the n.p.p.are discussed below. The most important factors are economic and environmental criteria and the stage of technological development.

Economic Factors. Economic considerations have played a major role in preventing the government from reaching a positive decision regarding a n.p.p. The initial investment in the n.p.p. is very high compared to the c.p.p.,while operating expenses are relatively low. The major factors determining the economic feasibility of a n.p.p. are the cost of conventional fuel and the initial investment, which depends on the size of the production unit and the financing conditions[6].

In the last few years, the cost of conventional fuel (bunker-oil in Israel) has been rising steeply. Any forecast about the economics of a n.p.p. has to be based on various shifting factors, mostly related to the cost of conventional fuel. Nuclear fuel is considerably cheaper than fossil fuel, and its compact shape contributes to the ease of its handling and transportation, as compared with fossil fuel[7].

The major obstacle to the development of a n.p.p. in Israel has been the relatively small size of the Israeli power network. However, a study by Ashner[8] indicates that a n.p.p. of 600 MW(e) or more may be more economical than a conventional unit, when the following conditions exist: the cost of crude oil is US$16/tonne (US$0.393/Btu), the load factor is 80%, and the interest rate is 10%. (Fig.1).

Surveys and forecasts, done by the IAEA, show that from both economic and environmental viewpoints a n.p.p. of 500 MW(e) or more constitutes the best and cheapest form of power generation. The share of n.p.p.'s in the world power generation is expected to grow from 8% in 1975 to 27% in 1985, and 63% in the year 2000[7,9].

Public Attitude. Several years ago, in spite of widespread objection the Israeli government decided to install a 428 MW(e) c.p.p. within the city of Tel Aviv. The government was severely attacked by public organizations and a continuous dispute about the merits versus the shortcomings of the project has captured the headlines of the daily press for a long time. The decision created an unpleasant antagonism among the people and, at present, the attitude of the general public is one of suspicion towards the c.p.p. (A similar conflict arose in 1971 when plans for installing a new c.p.p. in a relatively

unpopulated area, north of Tel Aviv, were made public).

The Israeli public does not have,as yet, an antagonistic attitude towards a n.p.p. This is in contrast with other countries such as the U.S.A., where public opposition occasionally causes delays in the construction of n.p.p.'s[10] Israel already has two research reactors, which have been functioning without problems since the early sixties. These reactors have boosted the development of nuclear research and created a sound basis for the rapid absorption of the first n.p.p. into the Israeli power supply network.

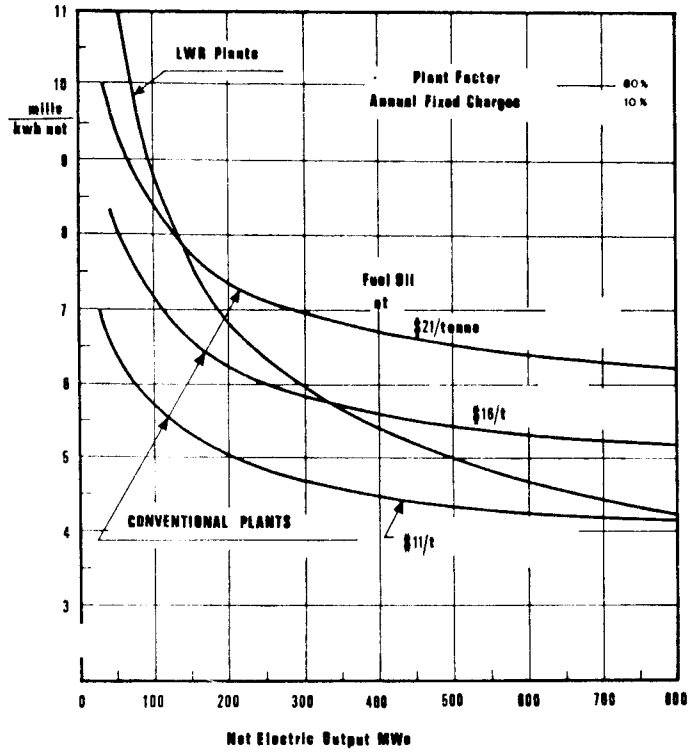

Fig.1 - Comparison of cost per kwh net in conventional and LWR power plants (after Ashner[8]).

