Nuclear Power in Developing Countries: The Transfer of Regulatory Capability

by M. Rosen

By 1985, 17 developing countries will each have at least one nuclear power plant in operation The natural desire of these countries to acquire some capability in the implementation of nuclear power projects, requires that special emphasis be given to programmes for the transfer of industrial technology. This, however, can detract attention from a vital area of technology transfer – the establishment and operation of a competent regulatory body. If more emphasis were placed on the safety and regulatory aspects by the exporters, this would assist responsible government officials in recognizing the importance of a regulatory organization's role in coping with the unreviewed aspects of the imported nuclear facility and the unique safety issues involved.

Numerous means of obtaining assistance and a transfer of regulatory capability are available. What is necessary is an awareness of the need, and an intensification of efforts to promote the establishment of a competent nuclear regulatory authority in all nations having nuclear power programmes. The development of definitive and co-ordinated plans by the importers and their governments as well as by the exporters and their governments to upgrade safety programmes in developing countries can be accomplished with the co-operation and assistance of the IAEA.

BACKGROUND

There are presently 7 developing countries operating nuclear power plants whose combined output is 4000 MWe. By 1985 this will increase to 17 countries and 54 power reactors with a combined output of 30 000 MWe. In addition, at least another 7 countries are presently involved in active feasibility studies or bidding (see Table 1). There are many ways in which requirements for nuclear power programmes in the developing countries differ from those in industrialized countries. Some of these were highlighted recently in the International Symposium on Problems Associated with the Export of Nuclear Power Plants held by the International Atomic Energy Agency, Vienna, on 6–10 March 1978 Ref. [1]. Two recurring themes dominated the papers and discussions: the need for transfer of industrial technology, and the vital importance of an effective regulatory organization.

Dr Rosen is a staff member of the Nuclear Safety Section, Division of Nuclear Safety and Environmental Protection, IAEA

Table 1: Reactor Units and Nuclear Electric Capacity (MWe) in Developing Countries

Country*	Operating in 1978	Planned for Operation by 1985
Argentina	1(345)	2(945)
Bulgaria	3(1260)	4(1680)
Brazil	—	3(3115)
Czechoslovakia	2(490)	9(2970)
Cuba	—	2(880)
Hungary	—	3(1225)
India	3(600)	8(1690)
Iran	—	6(6580)
Korea, Rep. of	1(560)	4(2700)
Mexico	—	2(1310)
Philippines	—	1(620)
Pakistan	1(125)	1(125)
Poland	—	1(410)
Romania	—	1(440)
Taiwan	1(600)	5(4000)
Turkey	—	1(620)
Yugoslavia	—	1(630)
Total	12(3980)	54(29 940)

* Some additional countries involved in feasibility studies or bidding Bangladesh, Chile, Egypt, Greece, Indonesia, Libya and Thailand.

The requirement for a transfer of technology arises from a clear trend of increasing national capabilities in the construction and implementation of nuclear power projects with a corresponding increase in the domestic contributions of manpower, equipment, materials and engineering. The benefits of using domestic resources are well known and because of its importance many government ministries and agencies will be involved, with the goal of maximal participation of local industry as soon as possible. Provisions for industrial technology transfer may then be incorporated into detailed bilateral agreements and into the nuclear project contract itself.

The need for a regulatory organization and a safety review is tacitly recognized. This is shown by use of the reference plant concept and the requirement that licensability be demonstrated. Both these items are normally incorporated into project contracts. The importing governments will usually set up some type of regulatory organization with authority to carry out licensing functions. However, the benefits of competent regulation are not as obvious as the economic benefits derived from industrial technology transfer. In many cases then, insufficient consideration is given to the requirement for a highly competent body and for the necessary transfer of regulatory capability from the exporter

during the initial years, the period in which staffing and training plans must originate. This is especially significant in view of the fact that developing countries embarking on nuclear power programmes can lack the technical and managerial experience and expertise required to establish and staff an indigenous nuclear safety organization.

This article briefly reviews the essential features of a regulatory body for nuclear power in a developing country and then presents some of the available means for achieving a transfer of regulatory capability. A developing country obviously enters the nuclear power market lacking a well established regulatory capability. However, if it were convinced of the necessity and importance of this function, such a country generally would take advantage of co-ordinated and timely advice and assistance to increase the level of its regulatory competence and thus augment the level of safety. The ultimate responsibility for the safety of a nuclear power plant is with the importing country and it cannot be assigned.

