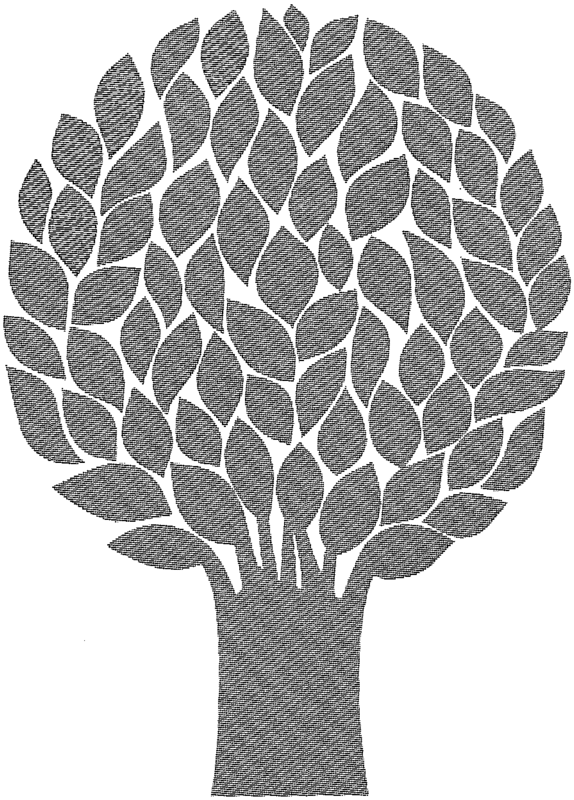


The Environment - Siting Nuclear Power Plants

These excerpts are from the discussions of a panel of experts on the subject, "The Environmental Aspects of Nuclear Power and the Siting of Nuclear Power Plants," held on October 2 last year at the Salazar Nuclear Centre, Mexico.

The Russian Viewpoint was contributed by Dr. I.D. Morokhov:
Twenty years' experience of operating nuclear power stations in the USSR has shown them to be safe, both for the operating staff and for the population in the areas surrounding the power station sites.

Radioactivity monitoring in these areas has not revealed any major fluctuations in background levels which can be attributed with certainty to the presence of nuclear power stations.

In fact, the release of radioactive substances to the atmosphere at nuclear power stations is up to hundreds of times less than the maximum releases permitted in the light of ICRP recommendations.

Water contaminated with radioactive substances is generally decontaminated and reused, only insignificant amounts being discharged into the industrial domestic sewer system. The contamination of such discharged water does not exceed the maximum levels permitted for drinking water.

Highly-active liquid waste is buried at special burial sites or stored underground. Safety measures are taken to preclude serious radioactive contamination of the environment, with the result that the radioactivity levels monitored around existing nuclear power stations have not changed at all relative to the period before start-up of the reactors. Thus, many years' experience of operating nuclear power stations has convinced us of their advantages over conventional power stations, the operation of which results in serious pollution of the environment by organic fuel combustion products such as sulphur dioxide, carbon monoxide, soot and ash.

According to data compiled by the USSR State Committee of the Utilization of Atomic Energy, conventional power stations with a capacity of 1000 MW and burning organic fuel release the following amounts (in tons per day) of noxious substances into the atmosphere:

Name of noxious substance released	Type of fuel		
	Coal (consumption: 6380 t/day)	Oil (consumption: 4600 m^3/day)	Gas (consumption: 536 000 m^3/day)
Sulphur dioxide	382	145	0.04
Oxides of nitrogen	60	60	34
Ash	12	2	1.2
Oxides of carbon	1.4	0.03	-
Radium-226	10^{-6} Ci/day	10^{-8} Ci/day	-

These release rates give rise to atmospheric concentrations near the ground, which exceed the maximum permissible levels by several hundred per cent at distances of up to 10 km from the point of release.

In addition to causing local pollution, conventional power stations may become dangerous sources of pollution of the biosphere on a global scale.

The Insitute of Applied Geophysics of the Soviet Hydrological and Meteorological Services Administration has forecast global environmental conditions up to the year 2000 on the basis of data relating to releases from power plants.

