Nuclear power technical co-operation in the Republic of Korea

The country's nuclear plants now generate about half of all the electricity

by M.M. Islam, J. Fischer, and F. Calori

The Republic of Korea has an extensive nuclear programme involving power reactors, research reactors, and nuclear fuel cycle facilities. The construction of the first nuclear power plant, Korea Nuclear Unit No. 1 (also known as Kori-1) commenced early in 1970 and went into commercial operation in April 1978. At the end of 1988, the Republic of Korea had eight nuclear power plants in operation and one at the advanced stage of construction; total installed net capacity is expected to be 7180 megawatts-electric (MWe) by the end of 1989. Two more nuclear power plants of about 1000 MWe each are planned and scheduled for operation in mid-1995 and 1996. During 1988, nuclear power contributed 46.9% of the total electricity generated in the country. Such a strong nuclear power programme was made possible by a well co-ordinated organizational and industrial infrastructure. The backbone of this infra- structure is the Korea Electric Power Corporation (KEPCO) and its subsidiary, the Korea Power Engineering Company, Inc. (KOPEC). KEPCO, the sole national utility, is responsible for the construction and operation of all the nuclear power plants in the country. Scientific support in the nuclear and specialized fields has come from the Korea Advanced Energy Research Institute (KAERI). Also of high importance has been the participation of the Korean manufacturing industries. Regulatory surveillance and control is enforced by the Ministry of Science and Technology (MOST), assisted by the Nuclear Safety Centre (NSC).

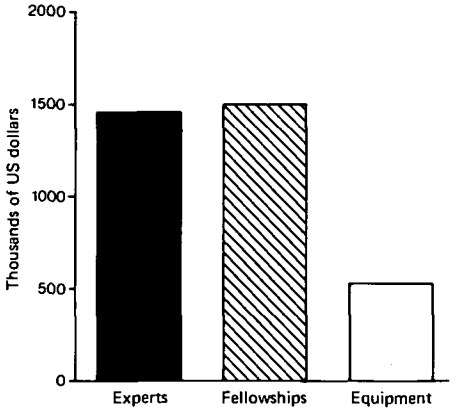
Technical co-operation trends

The Republic of Korea became an IAEA Member State in 1957 and since then it has been actively participating in the Agency's technical co-operation programme. However, in view of the extensive nuclear power programme, it was natural that during the last 10 years the Agency's technical co-operation was oriented towards the areas of nuclear engineering and safety. During the 8-year period from 1981–88, the total volume of technical assistance provided to the country amounted to over US $5.382 million, of which US $3.480 million (65%) went to nuclear engineering and safety-related projects. From this US $3.480 million, US $1.459 million (42%) was utilized for expert services, US $1.495 million (43%) for fellowship training, and only US $0.526 million (15%) for the supply of equipment. *(See accompanying figure).* These figures, however, do not include cost-free experts provided by some donor countries.

In addition to the above, an amount of over US $0.700 million, constituting about 90% of technical assistance to be provided to the Republic of Korea, is available for implementation during 1989 in the fields of nuclear engineering and safety. (This figure does not include a project in the field of agriculture supported by the United Nations Development Programme.)

As evident from the above, the scope of technical assistance the Agency provided to the Republic of Korea within the last 8–10 years is closely related to the country's nuclear power programme and the internal structure and organization of the nuclear community in the country. The most striking feature of the assistance programme is the distribution of recipients. From a financial point of view, the group of people who

Overview of IAEA technical assistance to the Republic of Korea, 1981–88



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represent the largest part of the nuclear programme are affiliated with KEPCO, the national utility. Over 90% of the Agency's assistance, however, went to national organizations other than KEPCO. This is not meant as a critical remark, but rather as an indication of where the help was needed: the regulatory body and its technical support organizations KAERI and NSC. KEPCO, on the other hand, had sufficient financial resources to acquire outside help if needed, and the general plan to increase the national contribution in design and delivery of hardware to the construction of nuclear power installations put enough pressure on the management to enable its staff to get the "know-how" in time.

On the other hand, the regulatory body had to live with a very limited budget and the understanding grew only slowly in the Government that such a huge ambitious nuclear programme requires a strong independent counterpart on the regulatory side. The first step to give the small regulatory organization some freedom and technical support was the creation of the NSC in 1982 as part of KAERI. Thus, the Agency's support went essentially to KAERI with a limited discrimination between fundamental research, applied research, safety assessment, and regulatory inspection. Over the years, the scope of the Agency's technical assistance increasingly shifted its emphasis to specific subjects of regulatory activity and an attempt was made to concentrate on types of assistance which were less easy to acquire on a commercial basis.