REGULATORY BODY

The IAEA has recently published a Safety Code of Practice on Governmental Organization for the Regulation of Nuclear Power Plants which includes the statement "It is regarded as essential that the government of a Member State embarking on or implementing a nuclear power programme establish a regulatory body". Ref.[2]. Obviously in a developing country this regulatory body need not have a staff of the size or with the range of technical disciplines of its counterpart in the exporting country. It must, however, in spite of its relatively small size, possess sufficient competence and resources, with the aid of consultants and technical assistance, to cope with aspects of the imported plant which have not been reviewed in the supplier's country (such as those due to non-standard features that may arise from site-related factors and the continuous evolution of technology and safety requirements). Particularly, it must be able to deal with the somewhat more difficult aspects of supply, construction and operation in a developing country Refs [3, 4].

The Safety Code of Practice points out that it is necessary to start planning for the regulatory body well in advance of the construction of the first nuclear plant. At the outset, the staff could consist of as few as 6 to 8 individuals possessing broad technical expertise. However, the experience of IAEA Member States has shown that with an ongoing nuclear programme, even when extensive use of consultants is planned, a full-time regulatory staff of around 50 professionals may be the minimum for a country planning to license and operate 5 to 7 power reactors of the same type. Recognizing that the exact structure of the regulatory body will depend on many factors such as the constitutional and legal framework of a particular country, the code does not recommend any specific organization. Nonetheless, the major regulatory functions suggest an organizational structure such as that shown in Figure 1. In addition to the legal and administrative staff, as the regulatory body reaches maturity, its technical staff should be well-balanced, possessing, or having ready access to the expertise listed in Table 2.

A developing country can not initially have the proper balance and quality of skills required. Therefore, consideration must be given to the availability and proper use of technical advice and assistance in the early phases of the nuclear power programme. But, more importantly, consideration must be given to using this advice and assistance as part of an overall co-ordinated programme to facilitate the necessary transfer of regulatory capability. This transfer must insure an indigenous capability during later project phases

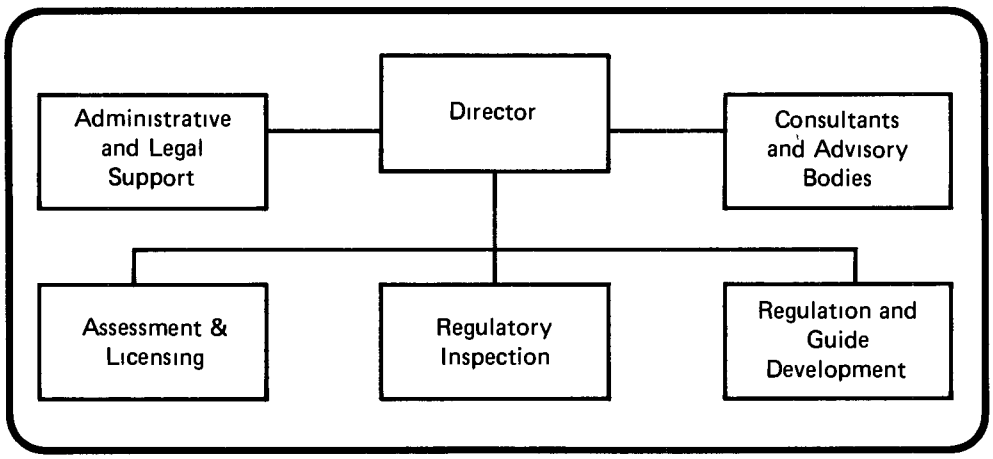

Figure 1. Organization for the Regulation of Nuclear Power Plants.

of the first plant, such as start-up and operation, and for subsequent nuclear projects Assistance will be available through the IAEA and other international organizations, from the supplier and his government, through bilateral arrangements with other countries, and domestically.

AVAILABLE SAFETY ASSISTANCE

The principal exporters and users of nuclear power plants have all established bilateral and multilateral approaches to safety co-operation and assistance to developing countries. The technical advice and assistance take many varied forms such as providing documentation,

Table 2: Expertise Required for the Regulation of Nuclear Power Plants

Chemical engineering	Metallurgy
Civil engineering	Meteorology
Computational methods	Nuclear engineering
Corrosion chemistry	Nuclear safety
Ecology	Occupational health
Electrical engineering	Public health
Fluid mechanics	Quality assurance
Geology	Reactor operation
Health physics	Reactor physics
Heat transfer	Reliability engineering
Hydrology	Seismology
Instrumentation and control	Soil mechanics
Mechanical engineering	Structural engineering

training opportunities and experts. It can be applied on an *ad hoc* basis merely to carry out some of the regulatory work load of the developing countries or it may be more systematic and help build up some indigenous regulatory capability. Some countries supply assistance, in varying amounts, on a cost-free basis while others may supply bilateral assistance through commercial organizations or commercial elements of national atomic energy agencies using formal contractual arrangements. All exporting countries co-operate in the IAEA technical assistance and other safety programmes, and participate in either the OECD or CMEA nuclear energy safety activities.

