NUCLEAR ENERGY IN ISRAEL TOWARDS THE 21ST CENTURY

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ABSTRACT. Nuclear energy utilization has been facing substantial difficulties worldwide in the last decade. Safety problems led to public distrust and economic performance did not always fulfill the utilities expectations. However, recent events in Israel and worldwide call for a review of the national energy policy. Nuclear power should be considered a viable solution to energy problems which may confront us in the future. The main objective of incorporating nuclear power in Israel's energy program is to minimize its total dependence on imported fossil fuel, which may be hindered by fluctuations in fuel prices and disruptions in regular supply. In order to achieve this goal, 50% of the electric power generation should be obtained from nuclear plants. Thus, long-term planning is required, extending over a period of 25 to 30 years, for implementation of a nuclear program. The projected Israeli installed capacity for 1995 is 5600 MW at an annual development rate of 4%. If this trend continues, it will require installation of approximately 5 units, 600 MW each, every ten years, about half of which should be nuclear. It is in Israel's interest to opt for an advanced type of nuclear reactor, that could provide many important advantages, e.g., improved safety, prolonged life, high load factor, etc. A high local participation in the planning and construction of the plant is also desirable.

Energy consumption is a measure of the living standard. Currently, the annual energy consumption in Israel is 4000 kWh per capita; in the U.S. it is 10,000 kWh per capita, while in third world countries, this value is only 1000 kWh.

An improvement in living standards, or even more so, an increase in population, will inevitably be accompanied by an increase in energy needs. This fact is particularly applicable to the current situation in Israel: to absorb very large numbers of new immigrants, industry must develop in a fast pace, to provide work and a reasonable living standard to the population. So, an annual increase of 4-5% in the demand for electricity which has been projected over the next decade is reasonable.

Israel is almost devoid of natural energy resources and is totally dependent on import of fuel for all kinds of energy requirements. It is well known that all power stations in Israel operate on fossil fuel. Luz International's achievement in solar energy is encouraging and should be followed closely, but as yet, it does not present an effective solution for electricity generation on a national scale.

Oil shale plants, at best, will provide a small contribution to our energy requirements, assuming the first unit of about 70 MW in 1997 and about 150 MW units in the year 2000, followed by additional units of 150 MW. Thus, to attain independence and control over our energy generation means that the only viable option available is nuclear energy. At present, Israel must maintain a continuous unhindered supply of imported fuel for its energy production. Fluctuations and hikes in oil prices, as we have witnessed recently, or disruptions in regular supply of coal, could be detrimental to the economy; this is particularly true in a growing economy which strives to reduce production costs in order to be competitive on world markets.

In the last decade, nuclear energy utilization has been facing substantial difficulties worldwide. Safety problems led to public distrust and economical performance did not always fulfill utilities' expectations. However, recent events in Israel and worldwide call for a review of the national energy policy and nuclear power should be considered as a viable solution to energy problems that may confront us in the future.

As was mentioned earlier, the main objective in incorporating nuclear power in Israel's energy program is to reduce our dependence on imported fossil fuel. Fuel diversity is a strong asset of an electricity supply system. In order to achieve this goal — 50% of the electric power should be obtained from nuclear plants. Thus, long-term planning is

required, extending over a period of 25 to 30 years, for the implementation of a nuclear power program.

The projected Israeli electricity installed capacity for 2003 is 8000 MW. Thus, in the next decade the installation of approximately 5 power units of 550 MW is required; hopefully, one of them will be nuclear. Following that, the nuclear power program calls for the installation of one nuclear power plant every five years.

It is in Israel's interest to opt for an advanced nuclear reactor type, that could propose many important advantages, such as improved safety, prolonged life, high load factor, better economy, etc. It follows, therefore, that a nuclear energy program for Israel is a national endeavor which requires the commitment of large resources in manpower and finance. It is a long-term commitment and requires thorough planning. There are many gains to this endeavor:

- first and foremost, it will provide us with better control of the national energy supply;
- it will make a major contribution to the development of industry, nuclear sciences and technology;
  we will benefit from diminished pollution in densely populated areas;
- and last but not least, a significant portion of the budget for this project will be invested in Israeli industry if we succeed in incorporating a large local interest in this project.

Currently, there are some commercially available large LWR reactors, which do not fully conform with the latest safety standards of passive core cooling systems. The nuclear industry concentrates, therefore, on new types of reactors, smaller in size (500 - 600 MW), to accommodate contemporary needs. The principal efforts in the U.S., Japan, Germany, France and the USSR are the development of passively stable, light water reactors. The PWR AP-600 (by Westinghouse) is based on a proven technology, plus passive emergency core cooling and ensured integrity. The advanced 600 MW BWR employs proven General Electric technology, at a reduced power density and safer thermal margins. Similarly, the VVER 500 being developed in the USSR has passively operated emergency cooling systems.

The 135 MW Modular High Temperature Gas Cooled Reactor (MHTGR) remains the only option available in advanced, gas cooled reactor development. Its low power density combined with a large heat sink, provided by the core structure and fuel elements, makes this reactor inherently safe. Inherent safety is a very important consideration for a country with little experience in operation of nuclear plants and which is bound to encounter human errors and mishandling, at least in the beginning.

