nuclear power and the environment

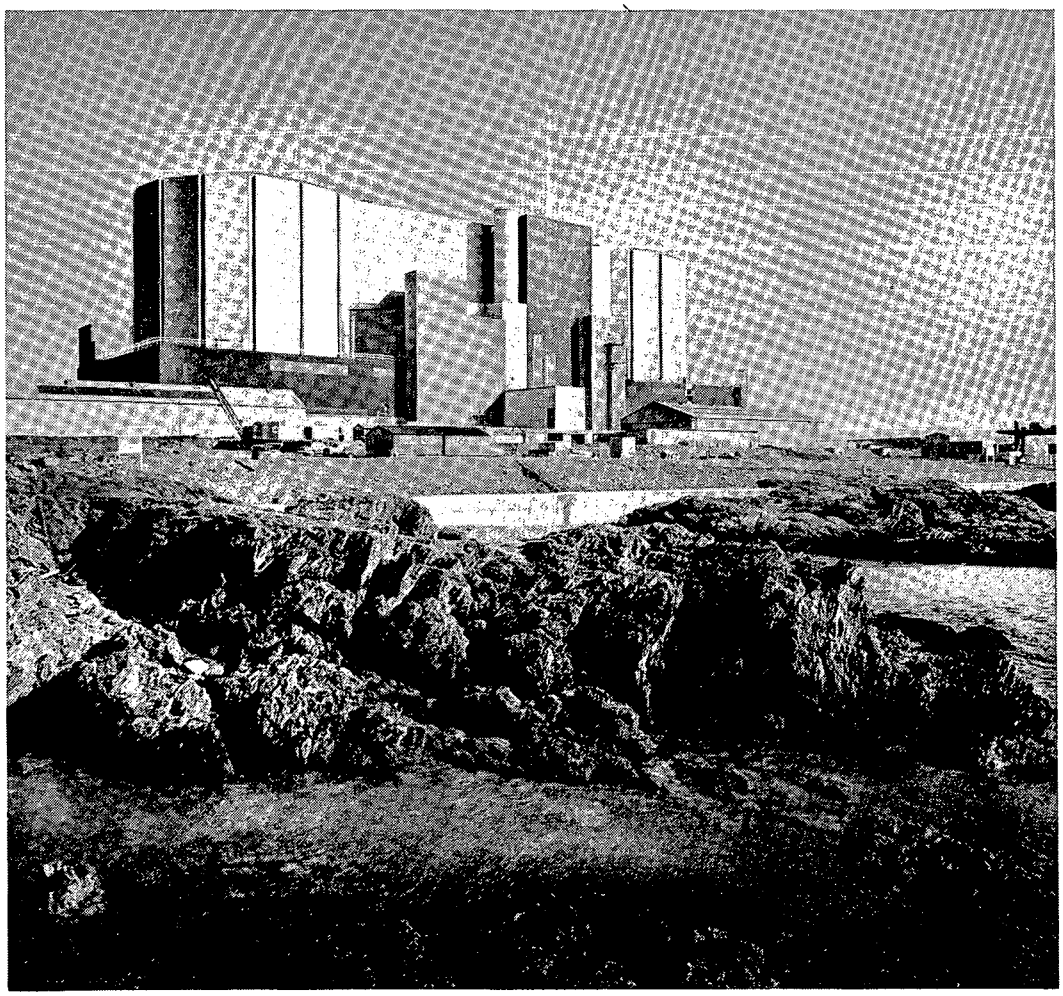
One of the most important points of agreement arising from international studies of nuclear energy is that no significant change to the environment has occurred as a result of operating power plants. This emerged from the Agency's symposium at United Nations headquarters during August on Environmental Aspects of Nuclear Power.

It was appropriate that the Agency's first big meeting to examine the environmental effects of nuclear power should have been in the United States and at the headquarters of the United Nations. The US Atomic Energy Commission, which helped in the arrangements, is subject to strict governmental and state safety controls; the United Nations has given the Agency a mandate to ensure health and safety in its nuclear activities; and the governments of countries from which there were participants all exercise their own controls.

