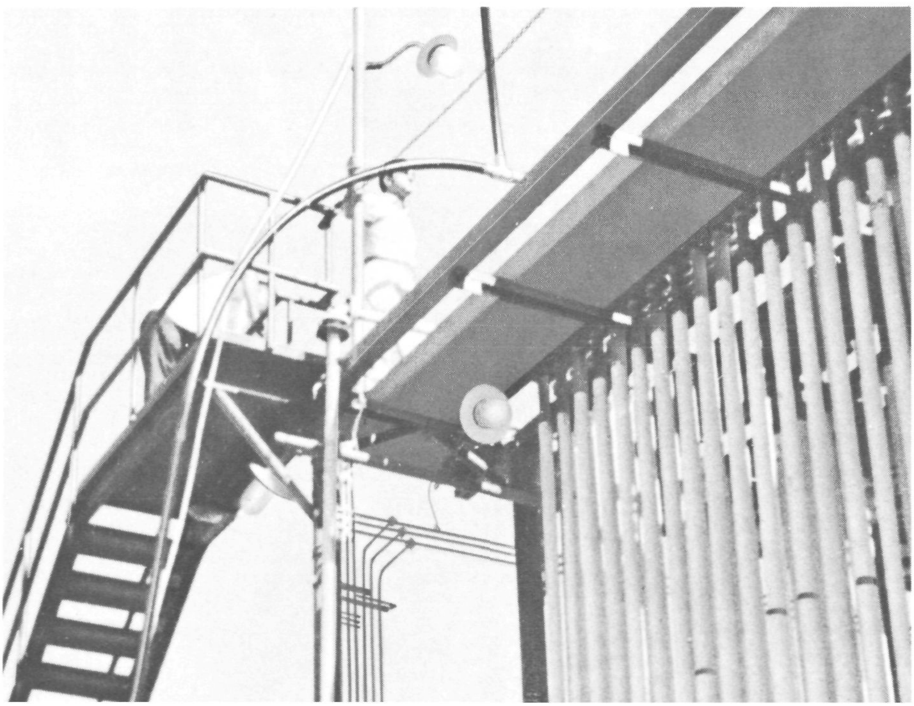
NUCLEAR DESALTING POTENTIAL FOR DEVELOPING COUNTRIES

Nuclear power, having proved its success in large units, now poses problems for application in developing countries. Possible solutions for electricity supply, desalting systems and agricultural development are suggested by Joseph R. Wilson, of the Agency's Division of Nuclear Power and Reactors. His article is adapted from a lecture to students in Switzerland.

The world's first experimental power reactor started operation in May 1954, at Obninsk in the USSR. It was a little more than twelve years ago that the first "commercial" nuclear power was produced at Calder Hall and Shippingport in the United Kingdom and the United States.

One desalination process is known as reverse osmosis, a method of using membranes. This plant in an Israeli kibbutz is processing water found beneath the desert. Each tube supplies 250 gallons of fresh water a day, and the total capacity will go up to between 50 000 and 65 000 gallons. The pressure of 50 atmospheres requires power, and nuclear sources seem to be most promising for very large plants. Photo: IAEA/Moir



Since then the UK has produced more than 138 thousand million kilowatt hours of nuclear-electrical power - which is more than twice that of any other country. In fact, today, the UK has 3,500 megawatts (MW(e)) of nuclear power generation capacity. To put this number into proper perspective, I might mention that according to Dr. H. Kronberger, if you switch on an electric light anywhere in England today, one-ninth of the electricity flowing through the lamp will have come from nuclear power; and if you do this late at night when a number of the coal fired stations have been switched off, the fraction is even higher. If you switch on a light in Scotland, one-quarter of the electricity in the lamp will come from nuclear power.

During this same period more than 45 thousand million kilowatt hours of nuclear-electricity has been produced in the US, and France and Italy have produced more than 10 thousand million kilowatt hours each. Today nuclear-electric power is also generated in West Germany, Japan, Canada, Sweden, Holland and Belgium, and soon many more countries will join these ranks. It is a fact that nuclear power is a success, and the benefits of this assured supply of low-cost energy are just beginning to be realized.