Environmental Comparison of Nuclear and Conventional Power Plants. The most important ways in which a n.p.p. may affect the environment are the following: a) releasing minute quantities of radioactive materials into the air and water, (b) releasing large quantities of heat into the cooling water, and (c) making necessary a reevaluation of plans for development and uses of the land in the vicinity of the reactor. The environmental effects of nuclear and conventional power plants are compared in Table 1.

It is not easy to make an environmental comparison of a c.p.p. and a n.p.p. While the information regarding the environmental hazards of a n.p.p. is ample, much less data exist regarding the c.p.p. It should also be noted that it is hardly possible to compare a population exposure to a few mrem/year with an exposure to a yearly average SO_2 concentration of 0.03 ppm. However, a few investigators [11-13] have tried to compare the effect of radioactive pollutants to that of conventional air pollutants, and reached the conclusion that, from the environmental standpoint, the n.p.p. is preferable.

The importance of environmental criteria is steadily increasing, as a result of the growing public awareness of the problems. There are indications that future environmental standards for c.p.p.'s will be stricter, resulting in greater expenditures for control devices. The n.p.p.has already reached a

much higher level of environmental control, which clearly gives the n.p.p. a certain advantage.

Both n.p.p. and c.p.p. affect the land-use and development of the area. However, because of the present trend to minimize land-use restrictions around nuclear reactors, it seems that the effect of a n.p.p. on its close environment becomes marginal.

Table 1. Environmental Effects of Nuclear and Conventional Power Plants

Type of pollution	Conventional Power Plant	Nuclear Power Plant
Sea and Ocean	Oil spills from storage facilities pollute the marine environment. Floating oil alters the heat and oxygen exchange balance between sea and air.	Transportation of nuclear fuel does not result in any release of pollutants to the sea. Minor quantities of radioactivity are released to the sea during the normal operation of the reactor. These have negligible environmental effects.
Soil and land pollution	Pipelines, storage facilities and the plant itself affect landscape. Accidental spills may result in soil and water pollution.	No effect due to fuel transportation or storage. No release of radioactivity to land. Effects on landscape are less than in c.p.p.
Thermal pollution	Large amounts of heat released to the marine environment may adversely affect marine ecology. On the Mediterranean coast a properly designed outfall can reduce these effects to a negligible level.	
Air pollution	Air pollutants such as SO_2, NO_x, CO_2 and particulates in large quantities are released from a c.p.p. Radioactive pollutants are also released from a c.p.p. as a result of burning coal or liquid fuel. Solutions to air pollution problems are expensive. They include tall stacks, scrubbing and filtration of stack gases, and pretreatment of fuel.	Emission of radioactivity is low and may be stored until favorable meteorological conditions prevail. The probability of major accidents is extremely low, thus almost no air pollution problems arise from a n.p.p.

Need for Diversification of Power Sources. Israel has neigher solid-fuel resources nor hydroelectric options, and its power generation is completely dependent upon a single energy source - liquid fossil fuel - which must be imported and transported, mostly by tankers. By installing nuclear power plants, which use only a few tons of fissionable material that has to be partially replaced about once a year, the country could attain a certain independence. This is of importance when considering the present political conditions in the area.

Need for Desalination Plants. Israel has reached the point where it exploits practically all of its conventional water resources. Water desalination is already practiced in the country on a small scale and installation of ajoint n.p.p. and water desalination plant has been investigated. However, due to the high cost of desalted water and the lack of experience, not much progress has been made in this direction.

Future of Nuclear Power in Israel

Israel's power supply system is too small to have justified, in the past, the inclusion of a n.p.p. of a practicable size of 400-500 MW(e). Usually a single power supply unit should not exceed 10-15% of the network's total capacity. However, based on the projected demand illustrated in Fig.2 it is obvious that the operation of such a n.p.p. in the early 80's will become practicable.