In view of all these considerations and of exhaustive research in many parts of the world designed to examine the possible hazards, an impressive unanimity of views was seen. These emphasized that from its earliest days nuclear energy has been subjected to rigorous control; that as a result of the research carried out for safety reasons an immense amount of knowledge has accumulated on many environmental problems; that the radioactivity released to the environment from nuclear power plants as compared with that arising from natural sources has been negligible and often undetectable (i.e. that waste releases have been far below the permissible quantities); and that the sources of nuclear fuel will, particularly when breeder reactors become operational, enable power to be generated for centuries — perhaps for thousands of years — and will help to reduce wastage of other forms of fuel.

View of a panel of experts in the United Nations building, New York,
during the symposium on Environmental Effects of Nuclear Power Stations. Photo: United Nations/Nagata jr.

"No industry has shown such a preventive approach to pollution control". A 1,180 MW(e) nuclear power station nearing completion. Photo: UKAEA



At the opening of the symposium Professor Ivan Zheludev, the Agency's Deputy Director General responsible for Technical Operations, spoke on behalf of the Director General, Dr. Sigvard Eklund.

"No industry has shown such a preventive approach to pollution control as has the nuclear industry", said Professor Zheludev. He pointed out that 90 power reactors in 14 of the Agency's Member States had already accumulated 700 reactor years of operating experience with a remarkable record of safety.

"We in the IAEA", he said, "have observed a growing public awareness in maintaining the quality of the environment in which we live. It is with satisfaction that we can point to a strong continuing Agency programme on matters of health and safety and on the management of wastes in the peaceful application of nuclear energy."

Internationally-approved health and safety rules drawn up by the IAEA covered almost every type of activity in which nuclear energy was used for peaceful work. They had been prepared with the help of numerous other agencies of the United Nations and of expert bodies.

Symposia and meetings of experts were being held on many aspects of the subject and 41 research contracts were currently in operation dealing with radiation protection, accident dosimetry, marine radioactivity and low and intermediate level radioactive wastes management. In the present symposium, they planned to discuss all aspects of power station site selection, to review available experience in power plant siting and to outline standards for the control of effluents and methods of their control, and the monitoring of the environment.

Dr. Glenn T. Seaborg, Chairman of the US Atomic Energy Commission, in pointing to the recent air pollution levels and shortage of electric power on the eastern seaboard of the United States, said: "Those of us who for years have anticipated rising power demands and pointed out the advantages of smokeless nuclear electrical power generating stations could not help being distressed by these foreseeable events. That this could occur underscores the urgent need to acquaint the public with its energy choices and the relative risks and consequences of each. Obviously, it would be a gross over simplification to imply that nuclear power is a panacea — a perfect solution to all of our problems. The question of energy choice needs to be considered in the context of the global nature of the environmental problem."

He added that this symposium, recognising the global nature of our environmental problem, brings together two of the essential resources for its therapy — science and international co-operation.

Speaking optimistically about our ability to reverse the growing pollution problem, Mr. Seaborg said: "The tremendous world-wide concerns about environmental matters are certain to cause significant changes in our technological approaches to energy problems. Looking well into the future one can imagine world-wide power transmission networks which will take full advantage of time zone differences and seasonal diversities to equalize the overall global daily demand for electricity... For example, it may be possible to convert large amounts of electrical power into light with a laser beam, transmit this light between continents by satellite and then reconvert the energy to electricity."

Forecasts for the near future made by Bernard I. Spinrad of IAEA, were that by 1980 about one-sixth of the world's electricity production would come from nuclear energy and by the year 2000 the proportion would be more than 60 per cent. In terms of installed nuclear capacity the figure for 1980 would be about 350 000 megawatts and in 2000 about 4 300 000 megawatts. He believed that nuclear power would dominate the market for new power plants in advanced countries by 1980 and almost every where else by 1990.

World Fuel Reserves

M. King Hubbert, of the US Geological Survey, estimated that 1.7 per cent of the world's total reserves of coal and lignite, and about 8.7 per cent of the crude oil reserves have so far been used. Only nuclear power was of large enough magnitude to meet the world's power requirements for more than a few centuries and then only through the development of breeder reactors.

T. J. Thompson, Commissioner of the United States Atomic Energy Commission, said that all efforts would be made to reduce environmental effects, "but we know that the present technology is a sound and viable one which can be utilized with confidence in the best interests of the public". The fact that the US nuclear power industry was committed to a total investment of almost $60 billion over the next 30 years made it clear that the nuclear power industry is becoming an important factor in the nation's economy.