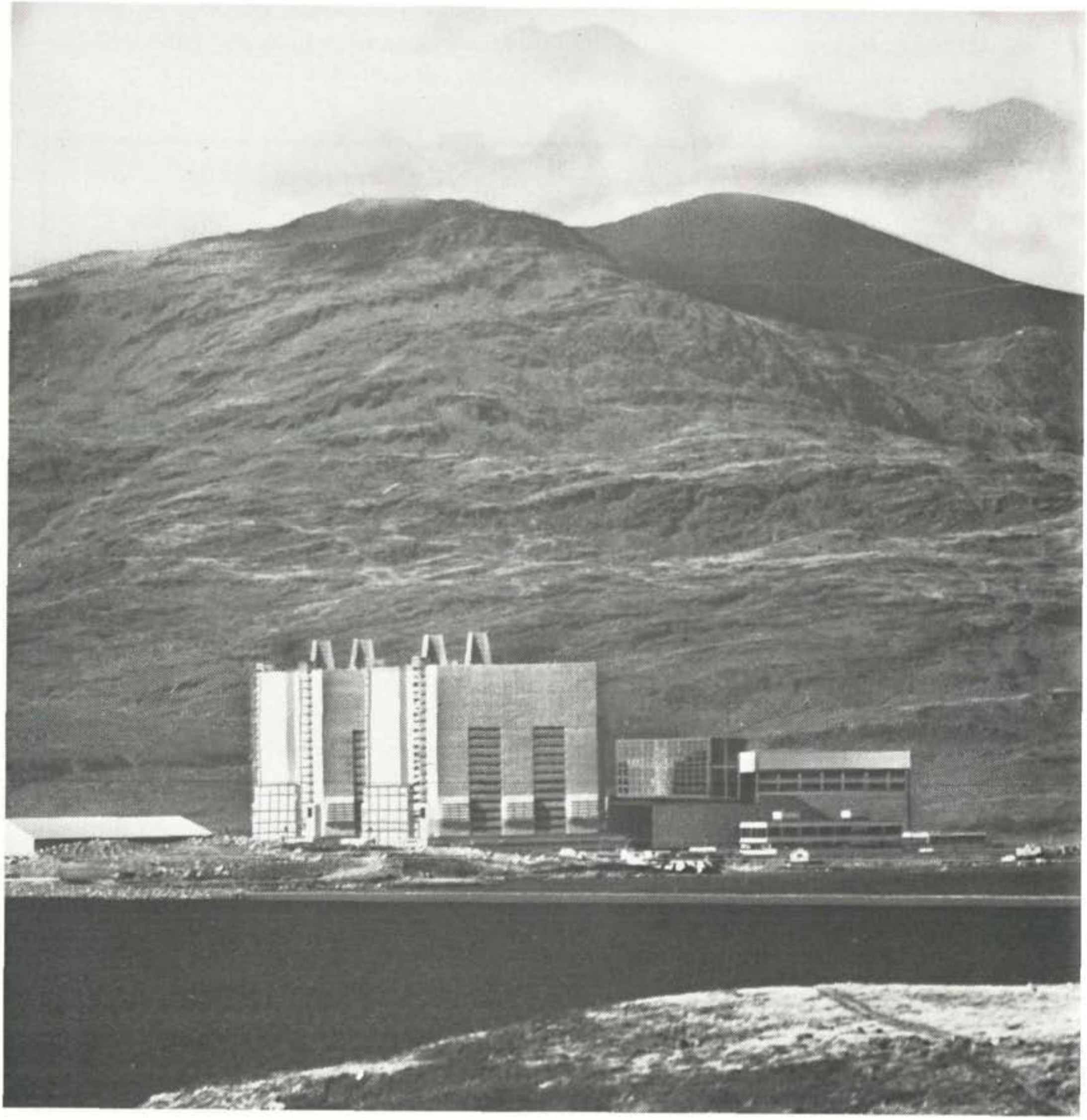
By the year 2000, conventional power stations (with a total capacity of 5.5×10^6 MW) will be releasing 60 000 000 tons of sulphur dioxide and 250 000 000 tons of ash to the atmosphere.

Above land, releases on that scale may, by the year 2000, have created an atmospheric sulphur dioxide concentration ten times the permissible daily mean.
If we add the releases of industrial enterprises to this, the forecast becomes even more depressing.