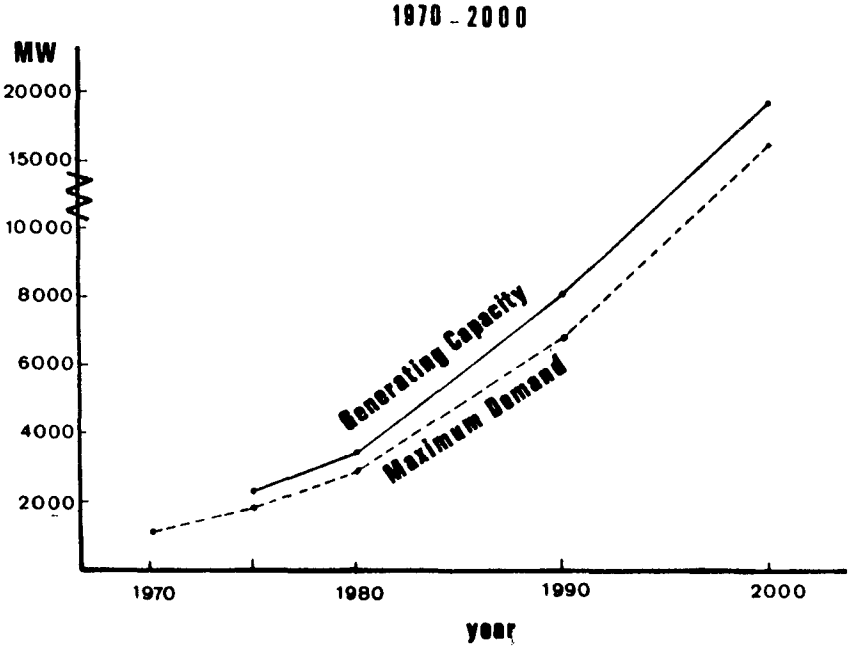

Fig.2 - Projected demand for electric power in Israel

Only reactors of proven technology will be considered as suitable for Israel in the foreseeable future.

The basic criteria for siting the n.p.p. are similar to those considered in locating a c.p.p. (e.g., proximity to cooling water, safety from floods and earthquakes, strength of the subsoil where the foundations of the station are to be laid, proximity to power consumers, existence of roads and availability of manpower to be engaged in the construction). In addition, criteria of radiation safety are also taken into consideration. The experience obtained during the last years, the improved design of the reactors and the various control measures, now permit the installation of a nuclear reactor even in the vicinity of dense population centers. A nuclear reactor should be safe everywhere its safety depending primarily upon safeguards which are an inherent part of its engineering.

As power stations should be located along the seashore, and because the population there is already very dense, only four sites could be reserved in Israel for n.p.p.'s until the end of the 20th century. This siting took into consideration forecasts of population increases in the big cities. Around each of these sites there are two regions - one which could be relatively restricted to civilian population (because it is uninhabited at present), and one(farther from the reactor) which is recommended to remain a low population density region. It is noteworthy that in some countries (Canada, Czechoslovakia and Japan) the buffer zones where construction is restricted does not exceed 500-1000 m.

Summary and Conclusions

Many developing countries, most of them not more developed technologically than Israel, have already ordered n.p.p.'s. It is especially difficult for a developing country to justify installation of its firs n.p.p. Its inclusion within a conventional power generating system poses special difficulties. The various approaches to these questions are presented in Appendix A, where a comparison between Israel and Greece (a developing country, also) is given.

This investigation, based on a study carried out for the city of Ashdod[5], showed that from ecological and environmental aspects there is a distinct advantage in installing a n.p.p. rather than a c.p.p. Even from the economic viewpoint, a decision should be made now so that the n.p.p. could be operational by 1980.

According to some approaches, a delay may be desirable in the long run because it may save some money. Other investigators believe that this delay is already economically unjustified. These debates indicate that Israel will probably make a positive decision in the near future, in accordance with the general attitude of most of the Israeli workers who have investigated these questions.

References

1) "Nuclear Power Plants in Israel", Israel Atomic Energy Commission, May 1962 (in Hebrew).
2) Proc. of a symposium on "Nuclear Power Plants in Israel", Tel Aviv, Oct. 1972 (in Hebrew).
3) Proc. of the Regional Conference on Radiation Protection, Jerusalem, March 1973 (Sponsored by I.R.P.A.).
4) Y. Argaman et al. "Examination of the Location of Power Stations in Southern Israel and its Effect on the City of Ashdod", The Technion Research and Development Foundation, Haifa, May 1973 (in Hebrew).
5) United Nations Statistical Yearbook, 1970.
6) S. Yiftah, "Nuclear Energy in Israel", Proc. of the Regional Conference on Radiation Protection, Jerusalem, March 1973.
7) B. I. Spinrad, "The Role of Nuclear Power in Meeting World Energy Needs" IAEA Conf. on Environmental Aspects of Nuclear Power Stations, p. 57, IAEA, Vienna, 1971.
8) P. S. Ashner, "Nuclear Energy in Israel", a lecture given at Technion, Haifa, 1972 (in Hebrew).
9) D.S. Briggs, M. A. Khan, P. H. Kruck and M. Ristic, "Small and Medium Power Reactors; Present Status and Prospects", Atomic Energy Review, IAEA 7, No.3, p.119, 1969 .
10) "Public Attitudes about Nuclear Power", INFO, Atomic Industrial Forum, Dec.1972.
11) C. M. Eisenbud and H. Petrov, "Radioactivity in the Atmospheric Effluents of Power Plants that Use Fossil Fuel", Science 144, 288, 1964.
12) J. G. Terril et al. "Environmental Aspects of Nuclear and Conventional Power Plants", Ind.Med. Surg. 36, 412, 1967.
13) A. P. Hull, "Some Comparisons of the Environmental Risks from Nuclear and Fossil-Fueled Power Plants", Nuclear Safety 12 , 185, 1971.