Support for the near-future estimates was given in figures presented by T. Ipponmatsu of Japan, who said the position in his country as far as public acceptance was concerned was satisfactory.

In discussing standards for the control of effluents from nuclear plants, Professor E. E. Pochin, M.D., of the Medical Research Council, London, said that no valid assessment could be made of the adequacy of radiation protection measures without some assessment of the risk, or the maximum likely risk, that is entailed in any given radiation exposure. International Commission for Radiation Protection (ICRP) recommendations on public exposure were that permissible population exposure should not exceed a dose of 1 rem per person per 30 years. Within this framework, however, an attempt was being made, having due regard for cost, to reduce the dose far below this level.

Observing that the basic standards of exposure are not usually capable of direct application, A.Preston of the Ministry of Agriculture, Fisheries and Food, United Kingdom, said that final authorizations for waste disposal were subject to absolute safety limitations as well as being related to justifiable operational needs.

L. Rogers, US Atomic Energy Commission, describing the basic considerations followed in translating into regulatory limits the radiation protection guides recommended by the Federal Radiation Council (FRC). asserted that operating experience showed that radioactivity in water and effluents from nuclear power reactors had generally been less than a few per cent of the limits specified in the Atomic Energy Commissions's regulations; exposures to the public in the immediate vicinity of operating power reactors had similarly been small fractions of FRC guides.

P. Candés, Centre d'études nucléaires, Saclay, described the control of radioactive effluents for the fast neutron reactors developed in France, concluding that the arrangements made ensured that radiation levels would remain well below those established by the European Communities and gave confidence that the consequences of an accident would not be harmful to local populations.

P. Courvoisier, Federal Office of Energy, Switzerland, reported on an extensive study to ascertain permissible limits in using river water for direct cooling of the first group of nuclear power stations being constructed and operated in Switzerland. The primary result was the demonstrated need to set up careful planning for the disposal of heat into the rivers.

D. I. Mount of the National Water Quality Laboratory, USA, described the approach adopted in the United States to face the problem of thermal effects and to trace the effects of waste heat on the environment. Public concern was justified by the fact that temperature remains a primary regulating factor in all chemical and biological processes occurring in water. Standards established should specify as completely as possible the acceptable conditions in the receiving body of water, so serving as a planning guide for both the water user and the regulatory agency.

Controlling Radioactive Effluents

In a session dealing with criteria for the control of radioactive effluents from nuclear power plants, D. S. Barth, Environmental Health Service, North Carolina, USA, reviewed the provisions of the Clean Air Act and anticipated that, by 1975, all area pollutants known to be hazardous at existing or predicted ambient concentrations would be similarly controlled.

The desirability of uniformity was stressed by K. Z. Morgan, Oak Ridge National Laboratory, United States. He said that it must be kept in mind that everything, including effluents from all power plants whether they operate with fossil fuels or nuclear energy, contained some radioactive material. The environmental debate should aim not at speculating how the levels of radioactive contamination might be reduced to zero, but on how the total contribution to the environment could be kept at a practical and reasonably safe level.

M. Hendrickson, Battelle Memorial Institute, United States, discussed the ICRP recommended method for calculating total body exposure doses from gas nuclides in the atmosphere.

Y. Tsunetoshi of the Pollution Control Center, Osaka, Japan, reported on an investigation conducted in the Osaka region of the effect of air pollution on human health. This investigation, based on the Air Pollution Control Law enacted in Japan in 1968, lasted five years and led to results of major scientific relevance.

In examining the waste control problems of an expanded nuclear power industry, J. L. Ophel, of Atomic Energy Limited, Canada, pointed to several advantages of nuclear stations over those using fossil fuel, including a lower pollution load per unit.

Methods adopted to evaluate the possible biological effects of tritium were described by V. P. Bond, of the Brookhaven National Laboratory, USA. The dose to the public of this and other isotopes released from nuclear power plants was related to the maximum permissible dose to the public from all radiation sources both now and in the future.