At the same time, it is estimated that by the year 2000, when the world's total nuclear power station capacity is 5.5×10^6 MW, the annual mean concentration of radioactive substances in the air will not exceed 10^{-3} of the permissible level. At present, however, public opinion is not altogether convinced by this optimistic forecast of negligible contamination of the environment by radioactive releases from nuclear power stations.

In the USSR, a great deal of attention is being devoted to protection of the environment. During a session of the Supreme Soviet of the USSR that ended only a few days ago, a special resolution on environmental protection and the conservation of natural resources was adopted.

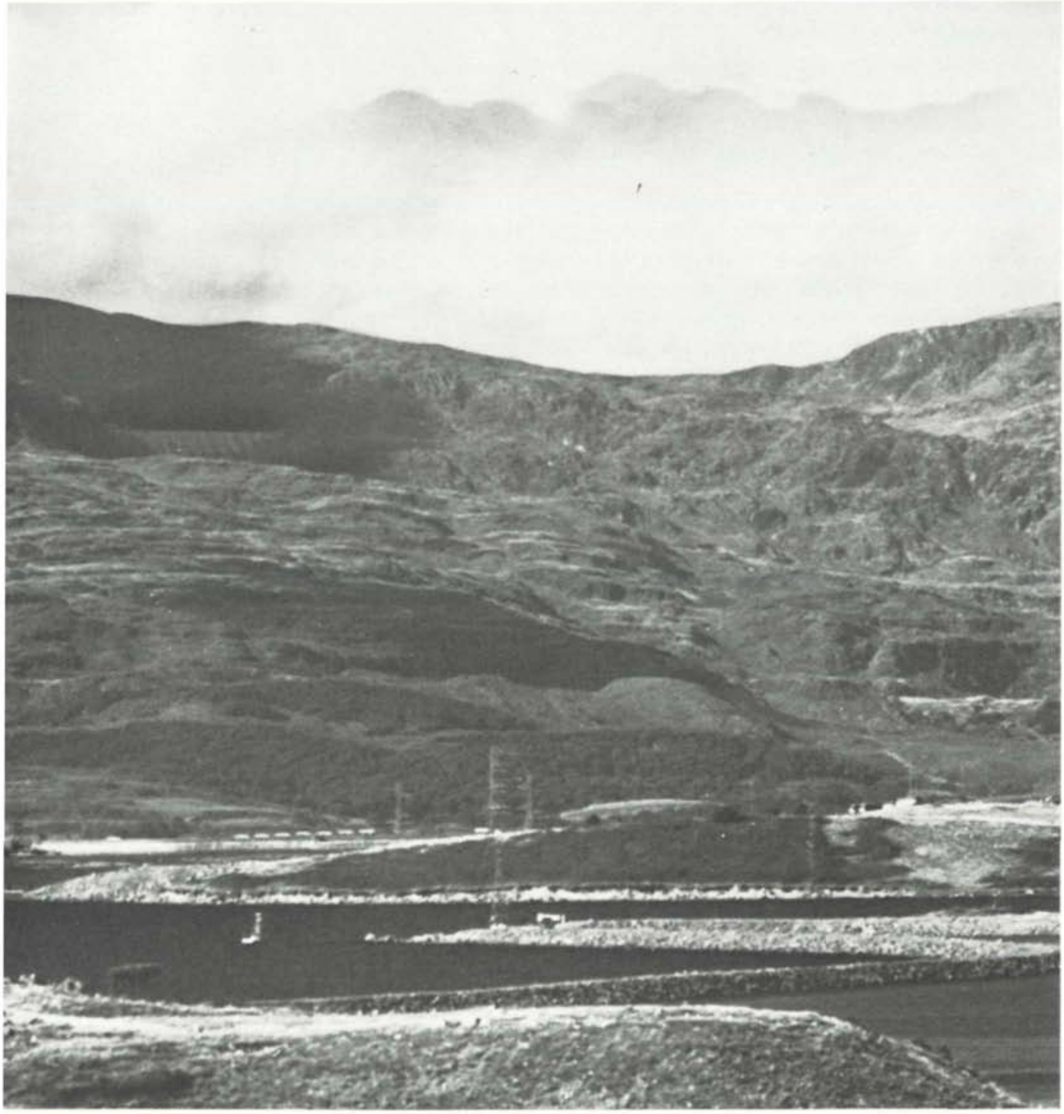
The economic advantages of siting nuclear power stations near or even within large towns has brought to the fore the problem of ensuring the radiation safety of the surrounding population. As a result, when a site is being selected for the construction of a nuclear