Especially at the beginning, the fast growing programme in the Republic of Korea required all possible input of know-how, particularly on the regulatory side to compensate for the obvious imbalance towards the strong self-confident utility work force. This was also the reason for not enthusiastically following some requests for assistance from KAERI as it was taking over more and more of the commercially-oriented work in design and manufacture.

A typical outcome of this trend was to limit equipment supplies by the Agency, and since 1985, very little equipment has been provided for projects related to nuclear engineering and safety. Meanwhile, KAERI experts were themselves much better suited to buy exactly the equipment they needed and which best fit the laboratory installation already available.

To ensure efficiency and proper placement of Agency assistance, Agency staff and other experts conducted regular monitoring visits to the country's recipient organizations. In 1985, a 3-week mission, including two outside experts, was performed that analysed and evaluated with national counterparts each individual project of the past 5 years. While the mission confirmed the general picture of the usefulness and appropriateness of Agency technical assistance, it also became obvious that the lengthy and complicated procedure of accepting original requests and the recruiting of experts thereafter often did not match the country's expeditious development. Improvements in direct communication with counterparts in the Republic of Korea has helped to make last-minute adjustments to changing conditions easier.

From time to time, the Agency has given due consideration on an urgent basis to some specific requests from the Government. The following is an example: The Republic of Korea is now planning for the construction of two pressurized-water reactors (each with 2825 megawatts-thermal power output) supplied by Combustion Engineering, Inc., USA at Yeonggwang. At this site, two Westinghouse units are already stationed. For the planned units, the Government has requested the Agency to provide 5 man-months of expert services to review the preliminary safety analysis report (PSAR) prepared by NSC. The objective is to confirm that the design of the planned units meets the currently applicable safety requirements (including applicable codes and standards stipulated in the safety regulations) and to confirm that all safety provisions are adequately incorporated into the design and will be properly implemented during construction. Accordingly, five outside experts and one Agency staff member will carry out the review mission in 1989.

Manpower development

About 85% of the IAEA's technical assistance to the Republic of Korea has been devoted to the development of manpower and transfer of technical know-how. There are different ways of doing this, including training courses, on-the-job training, and fellowships abroad. The most important subject areas for which one or more IAEA experts have visited the Republic of Korea to give advice are site selection and review; safety review and analysis; commissioning and in-service inspection; emergency planning and health physics; waste management; fuel development; and quality assurance. In order to give some idea about the expertise provided, two areas may be looked at more closely.

Safety review and analysis. In 1980, system or procedure modifications following the accident at Three Mile Island (TMI) in the USA were carefully studied and an expert from the US Nuclear Regulatory Commission went to the Republic of Korea to interpret the USA's TMI Action Plan and to help to implement it for the nuclear power plants already operating or under construction in the Republic of Korea. Similarly, a French expert explained a few years later the modifications introduced to the French plants under construction at that time. He also assisted in several missions to evaluate the French safety analysis report.

One outcome of TMI was the critical review of man-machine interaction provisions, in particular the layout and display design in the control room. Two missions of an expert from the USA analysed the control rooms of the existing plants and gave concrete advice on how to change the configuration to improve the information shown on the control room panels. Since the KAERI/NSC experts had adopted in the meantime standard computer programs mainly from the USA, several missions between 1986 and 1988 took place to discuss in detail the thermohydraulic-neutronic programs and safety analysis problems. They served to update KAERI analysts of recent code developments and input preparation or result evaluation.

In the last few years, KAERI and NSC also have developed a considerable capability in the use of probabilistic safety analysis (PSA) methods. Practical problems of component reliability data acquisition and system modelling have been discussed with several experts. A special problem to the operational reactor at Wolsong is the failure mechanism analysis and prediction of consequences of the pressure-tube failure experienced in Pickering. Expert missions to the Republic of Korea and fellowships in Canada have increased the Korean ability to handle these problems.