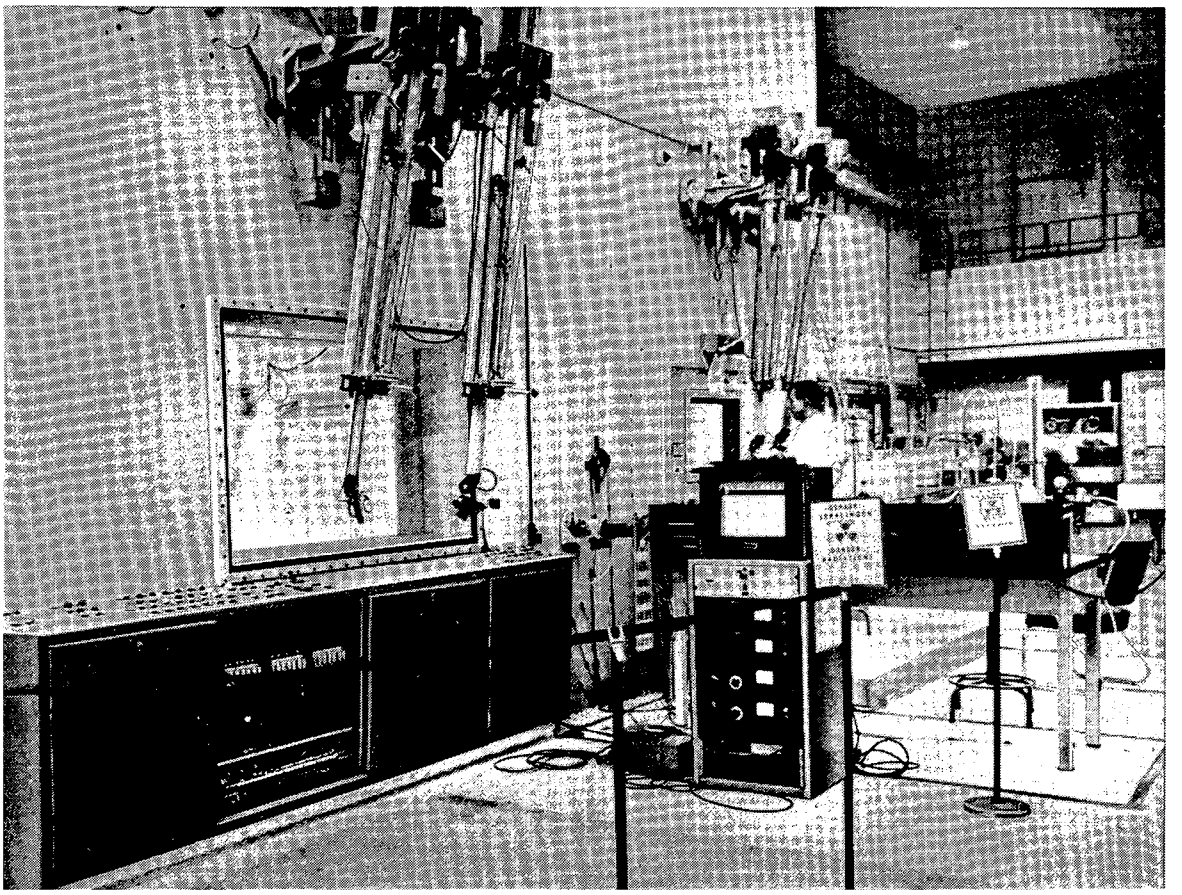
R. N. Krishnamoorthy, of the Bhabha Atomic Research Centre, India, explained methods adopted for treating all effluents before they were disposed of or dispersed to the environment, and the control of heat output from the plants.

In a comparison of nuclear and fossil power plants, J. E. Martin of the USA Public Health Service drew the conclusion that over the long term nuclear plants imposed a greater overall radiological burden on the environment, although all were well within protection guides established by the Federal Radiation Council. Older, less efficient coal-fired plants produced more radiation exposure than a pressurized water reactor, but boiling water reactors produced more than the coal plants.

More than a decade of experience with commercial boiling water reactors showed that they had achieved a high degree of compliance with the conservative design objectives, said J. H. Smith, USA. Off-plant radiation doses had been small compared to the natural background. He felt that the use of nuclear energy to generate electricity was in the real interest of improving the environment and public health.