APPENDIX A

In this appendix an attempt is made to compare the various approaches to the question of the integration of a nuclear power plant into the power supply system of a developing country. For this purpose Greece, whose power problems are similar to those of Israel, has been selected for comparison with Israel. This comparison is based upon data reported by officials of the Greece Public Power Corporation (Skelakalos and Karangelos*) and is presented in the following chart:

A Comparison of Approaches towards the Question of Installation of a N.P.P.in Two Developing Countries

Problem	Israel	Greece
Type of body supplying the electricity	The Israel Electric Corp.Ltd. (I.E.C.) is a public utility concerned with the generation and supply of electricity.	Public Power Corporation (PPC) is responsible for the generation, transmission and distribution, transmission and distribution of electricity.
The type of energy	Mostly liquid-fuel imported into Israel; local deposits of oil and gas supply only 2-3% of yearly demand; uranium ore deposits have been found mixed with phosphate rock.	Deposits of solid fuel; indications of oil and natural gas deposits; hydroelectrical potential of 15,000 GWh/year; uranium ore deposits under exploration.
Proposed date of installation and number of units to be integrated in the national supply network	4-5 n.p.p. of 500-600 MW(e) each to be installed between 1980 and 1990 plus 4-5 fast power reactors of 800-1000 MW(e) each, to be installed between 1990 abd 2000.	8 n.p.p. of about 600 MW(e) each of the LWR type will be installed between 1982-1991; 8 n.p.p. of 1000 MW(e) each will be installed between 1993-2000.
Determination of the size of the first nuclear power unit.	The appropriate size will be determined by considering two opposite trends: a) Large units are cheaper (per kWh) b) Operational requirements of the system give preference to small units.	
Type of reactor	The first reactors will probably be of the LWR type, due to the proven good experience obtained with these reactors.	
Siting of the n.p.p.	The fact that both Israel and Greece are Mediterranean countries having a long sea coast practically solves the question of thermal pollution. However, development of seaside tourism dictates the need for early n.p.p. siting. The two countries have already selected potential sites for the n.p.p.'s that will be built by the year 2000.	
Feasibility of a joint n.p.p. and water desalination plant	Because of water shortages, serious consideration is given to the possibility of installing a joint project for nuclear power production and water desalination. This integration will become a necessity in the eighties.	The idea of an integrated n.p.p. and a water desalination plant is being investigated by Greek scientists.

A Comparison of Approaches towards the Question of Installation of a n.p.p. in two Developing Countries (continued)

Problem	Israel	Greece
Forecast	Nuclear energy is probably the best answer to the rapid growth of electricity demand. This solution relieves Israel from complete dependence on one type of fuel (crude or bunker-oil), enables acquisition of experience and know-how, and partly solves the problem of conventional air pollution.	In Greece "Nuclear energy is considered as the unique solution for meeting the future energy needs, not only because the country's conventional energy resources are being depleted, but also because it is believed that they should be saved for future generations for other uses".

Both countries have power-generating systems of a relatively limited size. As yet, there is no decisive economic advantage in including a n.p.p. in the conventional power network. However, both countries are rapidly approaching the stage where such an inclusion will be economically justified. Greece, in spite of the fact that its need for diversification of its power resources is less urgent than that of Israel, has already taken a positive attitude, by deciding in principle upon the installation of the first nuclear power plants. Israel, on the other hand, has not yet made a decision. As both countries are on the verge of economic justification of such a venture the outcome may fall either way. The difference in the approach of the two countries may stem from a certain difference in the local conditions and on other factors besides economic ones which are involved.

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* K. Skelakalos and J. Karangelos: "Integration of Nuclear Power into the Greek System", in the Proc. of the Regional Conference on Radiation Protection, March 5-8, Jerusalem, Israel.