International Atomic Energy Agency Assistance

The IAEA has a number of active programmes specifically to assist its Member States with the safety and regulatory aspects of nuclear power In addition to those listed and discussed below, the Agency has since its inception been active in the radiological safety and waste management aspects of the various uses of nuclear energy. The standards, publications and training activities developed for these programmes are also relevant to nuclear power activities. The Agency's programmes relating to nuclear power safety and regulation are:

1. A programme to establish internationally accepted safety codes and guides for nuclear power plants in the areas of governmental regulatory organizations, siting, design, operation, and quality assurance (the Nuclear Safety Standards (NUSS) programme).
2. The dispatch of short-term safety assessment and advisory missions to Member States, composed of Agency and recruited experts who give advice on legal and regulatory requirements and on the many safety aspects from siting through operation of nuclear power plants.
3. A Technical Assistance Programme which can supply on request short and long-term experts in the various nuclear power safety fields, as well as fellowships, scientific visits and equipment.
4 Training courses, seminars, and publications dealing with general as well as specific technical aspects of nuclear power safety and regulation.

The Agency's safety standards programme for nuclear power plants is a relatively recent activity, begun in late 1974. It is based on documentation and experience from various national systems and practices. The Safety Codes of Practice establish the objectives and minimum requirements that should be fulfilled to provide adequate safety in the operation of nuclear power plants and the Safety Guides describe methods of implementing specific parts of the relevant Codes of Practice. A list of the more than 40 Codes and Guides issued or presently under development is presented in Reference [5].

These safety publications contain documented advice which can in many instances be used to alleviate the need for specific technical assistance from experts and can also be used for training purposes. However, although the Codes and Guides establish an essential basis for safety they sometimes may give more than one acceptable approach for the solution of a problem, and they may not in some special situations always be entirely sufficient or entirely applicable. Thus, the interpretation and use of these documents requires a thorough knowledge of the topic and sound engineering judgement, characteristics which can only be found in countries with adequately staffed regulatory bodies.

Table 3: Nuclear Power Safety Assistance to Member States (since 1975)*

Missions**				Expert Assistance	
Siting	Safety Report Review	Regulatory Body Advisory	Nuclear Legislation Advisory	Long Term***	Short Term
Argentina Chile Indonesia Kuwait Malaysia Pakistan Philippines Turkey	Brazil Iran Korea, Rep. of Philippines Yugoslavia	Brazil Chile Egypt Greece Korea, Rep. of Mexico Philippines Portugal Spain Turkey	Algeria Brazil Egypt Kuwait Malaysia Morocco Yugoslavia	Brazil Korea, Rep. of Mexico Philippines	Argentina Brazil Bulgaria Chile Greece Iran Israel Korea, Rep. of Mexico Philippines Portugal Romania Turkey Yugoslavia

* founded by various departments of the IAEA (does not include fellowships, equipment on scientific visits).
** 1 to 3 weeks duration, 1 to 5 experts.
*** one year residence or longer.

As a consequence of the increased commitment to the use of nuclear power by developing countries, the number of requests to the IAEA to dispatch short term safety assessment and advisory missions of experts has increased during the past several years and should continue to increase in the near future. This is a long established programme under which advice is given on the legal and regulatory aspects of nuclear power, on the safety aspects of site selection, and on the safety assessment of plants during construction and operation. These missions usually consist of 2 to 5 experts who are assigned for a period of 1 to 3 weeks. They are composed of one or, where possible, two Agency staff members with the remaining safety experts individually recruited for each specific assignment. The dispatch of these short term missions has provided valuable assistance to developing countries, particularly in giving guidance on how to conduct highly technical safety reviews and highlighting the potential problem areas during the initial phases of the nuclear programme when a sufficiently trained staff is not available. Table 3 contains a list of countries which have received this type of assistance since 1975.

The well known Technical Assistance Programme of the IAEA has provided safety assistance through expert services as well as in the form of fellowships for individual study and training, scientific visits, and equipment for research Expert services are provided by safety specialists, specially recruited for short or long term periods to advise on specific safety aspects of nuclear power programmes. The short-term experts are sent for periods of several weeks to several months, and the longer term resident experts have served as safety advisors to the regulatory or electric utility organization for periods exceeding one year. Table 3 also indicates the countries that have made use of these safety experts since 1975.