The Central Electricity Generating Board's 500 MW Magnox power station built on the northern shore of lake for obtaining cooling water.

power station, attention is devoted first and foremost to protecting the population against the harmful effects of radiation and to preventing dangerous contamination of the environment; this is acieved by developing reliable equipment and systems whereby radioactive substances can be trapped and localized.

One of the factors affecting the environment is heat release. When a site is being selected for the construction of a nuclear power station, account is taken of the temperature regime in the water body into which heated water from the station will be released. It must be borne in mind that the discharge of high-temperature water can lead to a breakdown in the ecological balance of the water body, with untoreseen and unpleasant results, such as the destruction of valuable fish species.



Trawsfynydd lake in Wales. This was the first nuclear station in Britain to be built inland, and the first to use a

Even from the point of view of "thermal pollution" of the environment, however, nuclear power stations should prove to be preferable to conventional power stations. The high energy potential of nuclear power stations, coupled with the use of advanced methods of energy conversion, permits more efficient conversion of thermal energy into electricity.

As I have already said, environmental pollution can occur on a global scale; radioactive contamination of the environment is no exception. Co-operative measures to protect the environment, particularly against radioactive contamination, are therefore extremely important. This is why the USSR fully support international co-operation to protect the environment, and recently concluded an agreement with the USA on co-operation in the field of environmental protection.

At the same meeting,
Rear-Admiral O.A. Quihillalt,
Chairman of the Atomic Energy Commission of Argentina,
outlined, from a conceptual approach,
the "installation of a
Nuclear Power Plant on the Shore of a Lake." . . .

"I am going to consider the problems arising from the use of a lake as a cooling pond for a nuclear power station. We faced that problem in Argentina when we decided to set up a 600 MW nuclear power station at a site in the central part of the country, where an artificial lake was created 30 years ago to provide water for a hydro power station of about 25 MW capacity," he said.

At the start of studies, it was known that 1400 MW had to be dissipated, and there was a rule of thumb indicating that one hectare of water surface was required to dissipate one MW. The total area of the lake is about 4600 hectares.

The lake surface is 657 meters above sea level, and the volume 550 cubic hectameters. The mean depth of the lake is 12 m and the maximum depth 40 m. The lake is fed by three rivers, the inflow varying from extremes of 1.4 m^3 sec. to 2600 m^3 sec. with a mean flow of 26.4 m^3 sec.

The site near the center of the south shore, which was eventually selected, presented the problem that it is difficult to locate the intake and discharge points, so that a maximum surface area is available for cooling.

The flow characteristics of the lake water were then studied on the basis of an electric model. These showed that the nuclear stations could be installed, even if only half the surface of the lake were used.

At the same time climatological, geological, stratigraphic, seismological, radiological, environmental, ecological and other investigations were also carried out. The ecological problems associated with the discharge of warm water from the condenser into the lake and the determination of maximum discharge temperatures were of particular interest in this connection.

Studies relating to the survival of fish and the growth rate of certain algae were performed in aquaria with thermostatically controlled temperatures and it was found that the king fish (Basilichthys bonariensis) – a variety of mackerel – was the "critical" species, with the least ability to withstand thermal shock. Fish of this variety transferred from an air temperature of 13 deg.C to water at 27 deg. C survive for 55 minutes, while for those allowed to acclimitize at 16 deg. C the average survival time was 138 minutes; this time was even longer when the temperature distribution was unhomogenous. Since there is a marked vertical stratification in the lake, the fish would need to survive only 10-12 minutes in the warm water layer, this period being sufficient for them to move to colder waters.

Two difficulties remained: that of assigning the empirical coefficients required by certain formulas and that of obtaining overall approval from someone with appropriate experience.