Sheldon Meyers, of the US National Air Pollution Administration, reviewed several processes now at various stages of research and devel-

Remote control and handling of highly radioactive materials. Photo: E.N.I., Belgium



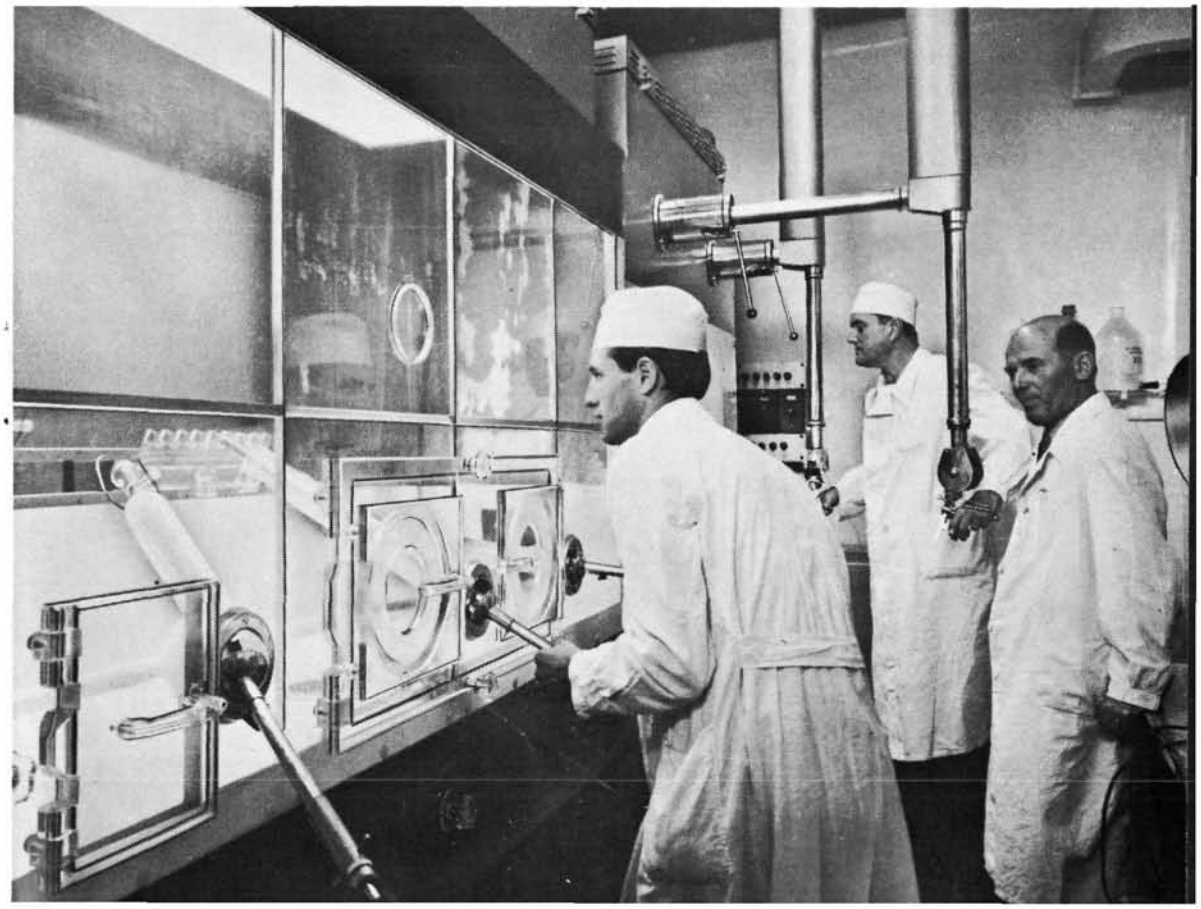
opment for controlling effluents from fossil-fuelled power plants. The effluents primarily concerned were gaseous sulphur and nitrogen oxides, solid slag ash and fly ash.

Isolated for ever

K. J. Schneider, of the Battelle Memorial Institute, USA, said that salt deposits were the most promising disposal location for highly radioactive wastes. Solidification of these wastes would soon be a requirement in USA and then the solid material could be safely transported to the salt repository, where it would be isolated for ever from the biological environment. The cost of solidifying, transporting and disposal in a salt mine was estimated to be only slightly higher than that of perpetual liquid storage.