However, one should also consider the disadvantages of the MHTGR:

- this size of reactor is not economical for generating electricity;
- its technology is not fully matured. Hence, failure due to lack of operating experience may impair the reactor's performance;
- lack of standardization and licensing regulations pertaining to MHTGR are bound to result in economic penalties.

Hence, light water reactors remain the preferred choice with PWR being the dominant system.

The responsibility to recommend the appropriate type of reactor, on which the long-term nuclear energy program should be based, lies on the shoulders of the scientific and industrial community. Issues which must be addressed in this context are:

- maximum safety;
- minimum cost;
- best performance, efficiency and load factor;
- standardization;
- compliance with regulations and licensing requirements.

Good ways to reduce capital costs are - minimizing construction times, to reduce interest charges; duplicating standardized systems, to gain maximum benefits from past experience; simplifying design and construction techniques; adhering to accepted international standards of safety regulations. Operation and maintenance costs can also be reduced by plants co-location which offers the advantages of common services and operations. The extension of plant operation life can also reduce electricity generation cost.

Safety, like justice, must not only be implemented — it must be visible, if we wish to gain the confidence and approval of the public. The approach to nuclear safety is based on several strategies:

- "the defense in depth concept" with three or more design barriers which provide several levels of protection;
- the use of very high standards of quality assurance, particularly in all systems which have a direct effect on plant safety;
- it must be recognized that people and machines are imperfect and, therefore, a variety of duplicated and triplicated safety devices should be installed, so if the reactor fails it should fail safely! Here again the question of "how much is enough" will be debated, especially if one considers advanced reactors and aims for a large local content;
- attention must be paid to operators' training and competence.

Standardization is also a major consideration, particularly when the long-term program comprises the construction of several nuclear power plants. Standardization is directly related to cost, maintenance, safety and licensing.

Regulation and licensing should rely on accumulated international know-how, on one hand, and local requirements adapted to Israel's environment on the other. In addition to generally established norms concerning nuclear power plants, attention should be paid to local seismic conditions and to the protective measures that must be incorporated in the reactor's design as a result of Israel's vulnerability to hostile attacks. All countries can more readily acquire and improve the operational knowledge and experience needed for sound regulatory judgement through international cooperation. International discussion on safety norms help national authorities to accumulate know-how and adapt it to the formulation of well balanced licensing recommendations.

Besides technology. there are many other issues relating to a nuclear power program that must be addressed, if such an endeavor is undertaken. A dominant factor in Israeli readiness to meet such a challenge is the availability of a domestic infrastructure to cope with such a formidable task. A competent industry, high quality standards, supporting scientific institutions, well trained staff and adequate training facilities, reliable safety authorities, cooperation among the designers - all contribute to the preparedness of a country to venture a nuclear project with a significant local input.

Some factors which are considered in the process of shaping our national energy policy are:

- mobilization of national resources in finance and manpower;
- incorporation into the electric grid in a stream lined manner;
- public acceptance;
- international relations and accords.

In many of these domains Israel has to develop further the essential infrastructure to cope successfully with this task.

If the main goal is gaining partial independence in electricity generation, we have to establish reliable organizations which would take responsibility over all phases of the nuclear plant life cycle; namely design, construction, operation, improvement, modification, fault analysis, trouble shooting and, finally, decommissioning.

Public awareness of the benefits and desirability of nuclear power is another important task the nuclear community has to promote.

In addition, nuclear energy is a cheaper power source than fossil fuel. This is concluded from data published in late 1989 by Nuclear Engineering International, which compared costs of generating electricity from coal and uranium. Similarly, a USCEA analysis indicates that in an advanced reactors built under stable regulatory conditions, nuclear energy costs will be 10% lower than coal, 30% lower than gas, and 47% less than oil. Naturally, these values are influenced by the cost of capital, as well as the fluctuations in the price of fuel, which is expected to rise, as this commodity becomes scarce.

To conclude, let me reiterate the key elements for developing an industrial nuclear program in Israel. A national project in nuclear energy is a viable long-term solution to Israel's energy needs. It also encompasses a vast potential for Israel's future development.

Realization of this potential demands indigenous efforts dedicated to the goal of building an Israeli nuclear power plant. A combined effort of all the organizations associated with nuclear energy is essential for the implementation of this long-term program within the time and budget framework allocated. In particular, Israel Electric Co., Israel Atomic Energy Commission, the large industries and the Government must be actively involved.

It needs a foresighted leadership with the resolution to launch a national nuclear power project. It requires large investments and supportive infrastructure. But the yields and benefits which will be gained in the future would fully justify these efforts.

Many important issues relating to a national nuclear power program must be addressed, to lay the foundation for strategic decisions. Some of them are:

- economic aspects, i.e., nuclear energy cost versus the cost of alternatives; financing and interest rates; construction and operation time; capacity factors; etc.;
- a survey of indigenous technological and scientific capability, which is desired and necessary in planning and construction of an Israeli power plant;
- regulations and licensing confronting with Israel's environmental conditions;
- allocation of suitable sites for nuclear power plants.
- cooperation with other countries to provide an important asset to the program;
- preparation of an appropriate infrastructure. This is an urgent requirement to insure Israel's readiness for the nuclear power era;
- public awareness and sound public knowledge of the risks involved vis-a-vis the prizes of success, namely: a clean environment, savings which will benefit all, and long-term freedom of our energy supply at a time of need.