The approval came from Dr. Spurr of the Central Electricity Generating Board, London, whose services were obtained within a few days through the auspices of the IAEA.

The behaviour of a large body of water subjected to an artifical heat load, such as the warm water from the condensers of a power station, is simply an extension of the natural behaviour of a lake under the influence of natural heat from the sun; a heat balance has to be established between the combined heat input from sun and station and the increased rate of heat losses, conveniently expressed in watts per square metre.
The natural heat input from the sun, is the total direct and diffuse short-wave radiation reaching the water surface plus the incoming long-wave radiation from the atmosphere. The heat losses are the sum of the heat loss by long-wave reflected radiation, plus evaporation, plus conduction, convection, heat advected into or out of the water, and heat stored in the water.

The reflected radiation admits the application of Stephan's law. For evaporation there are a number of empirical equations based on Dalton's expressions. Significant heat losses and evaporation from the surface of the water can be related by a fixed constant called Bowen's ratio.

As the difference between heat advented in the natural lake and in the artificially heated lake is negligible – the same being true for the differences in heat stored – it was possible to write the heat balance equation of the lake in terms only of temperature and wind speed. From this equation, the equilibrium water temperature appropriate to a given power station heat rejection can be calculated, provided the natural water temperature and wind velocity for the period are known, together with the area of water surface used for cooling.
In a flow-through lake there is a continuous decrease of temperature across the lake from the station to inlet, and an equation was stablished to find the rate at which the temperature falls along the lake surface for each increment of area.

A reservoir will behave as a flow-through cooling pond if the water is canalised or allowed to pass through a series of ponds before reaching the intake.

At this stage of the studies, systematic measurements of the lake temperature were already available in various places at the surface and at various depths, in addition to the usual climatological measurements. It was found that the maximum monthly average, which was 25°C, occurred in February and that the temperature at a depth of 15 m did not exceed 23°C.

On the basis of all the data the following hypotheses were established:

(a) From an ecological point of view no appreciable area of the lake would suffer an increase in temperature. The temperature would not exceed 30°C;
(b) The natural surface temperature is 23°C.
(c) The temperature rise across the condenser would be 7°C.

According to these hypotheses, the intake temperature must not exceed 23°C.
In view of this and in the light of the analysis of the measurements mentioned, it was established that the water intake should always be from a depth of more than 15 m below the surface of the lake, where there is a vertical temperature difference of 3°C.
On rare occassions the natural surface temperature could reach 27°C. In these conditions vertical temperature stratification will be most pronounced and at 15 m deep, the temperature is not likely to exceed 23°C.

However, the process of extracting cold water from deep areas of the lake and discharging warm water into the surface might lead to a general heating up of the whole mass of water. That factor could be an important one if no cold water were supplied by the affluent rivers, but the volume entering the lake is particularly large during the summer, so that such an eventuality may be discounted.

A whole series of studies were conducted in which variants were taken into account, such as a possible substantial fall in the lake water level, an assumed water intake from the surface, etc.

On completion of all the theoretical and experimental studies the conclusion was reached that the dissipation capacity of the lake surface is 1 MW per hectare, which was the rule of thumb adopted at the outset.

Although the conclusions set out here seem to guarantee that there will be no serious consequences, it cannot be denied that the thermal releases will have some effect, even if not a significant one on the ecology of the area. However, it should be remembered that all human activity has some impact on ecological equilibrium. Indeed, the very construction of an artificial lake doubtless had a much greater impact on the ecology of the region than that anticipated from the heat releases.

The studies are continuing in all spheres — in particular the seismological and limnological studies aimed at obtaining a thorough knowledge of the lake, its ecology and biota.

Forthcoming Conferences

Date	Subject	Place
5-9 February	Symposium on Principles and Standards of Reactor Safety	Jülich Germany, F.R.
12-16 March	Symposium on the Applications of Nuclear Data in Science and Technology	Paris
26-30 March	Symposium on New Developments in Radiopharmaceuticals and Labelled Compounds	Copenhagen
14-18 May	IAEA/NEA/WHO Symposium on Environmental Behaviour of Radionuclides Released in the Nuclear Industry	Aix-en-Provence France