However, as you may have noticed, the benefits are enjoyed almost exclusively by the most developed countries, and nuclear energy is therefore contributing to widening rather than narrowing the development gap.

Why is this so? Part of the answer can be found in the nuclear plant size range which is competitive with fossil fuel. If we look at typical electrical energy production costs of competitive fossil fuelled and nuclear plants, as shown in the following table, one finds that a utility can afford to pay up to 50% more for a nuclear plant because of the savings in energy costs.

ELECTRICAL ENERGY COST COMPONENTS

	Fossil Fuelled Plant	Nuclear Power Plant
Fixed charges, associated with investment	40%	60%
Energy costs	55%	30%
Operating and maintenance costs	5%	10%
	100%	100%

However, the relative capital costs of fossil fuelled and nuclear plants is strongly influenced by the unit size with the cost per megawatt decreasing faster for nuclear plants than for fossil fuelled plants as the plant size increases. Thus small size nuclear plants are generally quite expensive, but nuclear plants above 500 megawatt are usually competitive with fossil fuelled plants. This is borne out by the unit sizes which have been ordered by utilities in the United States – the average nuclear unit size in 1967 being 850 MW(e) and in 1968 being 950 MW(e).

As a result of capital cost and utility market characteristics, the major US manufacturers have standardized on several sizes of nuclear reactors of 500 MW(e) and above, but are currently reluctant to offer reactors below 500 MW(e). This standardization has been an important factor in reducing costs to their present competitive level.

In developed countries, utilities have found that unit sizes should be no more than 8 to 15% of the system size; this being the best compromise in the unit cost, ability to maintain a reasonable system load, and reserve capacity allowance for maintenance and for emergencies such as possible equipment outages.

Many smaller utilities whose size has precluded consideration of 500 MW(e) units, have merged or formed combines in order to benefit from the advantages achievable from nuclear units.

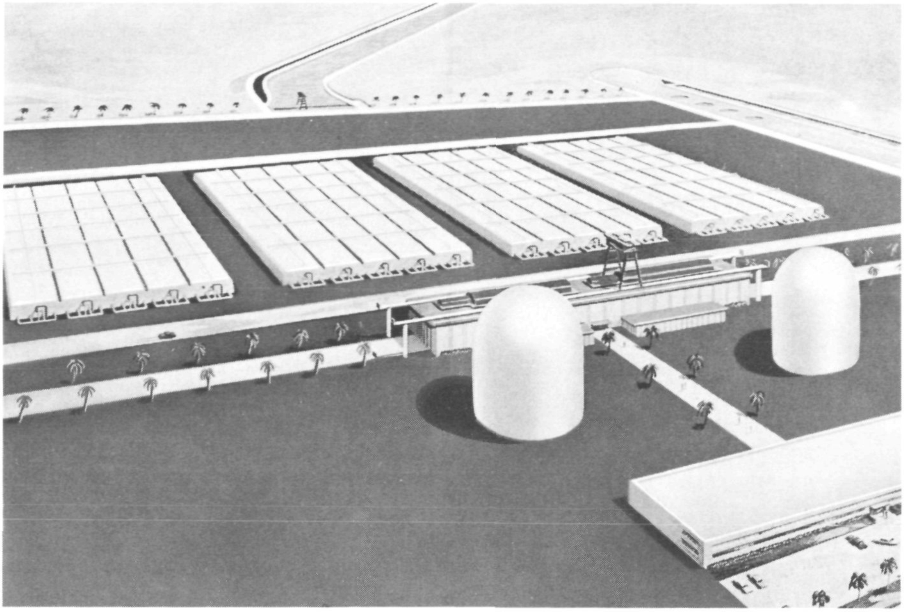
NEEDS OF DEVELOPING COUNTRIES

Now we come to the question of introducing nuclear power into a developing country. While the above rule of maximum size units may not apply to developing countries because of their faster growth rate and other factors, there are nevertheless limits to the capability of a small electrical grid to absorb a 500 MW(e) nuclear station. If we examine regional, or even national electrical generation needs of developing countries, we see that often their needs put them well below the range of economic nuclear power. For example, Chile, Peru, Israel, Greece and some other countries which would like to install nuclear reactors, have total national electrical system capacities of under 2000 MW(e).