The stages through which control was effected of environmental radioactivity were enumerated by P. Pellerin, France, Thorough site studies were necessary before a plant was built, monitoring was carried out on all types of effluent at their discharge point as well as in the air, the water and the food chain after the plant was completed. The path of critical radionuclides and populations must be established and periodical re-evaluations performed, with possible consequences of accidents always borne in mind. In all cases the public health authorities were responsible for making decisions on monitoring programmes, their method of application, and the interpretation of results.

Remote handling during production of radioisotopes, Institute of Atomic Physics, Bucharest, Romania. Photo: Institute of Atomic Physics



Clifford Beck, of the Atomic Energy Commission, detailed the various elements involved in the USA with monitoring licensed nuclear power plants. The Commission established for each plant the permitted levels of effluents and the monitoring requirements. In addition to receiving data from licensees, the Commission conducted an independent surveillance and double-checking programme. They had recently embarked on a joint programme with the States in which nuclear facilities were located, the Bureau of Radiological Health acting as an advisory participant. An important feature was the use of specially equipped aircraft capable of measuring, with a high degree of precision, the radiological profiles of ground deposits, the gaseous effluent plume pattern and the isotopic composition of ground deposits and plumes.

H. J. Dunster, of the UK Atomic Energy Authority's Health and Safety Branch, said that experience gathered in the past few years had proved that wastes from nuclear power stations had a very small impact on the environment, making it possible as a result to simplify monitoring programmes. While further simplifications might be suggested, more elaborate surveys were needed at plants reprocessing nuclear fuel.

This was supported by T. Toshioka, of the Japan Atomic Power Company. He reported that the environmental radiation monitoring programmes established for the two nuclear power stations now operating in Japan had proved that the status of environmental activity in the areas surrounding them remained unchanged after plant operation. Owing to the rapidity of nuclear power developments in Japan, however, the problem of radioactive waste disposal was likely to become a matter of serious concern in the next few years.

In order to appraise the effects of a large multi-unit plant on total environment, the Tennessee Valley Authority was planning comprehensive and integrated monitoring programmes, announced F. E. Gartrell, USA. At the Browns Ferry station now under construction in North Alabama studies were already under way to establish levels of natural and man-made radiation in air, soil, vegetation, water and aquatic life some two years before the start-up of the plant. Studies were also being made to acquire information on river temperatures, fish populations and other related aquatic organism.

According to J. B. Moore, USA, environmental factors had strongly affected both the design and siting of generating plant in the Los Angeles Air Basin. With an ever-continuing growth of population and industry, this was an area of restricted air replenishment where most of the drinking water had to be imported. Studies of thermal effects, impurity build-up and fish were being conducted at a power station where an artificial lake was used to dissipate the heat from condenser cooling water.

Discussing rivers in the Federal Republic of Germany, W. Feldt said that effective monitoring was made possible by obtaining relevant information before a nuclear power plant started to operate. The maximum radioactive burden of a river restricted the number of such stations and their release of activity.

"No drastic effects" from Yankee

The Yankee power plant on the Connecticut River began operating in 1968. A thorough study of the river had been conducted since 1965 and

had continued until the present, stated D. Merriman, of Yale University, USA. To date no drastic effects had appeared, though a strong attraction of catfish during the colder months into the canal built for routing water back to the river had been noted.

B. Kahn of the US Department of Health, said that radionuclide measurements at the Dresden nuclear power station and its environment provided the technical basis for reactor surveillance programmes in USA. The radiation exposure from discharged radionuclides was computed to be one per cent of the average annual concentration limit for air at the site boundary, and 0.1 per cent of the limit in the Illinois river at the point of discharge.

J. H. Wright, USA, said that the discharge of heated water into natural water systems had not developed any major problems yet, but continued growth in electrical power production might cause damaging environmental stresses in some areas. Environmental management would, however, permit the use of the heat dissipation capability of many bodies of water without significantly altering the natural ecosystem. Dilution, distribution and possible reconcentration of radioisotopes in the environment had been thoroughly examined ; the levels were found to be far below internationally established standards and would pose no problem to public health nor to the ecosystem.