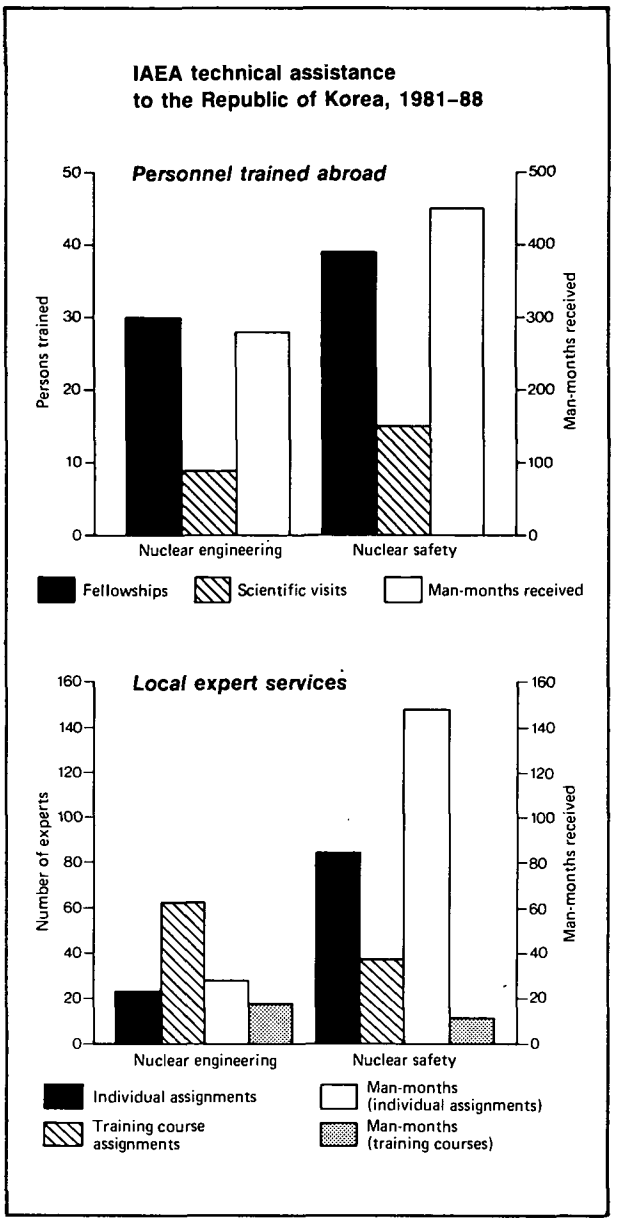
Commissioning and in-service inspections. Another area in which considerable expert services have been provided has been the commissioning and operation of nuclear power plants. Because more PWRs are in operation or planning than any other types, the number of experts in the Republic of Korea familiar with PWR systems was and probably is much larger than for the single reactor at Wolsong. Over a number of years (1982–85), several resident engineers from the Canadian regulatory body assisted the corresponding division of the Republic of Korea's Ministry of Science and Technology to train local inspectors on-the-job in Wolsong. They also served as a communication link between the Korean and Canadian licensing authorities and conveyed the newest developments in licensing and operational surveillance of reactors. As early as 1983, an IAEA Operational Safety Review Team (OSART) mission took place at Wolsong providing the plant operators and the management with practical operational experience on an international basis. Another OSART mission to the same plant is scheduled in 1989.

With the increasing share of Korean industry involved in the construction of new reactors, the share of the licensing body in surveillance of construction and commissioning has increased. In addition, the latest plants at Ulchin are of French design and not all procedures and practices from the previous US designs could be transferred. A number of US, Swedish, and French experts, therefore, have assisted in the preparation of procedures and the conduct of commissioning tests within the last few years.

Training opportunities

Fellowships and scientific visits. About 43% of the Agency's technical assistance in the field of nuclear engineering and safety has been used for fellowship training of Korean personnel abroad. From 1981–88, a total of 93 individuals were trained abroad in the fields of nuclear engineering and nuclear safety, under the IAEA's fellowship programme and as scientific visitors. *(See accompanying graph.)*

Expert assignments. The task of training the Korean scientists and engineers locally rested with the provision of experts, both long-term and short-term. While long-term experts were assigned for durations ranging from 1 to 12 months, short-term experts were mainly assigned for conducting training courses and workshops where a large number of Korean scientists and engineers from the management and the utility participated. *(See accompanying graph.)*



Training courses. To address the need for training as many Korean scientists/engineers as possible within a short time, due emphasis has been given to local training courses and workshops. A Committee on Manpower Development was formed within the Korean Electric Power Group to co-ordinate local training activities. The Republic of Korea has excellent facilities at KAERI and Kori training centres and the experience and resources to provide good training opportunities. However, the Agency has provided assistance regarding the overall management framework for systematically identifying training needs in all relevant organizations, and for co-ordinating training programmes to optimize the use of established training facilities.

At the request of the Government, two IAEA experts evaluated the training policy of the Korea Electric Power Corporation as well as the training programme, staff, and materials at the nuclear training centre at the Kori nuclear power plant site in 1983. Their recommendations considered organization and structure, in addition to aspects referred to above, so that the development of

manpower would be appropriate for the country's expanding nuclear power programme. Subsequently, three national training courses were successfully organized during 1985 on management of pre-project activities; nuclear power project management tools and methods; and maintenance of nuclear power plants. Twenty-one Agency experts were involved and 125 individuals from national organizations received training.