This would indicate that many developing countries need electrical plants in the 50 - 300 MW(e) range, and in this range nuclear plants are very expensive.

One might close the consideration at this point with the conclusion that most developing countries are not in a position to benefit from nuclear power. Some people have in fact come to this conclusion – a conclusion similar to accepting that underdeveloped countries are too poor, or too unskilled or too small to join the technological world. But such a conclusion is contrary to our aims of utilizing modern technology such as nuclear power to accelerate development in the developing countries. We must therefore look for ways to change one of the controlling factors in this problem.

One way to improve the outlook is to make nuclear power more competitive, especially in smaller size units. The Agency has an active pro
petitive, especially in smaller size units. The Agency has an active programme to study this possibility and progress is being made in this direction.



An artist's impression of a dual-purpose nuclear plant producing a billion gallons of fresh water a day and about 2000 megawatts of electricity. A study team of Agency, USA and Méxican experts has found that plants of this type could be feasible for the requirements of regions in Mexico and USA bordering the lower Colorado River. The illustration appeared in the publication of the team' s preliminary assessment.

THE ENERGY CENTRE CONCEPT

Another approach is to increase the electrical load in developing countries to the level where nuclear power is attractive. To do this one needs to make a step change. One must justify the use of a large block of power, and do it all at once. This thought seems a bit bold, but I would like to mention a solution along these lines which is looking increasingly attractive. This is to create both the electrical demand and the nuclear power plant as a planned entity - an energy and industrial centre.

The energy centre concept capitalizes on the cost advantages of large-scale nuclear power by clustering around the reactor those industries and processes which, because of their energy intensive nature, can best benefit from the low-cost power and process heat - such processes as aluminium plants and other metallurgical processes; ammonia, ammonium nitrate, urea, phosphorus, nitric phosphate and similar agricultural oriented processes; chlorine, caustic and the chlorine based industries; solar salt production and desalination.

In fact, the energy centre concept offers a possibility of providing, and efficiently utilizing desalted seawater for agriculture - an application which has heretofore been entirely too expensive. Water is a very low-cost commodity and desalted water, which may in the future cost as little as 10-20 cents per 1,000 gallons, is still too expensive to be considered in even advanced irrigated farms as we know them today.

But natural water supplies have many limitations and uncertainties - rain is either too much or too little and may come at the wrong time. Irrigation water is usually somewhat brackish, and thus an excess of water is required to flush away salt residues left by evaporation. And finally, the best climates for farming are those in frost-free areas where year-round, three and possibly four crop farming may be possible. Such intensive farming will make the maximum use of the investment in land, irrigation system and farm equipment, and will eliminate the undesirable seasonal aspects of farming. Thus a farm system based on a fully controlled, pure and dependable water supply (and in a near perfect climate) may make economic sense in arid, frost-free areas - even in present day deserts.

Furthermore, when one looks for industries which require large blocks of low-cost power, and which may match the industrial needs or markets available to developing countries, one finds that the fertilizer plants are high on the list. Therefore an energy centre making power, water and fertilizer may be especially attractive. This concept is called the agro-industrial complex, and there are several areas in the world where it may be workable: Australia, Chile, the Middle East, India, Pakistan, and North Africa. In fact, the concept makes the most sense in those developing countries where a desert can be changed from a liability to an asset.

Studies and experimental work are now in progress to determine the feasibility of construction of these agro-industrial centres. However, before one can begin on a project of this type there are a host of problems to be solved - social problems of establishing new communities in desert areas, training farmers in entirely new methods, determining crop yields and water and fertilizer needs under desert conditions, and organizing, financing and administering these large new enterprises.