Public participation

When siting strategy and public understanding of the problems involved were debated, James T. Ramey, Commissioner of the US Atomic Energy Commission, pointed out that ironically enough nuclear power had been widely hailed a few years ago for its potential to alleviate atmospheric pollution. There were, and should be, many ways in which the public could participate in its development and regulation. Public interest required a balancing of all the factors associated with the establishment of power plants, nuclear or otherwise, and there were sincere and genuine critics.

"Nuclear power will fulfil its promise" declared Mr. Ramey. "It is needed, and in environmental as well as economic and resource terms, it is the best hope for the world's power needs. It would be tragic if, because of a failure of public understanding, this promise were to be frustrated".

Probably the most difficult problems facing power station planners in England and Wales, said F. R. Hunt of the UK Central Electricity Generating Board, were the visual impact of large cooling towers emitting vapours, and the creation of confidence on the part of the public and the licensing authority in siting nuclear stations near to urban areas.

H. A. Maurer of the Commission of European Communities, Brussels, said that designs for nuclear plants depended to a large extent on conditions at specific sites, and it was impracticable to speak about generally applicable site criteria.

Sites satisfying all the necessary conditions were not numerous in Japan and tended to be concentrated in a few areas, said S. Miyake. Because the trend was to locate nuclear stations on the sea coast, effects on the fishing industry called for special consideration.

Contradictory factors affecting decisions on sites were referred to by P. Courvoisier, of Switzerland. On one side it was desirable to have stations close to the load centres to save transmission costs, to meet the desire to avoid spoiling the countryside with transmission lines and the wish to use spare heat for domestic purposes. On the other side was the desire to build the stations far away from population centres in order to protect them from possible harmful influences.

Comprehensive plans of the US National Air Pollution Control Administration to deal with effluents foreseen from a three-fold growth in fossil-fuelled power plants were presented by I. E. Niemeyer.

An assessment of the economic feasibility of metropolitan siting in today's climate of public understanding — or misunderstanding — of radiation risks and effects was made by N. J. Cahill, USA. For good site selection there was need for a balanced interplay between decisions of a political character and others which could be taken only on the basis of scientific judgement.

Procedure in Mexico for the selection of a site for the first nuclear power station there was reported by C. Velez of the Comisión Federal de Electricidad. In September 1969 an Agency mission visited Mexico at the request of the Comisión, toured the selected area and studied data relating to environmental conditions that might be of most importance for safety. It had made recommendations on further information to be collected.

Principles followed in siting Pakistan's first nuclear station were the prevention of environmental contamination through proper design and management, and the prevention of public contact with any released activity by maintaining adequate control. This was stated by M. Nasim of the Pakistan Atomic Energy Commission.

Thermal Effects in Water

W. L. Templeton of the Battelle Memorial Institute said that research had been carried out for 25 years on the biological effects of increased water temperatures on fish and other aquatic life in the Columbia River. All the life stages of salmon, including eggs, fry, juveniles and adults, had been studied. The review of the pertinent laboratory and field studies indicated that the heated water released from plutonium production reactors had no demonstrable effect on this fishery resource. Nevertheless, with more and more of the world's available water being used, greater emphasis would have to be given in future to the effects of total water use, of which the return of heated water from energy plants was but one.

There was no question, said D. Miller, USA, that some changes would occur from discharging heated condenser cooling water into public waters; but the biological problem was to determine the degree and extent of change and to ascertain whether the environment was significantly affected.

Studies of thermal effects were also being carried out in New York, stated T. Philbin, USA, since the increasing size of all generating stations had made this a major problem.

Switzerland depends more than most countries on river cooling for economic power generation, said P. Bøgh. In view of this a digital

Research has been carried out for 25 years on thermal and other effects in the Columbia River, USA. Part of the counting and weighing process for fish is shown here. Photo: Hanford Works, USA

simulation of thermodynamic behaviour had been prepared. If results were confirmed by further investigations, it might be possible to allow direct cooling of substantial additional nuclear plants without exceeding the limits of temperature increase.

Pollution "Not a Justifiable Word"

"With modern technology, a well-sited, well-designed power station makes so little impact on its environment, apart from the arguable aspects of aesthetics, that I do not think it justifiable to use the word pollution to describe the impact", H. J. Dunster stated in his concluding remarks as moderator of the Panel on Prospects for the Future on the final day.