Also in 1983, a training course to which 12 IAEA experts contributed was organized on different aspects of quality assurance relevant to the design and commissioning of a nuclear power plant.

In 1987, an IAEA advisory mission visited KAERI at the request of the Government. This mission, involving four Agency experts, reviewed KAERI's training activities to assess the training programme which would best meet the objectives of the Korean Manpower Development Programme. In particular, the mission was requested to propose actions by Korean authorities to promote overall co-ordination between KAERI and other national organizations to achieve a more effective use of the KAERI training centre.

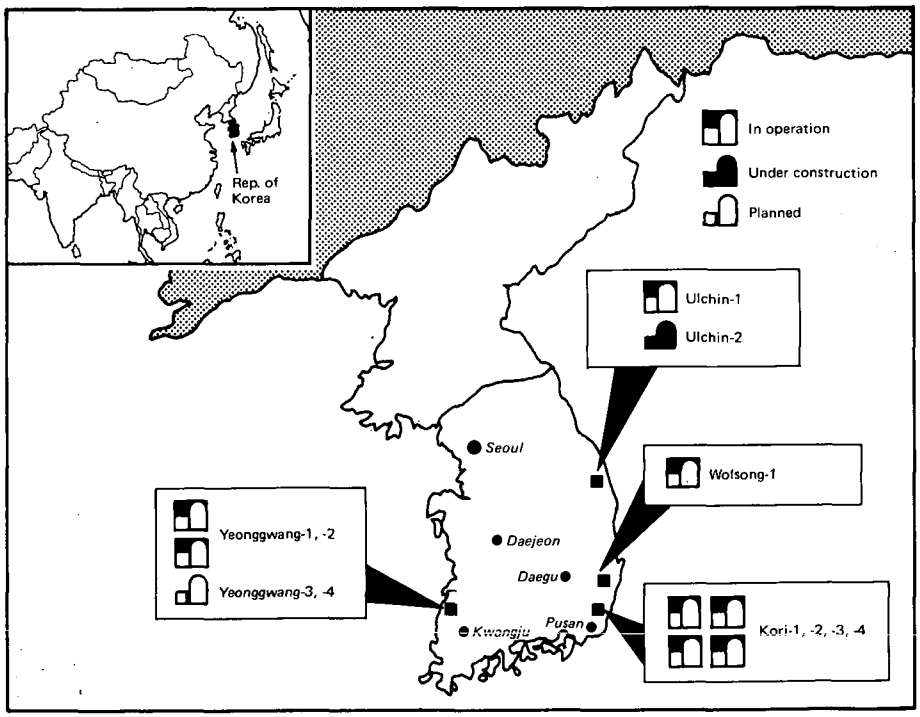
The rapid growth of the Korean nuclear power programme has created the need for qualified manpower in all fields of nuclear technology. In particular, to consolidate local expertise and capability in designing and architect-engineering, a training course on stress analysis was held in KAERI in October 1987. The Agency contacted several architect-engineering companies and finally contracted the support of the Division of Educational Programmes of the Argonne National Laboratory, USA, to organize and run the course.

With nuclear power providing about 50% of the overall electricity generated in the Republic of Korea, the need to operate nuclear power plants in load-following-mode became apparent. Thus, a seminar on load-following technology of power reactors was organized and held in KAERI in October 1988. Experts from vendors and electric utilities in France, Canada, and the USA were assigned to this seminar. Sixty-two participants, mainly from KEPCO and KAERI, were trained.

To ensure the competence of the operation personnel, a seminar on nuclear power plant operator training has been planned for 1989 to be implemented with extra-budgetary resources from the USA. The seminar will focus on the experience, costs, and benefits associated with the certification and accreditation of the utility training programmes in operation and maintenance of nuclear power plants.

The Republic of Korea has now reached the stage where it can also make a valuable contribution to training in nuclear power technology through the IAEA by sharing their remarkable experience and success in integrating this technology into their country. In this respect, a training course on nuclear power project planning and implementation was organized by the Government within the framework of the IAEA's Regional Co-operative Agreement for Asia and Pacific. The course was held at KAERI in November 1988 and attended by 15 participants from 12 countries.

Nuclear electricity plants in the Republic of Korea



At the end of 1988, eight nuclear plants were in operation in the Republic of Korea and one at Ulchin was in an advanced stage of construction. All but one are pressurized-water reactors (PWRs); the one at Wolsong is a pressurized heavy-water reactor (Candu). Two PWRs are planned for operation in the mid-1990s at Yeonggwang.

Adapted from *Nuclear Engineering International*. Plant status based on reports to IAEA PRIS.