COMBINED ACHIEVEMENTS

The recent experimental successes in agriculture apply very much to this new concept. New crop strains have been developed which have much higher yields, can take larger amounts of fertilizer, and which are suitable for intensive farming. In fact, it is the combined achievements in nuclear power, agriculture and desalination which may make this concept viable.

Before we go on to several other problems, it may be useful to have a feeling for the cost associated with nuclear power plants, and with the large energy centre concepts. Nuclear power plants cost in the order of

160 - 200 dollars per kilowatt. Therefore a 500 MW(e) nuclear plant costs in the order of 80 to 100 million dollars. A rule of thumb useful in estimating the cost of the industry is that the investment in the utilization of power is in the order of 10 times the investment in the generation of power. Therefore the cost of an energy centre is in the order of 1000 million dollars.

Perhaps the most positive thing I can say at this point is that investments of this magnitude should command top technical, economic, administrative and financial talent, and surely such expert talent can solve the problems of money.

THREE PROBLEMS

Now I want to mention several other problems which are lesser in nature, but which must be handled in order to effectively utilize nuclear power in the developing countries;

1. It takes time and long range planning to be ready to build nuclear plants. Usually 5 to 6 years are required after the decision to move ahead is made, and this decision must be based on sound preliminary studies, feasibility studies and financial arrangements which require an additional five or more years.

2. The nuclear fuel is available only from a developed country - one of the nuclear powers. Some governments are reluctant to commit foreign exchange for the 30 year nuclear plant life, and have reservations regarding the reliance on external supplies of so vital a commodity as energy.

3. Advanced technology is required for nuclear power - for engineers, physicists, operators, crafts and trades, managers and administrators. These skills are available in the developing countries in limited numbers, and long range training is necessary to develop a sufficient supply.

These three problems are within the interest of the Agency, and we have programmes to assist in their solution.

In regard to long range planning, we assist many countries in the early feasibility studies by sending experts to those countries and working with their administrators, engineers, planners and economists to develop a programme in nuclear energy application. Sometimes our efforts are focused on the long range planning to develop competence and to be ready when nuclear power becomes attractive. Such a plan is likely to consider that certain aspects of nuclear energy - the use of radioisotopes in medicine, food preservation, insect control, geology and research can be utilized immediately. Sometimes the assistance is in the form of implementing feasibility studies for impending decisions on nuclear plant purchases, and sometimes we assist with the evaluation of bids, and in establishing the governmental structure that will enhance the success of the nuclear project.

In the area of nuclear fuel, the Agency has an active programme in relation to uranium and thorium explorations, mining, ore concentration and processing, preparation of nuclear fuel materials, their fabrication into reactor fuel elements, and a study of their behaviour during reactor irradiation; and the reprocessing and recycling of the fuel material after irradiation.

And finally the Agency assists countries in nuclear research, such as the use of isotopes, and programmes involving research reactors and reactor physics. In this regard I might say that research reactors serve several purposes. They are a tool for research. They provide a focus for nuclear energy activities, and this tends to keep at home the high quality scientists and engineers. A research reactor may be used to produce radioisotopes for use in agriculture, geology, industry and medicine. It also encourages the training of new specialists and technicians who will ultimately play an important role in the applications of nuclear energy to their country, and serves to acquaint the countries' leaders with the value, and the legal, technical and administrative responsibilities of nuclear energy.

It is necessary for every country embarking on a nuclear power programme to train the skilled plant operators, scientists, engineers and plant and government administrators to staff the units. Research reactors and local research centres are one way to provide this training. Of course, not every country contemplating nuclear power should have a nuclear research reactor as it may be possible to establish regional centres, and thereby share the rather high annual cost or it may be more practical to arrange to train personnel in major facilities in the developed countries. In fact, in the case of the regional centre and the major facilities training programmes, there may be the additional benefit of mutual exchange of information between the many other countries represented and with a larger number of scientists who will be attracted to the centre.