The IAEA in the past several years has embarked on a large nuclear power training programme directed towards the planning, construction and operational needs of developing countries This programme has included consideration of nuclear safety and regulation by having several weeks of the overview courses devoted to these subjects Ref.[6].
The Agency is presently giving attention to shorter courses that expand on selected topics in the overview courses. Table 4 contains the safety-related training courses recently completed and those planned for 1979. In addition, one and two week seminars and workshops which have been held during the past several years on legal and licensing aspects will continue [Greece (1974), Thailand (1975), Brazil (1977)], and the Agency is planning to conduct highly technical safety review courses of about one month duration in some developing countries The IAEA has recently compiled and published an international inventory of training facilities on nuclear power which contains a listing of the nuclear safety-related courses available at academic, government and private institutions of its Member States Ref.[7]

Exporter Assistance

An integral part of the exporters' safety assistance and co-operation activities is the support given to the IAEA safety programmes. This support is principally in the form of safety specialists made available from the exporting countries domestic regulatory bodies or from other commercial or non-commercial organizations familiar with safety requirements and regulations. Each of the exporting countries has in varying degree provided safety specialists to participate in the programme to develop Safety Codes of Practice and Safety

Table 4: IAEA Interregional Safety-Related Training Courses (1978–1979)

Course*	Location	Starting Date	Duration (weeks)
Nuclear Power Management Overview Course	Argonne (USA)	Feb 1978	15
	Karlsruhe (Fed. Rep. of Germany)	Sept 1978	12
	Madrid (Spain)	Sept 1978	14
	Argonne (USA)	March 1979	14
	Karlsruhe (Fed. Rep. of Germany)	Sept 1979	12
Safety Analysis Review	Argonne (USA)	Aug 1978	8
Quality Assurance	Argonne (USA)	Oct 1978	5
Siting for Nuclear Power Plants	Argonne (USA)	Sept 1979	9
Quality Assurance	Madrid (Spain)	Oct 1979	6
Safety and Reliability in Operation	Argonne (USA)	Nov 1979	6
Safety Analysis Review	Karlsruhe (Fed. Rep. of Germany)	Nov 1979	4

* About 30 participants per course.

Guides, to serve on safety assessment and advisory missions, to serve as short term experts under the Technical Assistance Programme and on long term assignments in Vienna or in developing countries. They have also hosted and provided lecturers for IAEA training courses.

The more direct bilateral type of assistance can be provided through formal contractual arrangements to supply general as well as specific safety assistance. These arrangements

are with purely commercial organizations or commercial elements of national atomic energy agencies. The Atomic Energy Organization of Iran entered into an agreement with the United Kingdom Atomic Energy Authority (the UK is not an exporter but is a major user of nuclear power), and the Reactor Safety Company in the Federal Republic of Germany has provided assistance to the licensing bodies in Brazil as well as in Iran. The agreement with the United Kingdom Atomic Energy Authority calls for expert advice to assess design evaluation provided by the nuclear plant supplier and to advise the licensing body in making decisions. One of the important assignments of the United Kingdom experts is the assessment of the Safety Analysis Report and the issuance of the Safety Evaluation Report. Based on these documents and at the discretion of the licensing authority in Iran, the relevant licenses for the nuclear power plants can then be issued. Ref.[8] Several commercial consulting companies in the exporting as well as in the major user countries of nuclear power have also supplied specific safety advice to regulatory bodies in areas such as quality assurance, inspection activities, seismic design review and the evaluation of site characteristics.

Some of the exporting countries have provided a substantial amount of cost free assistance. Examples of these are:

1. Providing safety related documents and information with or without formal governmental agreements.
2. Bilateral consultations between the regulatory staff on specific technical issues.
3. Assignment of foreign regulatory staff to positions on their own regulatory staff for short and long term periods.
4. Admission of foreign regulatory staff to short term internal training courses and presentation of these courses in foreign countries.
5. Assistance in obtaining assignments of foreign personnel to supplier, architect-engineering firms, nuclear electric utilities and research institutes for on-the-job-training (sometimes in conjunction with the IAEA fellowship programme).

This type of cost free assistance can add up to many man-years of effort each year and involve considerable expense. For example, 500 foreign nuclear officials visit the USA Nuclear Regulatory Commission each year, mostly to participate in detailed technical discussions of safety analysis work that has been done by the NRC staff. In view of the cost and manpower involved, the various exporting countries have contributed cost free assistance in varying degree.