Giving an assessment of the symposium he added that it contained material sufficient to convince all who were willing to listen that the impact of nuclear power generation was even less than that of conventional generation, and that nuclear power thus made a positive contribution to environmental cleanliness.

"There must and will be further improvement, but it is the consensus of the symposium that we already have sufficient knowledge of the effects which might result from the use of nuclear power to exclude surprises of a dangerous nature, in particular with regard to the possible impact on the environment. Nevertheless, continued vigilance is necessary", he stated.

The members of the Panel were unanimous in identifying siting and public acceptance of nuclear power plants as the main problems now facing atomic authorities and utilities.

T. Yoshioka, Japan, suggested that the problem of ultimate disposal of highly radio-active waste be solved at the international level and that a general guideline be elaborated for educating the general public in matters concerning nuclear power. Basic concepts should be those of benefits versus risks in modern technology and the safety aspects of nuclear power plants.

F. K. Wachsmann, Federal Republic of Germany, said that sites are being considered close to cities in his country because of the increasing trust in the safety of nuclear plants. However, he added, this meant abolishing existing site restrictions, so it had been necessary to examine whether risks could be further reducced by such things as underground or underwater construction.

James T. Ramey said there was a growing awareness and concern about the way man was applying technology. A more cautious and careful approach would be demanded by society for the introduction of new technological developments than the scientific and industrial segments had faced in the past. In addition to the engineering challenge of meeting the power needs of a nation, "we also must better inform both the decision-makers and the public of the alternatives available and the environmental impact the different courses represent, and we must minimize environmental effects regardless of which generating method is chosen".

J. F. Weinhold of the US President's Office for Science and Technology remarked that the twin requirements of adequate electric power and environmental quality were frequently conflicting goals.

"If we can develop procedures and mechanisms to facilitate resolving conflicts between power and the environment, and I believe we must do it, the future for nuclear power is indeed bright", he said.

The other members of the panel were P. Courvoisier, M. Eisenbud, and C. Velez-Ocon.

S. I. Auerbach of the Oak Ridge National Laboratory, USA, said that present knowledge of the ecological effects of low-level radiation, such as that from reactors, indicated that such effects were undetectable. Support for this conclusion was limited to date, but all information being developed consistently agreed with it.

Heated water discharges would have a major bearing on siting and design of nuclear plants.

M. Saiki of the National Institute of Radiological Sciences in Japan said the basic rule in Japan was to reduce radiation exposure. Nuclear plant sites were in agricultural and fishing districts remote from urban areas. Increasing numbers near the plants were in favour of them, but this was partly due to the economic improvements in the communities.

Harry G. Slater, USA, focussed upon the history, nature and scope of public opposition to nuclear power development in the United States, which also was spreading throughout the world. Many of these views were raised in ignorance and fear, including a basic fear of advanced technology not understood and a distrust of people who did understand it.

The experience of the 21 civilian nuclear generating stations which have operated in the United States indicated that atomic energy "involves but minimal and insignificant radiation exposure of the public", Merril Eisenbud, Professor of Environmental Medicine at New York University, and New York's former Environmental Protection Administrator, declared.

"One finds the dose to the public to be so low as to defy quantification in many instances, and one is led reluctantly to the need to draw quasi-scientific comparisons", he added.

Mr. Eisenbud also considered that environmental radio-activity should pose no limitation on the number of power stations that would be required in the decades immediately ahead.

C. Starr, University of California, declared that "technological analyses for disclosing the relationship between expected performance and monetary costs are a traditional part of all engineering planning and design".

The public appeared willing to accept "voluntary" risks roughly 1,000 times greater than "involuntary" risks. As would be expected, society's acceptance of risk increased with the benefits to be derived from an activity.

F. D. Sowby, UK, a member of the International Commission on Radiological Protection, pointed out that radiation was but one of the many risks to which society was exposed. He had attempted to see whether some patterns emerged that would indicate society's present conclusions about the level of acceptability and non-acceptability of risk.

W. Schikarski, Federal Republic of Germany, said that plants for reprocessing the nuclear fuel contributed more air pollution than reactors. Therefore, attention should be given to siting reprocessing plants and to technical improvements in controlling their effluents.