Importer Assistance

The importing country may also have facilities for training and technical assistance through universities and governmental institutions (particularly those with inspection responsibilities) and through the construction and electric utility industries. If a nuclear research centre exists it can be the focal point for internal training programmes such as in radiological safety for both the regulatory and utility staff, provide specific consulting assistance, give support to advisory committees and safety review committees, and serve as a source of recruitment for regulatory staff. However, because of their more theoretical orientation, research centre and university personnel might act well as scientific advisors, but may not be suited for the more practical regulatory tasks.

UTILIZING ASSISTANCE

In order to use the available sources of safety advice and assistance adequately, there must first be a recognition of the need for regulatory competence and then a plan to build up a gradual but definite regulatory capability. The supplier has an important responsibility to bring about an awareness on the part of the buyer and his government of the unique demands of nuclear plants and the special safety and regulatory problems of the smaller and developing countries. This awareness can be promoted during the initial project contract stage by more candour regarding the safety and regulatory aspects of the proposed plant. The implication that the exported plant could be licensed in the supplier's country should be avoided. There are site and other factors which usually lead to significant differences between the exported facility as finally constructed and one which could be built in the supplier country, and although the project may strive to incorporate most safety standards and requirements normally used in the supplier country, this is not entirely feasible. In view of this, and since the facility will not undergo the ongoing detailed regulatory review usually performed by the supplying country's regulatory body and which usually results in specific modifications and additions, the exported plant can not be considered licensable in the supplier country as finally constructed. Removal of this myth of licensability would add emphasis to the need for technical competence and an adequate and well-trained regulatory body in the importing country.

The importing government must also recognize the need for and importance of the regulatory effort. Although sometimes the regulatory bodies (often with limited budgets) in developing countries establish training programmes, national shortages of trained manpower and the low pay scale of governmental employees results in the revolving-door pattern of attracting young and inexperienced staff who after training leave for higher paid jobs in industry. It is thus an absolute necessity to establish staffing policies which allow not only for an adequate number of staff at the appropriate level and salaries but also for enough lead time in their recruitment to permit for normal attrition and for training.

The basis of a comprehensive plan for the transfer of regulatory capability is a programme with long term objectives. It is clear that the approach to acquiring this capability will differ for the various developing countries, must be examined on a case by case basis and be flexible. Ideally this programme should be initiated during the early stages of the nuclear programme such as during site selection studies. At this time the details could be worked out with experienced regulatory experts easily obtainable through the IAEA and the initial training can draw on many of the programmes of the Agency. During the contract negotiating phase the supplier should be brought in. At this time a training programme could be drawn up in co-operation with the supplier, and perhaps the project contract itself could contain provisions for training of regulatory staff. This could include financing to allow participation of the regulatory staff in many of the specialized training programmes for utility personnel, particularly those for training of reactor operators, since knowledge of the plant and its operation is one of the more important aspects of effective regulation in developing countries.

While a review of the assistance available suggests that much attention and effort is given to the safety and regulatory areas, most of these efforts are expended, to a major extent, in an *ad hoc* fashion. The total effort could benefit from a more structured and integrated approach. The basic elements of assistance to importing countries exist from within the

IAEA, national regulatory bodies, the nuclear suppliers and associated companies. Joined with the best efforts of the developing countries, a more rapid growth in regulatory self-sufficiency can be attained.

References

[1] INTERNATIONAL ATOMIC ENERGY AGENCY (Proc Symp. on the Problems Associated with the Export of Nuclear Power Plants, Vienna, 6–10 March 1978), IAEA Proc. Series STI/PUB/488 (1978).

[2] CODE OF PRACTICE "Governmental Organization for the Regulation of Nuclear Power Plants", IAEA Safety Series 50-C-G (1978).

[3] ROSEN M., "The Critical Issue of Nuclear Power Plant Safety in Developing Countries", IAEA Bulletin, Vol 19, No 2, (1977) 12–21.

[4] ROSEN M , "Upgrading the Safety Assessment of Exported Nuclear Power Plants", IAEA Proc. Series STI/PUB/488 (1978) 27–42.

[5] IANSITI E , KONSTANTINOV L., "IAEA Safety Codes of Practice and Safety Guides for Nuclear Power Plants", IAEA Bulletin, Vol. 20, No. 5 (1978) 46–55.

[6] "NUCLEAR POWER TRAINING COURSES", IAEA Bulletin, Vol. 19, No 2 (1977) 22–30

[7] INTERNATIONAL INVENTORY OF TRAINING FACILITIES IN NUCLEAR POWER AND ITS FUEL CYCLE 1978, IAEA 217 (January 1979)

[8] BAHMANYAR H , BURKLE W , "Reference Plants, Safety Standards and Unique Safety Issues Related to the Bushehr Nuclear Power Plant in Iran", IAEA Proc. Series STI/PUB/488 (1978) 43–50.