Promotion and Financing of Nuclear Power Programmes in Developing Countries

INTERNATIONAL ATOMIC ENERGY AGENCY, VIENNA, 1987

PROMOTION AND FINANCING OF NUCLEAR POWER PROGRAMMES IN DEVELOPING COUNTRIES

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REPORT TO THE IAEA
BY A SENIOR EXPERT GROUP

INTERNATIONAL ATOMIC ENERGY AGENCY
VIENNA, 1987

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IN DEVELOPING COUNTRIES
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FOREWORD

by the Director General

One of the functions of the International Atomic Energy Agency is to assist developing Member States in their efforts to utilize nuclear power in order to meet their needs for energy, in particular electricity. Since its inception, the IAEA has worked to carry out this function. Responding to requests and needs of developing countries, the IAEA has since its inception organized many training courses, programmes in nuclear physics, projects of uranium exploration, etc. It is a fact, however, that so far only a few developing countries are using nuclear power. In some cases the non-use of nuclear power in developing countries can be explained by the availability of alternative sources of energy, such as hydro power. In many other cases insufficient trained manpower, inadequate infrastructures, economic problems and financial constraints are the reason. The fact that such constraints can be overcome is demonstrated by a number of technologically advanced developing countries which are making excellent and extensive use of nuclear energy for electricity production and have developed a broad research capacity in the nuclear field.

Against this background it has appeared timely to take a fresh look at the prospects and problems for nuclear power in developing countries, and the role of the IAEA in this regard. For this reason, I requested a group of senior experts to study the existing constraints on nuclear power development in developing countries, the requirements to be met for successful introduction of a nuclear power programme, and mechanisms to assist developing countries in overcoming the identified constraints.

This report summarizes the Senior Expert Group's study. It also presents a number of recommendations on mechanisms to assist developing countries in promoting and financing their nuclear power programmes.

I should like to thank warmly all the members of the group for their valuable contributions to this study.

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EXECUTIVE SUMMARY

GENERAL

The Director General of the International Atomic Energy Agency established in February 1986 a Senior Expert Group (SEG) on Mechanisms to Assist Developing Countries in the Promotion and Financing of Nuclear Power Programmes, which was asked:

(a) To identify and analyse the problems of and constraints on nuclear power introduction/expansion in developing countries, with particular attention being paid to the problems of financing nuclear power projects;

(b) To study mechanisms for dealing with the identified problems and constraints in order to assist developing countries with the promotion and financing of their nuclear power programmes, and to determine the role of the IAEA in this context.

The SEG participants comprised 20 experts with extensive experience in the topics to be studied, coming from 15 Member States plus the World Bank.

On the basis of a detailed analysis of information available from many existing studies, the SEG concluded that energy in all available forms will be needed to facilitate economic growth and improvements in the quality of life in the developing world, and that increasing use of electricity produced in bulk will be essential.

The electricity requirements of the developing countries can only be met through a more extensive use of conventional thermal and hydro power sources together with the introduction of nuclear power programmes in additional developing countries and increased use of nuclear power in those countries which have already introduced it.

In contrast to the proven status of nuclear power, the present technical and economic uncertainties surrounding solar power, wind power, biomass, etc., do not permit dependence on them for large scale electricity generation in the foreseeable future, although they could play a role in supplying electricity in villages and remote areas not connected to a centralized grid.

Only nuclear power with the highest practical reliability and safety standards and coal based power with suitable environmental protection standards could become significant substitutes for oil in the generation of the large amounts of electricity necessary for general socio-economic development in developing countries.

Thus, it is clear that there is a need for nuclear power in some developing countries. Experience has shown that nuclear energy generation is in many situations economically competitive with other sources of energy, and that, notwithstanding the Three Mile Island and Chernobyl accidents, nuclear power is a proven and acceptably safe technology, available for meeting growing electricity needs in both industrialized and developing countries, with minimal environmental impacts during operation.

Notwithstanding the efforts made so far, and in spite of the fact that the nuclear power option could make a very useful contribution to energy supplies in a number of developing countries, nuclear power has been introduced only to a small extent in a few of these countries. Nuclear power in developing countries today contributes only about 3% of their total electricity production, compared with about 18% for industrialized countries and a world average of 15.5%.

In order to identify the constraints that developing countries might face in the introduction and execution of a nuclear power programme, it is necessary to define the general requirements which need to be fulfilled for a successful programme. This approach is not inherently limited to developing countries, and lessons may be drawn from experiences in both industrialized and developing countries. A list of requirements was elaborated from information provided by the SEG participants and also from information from a number of additional countries about the importance attached, as a result of experience, to each requirement as a real constraint. As each country represents a unique situation, any list of general requirements results in a different definition of constraints for each country, and these may come into play at different stages of the development of the country's nuclear power programme.

Some of the constraints which have become important have a subjective background. This is particularly true in regard to acceptance by the public and, through its impact on political movements, by the government and authorities. This type of constraint could be more difficult to overcome than those which can be defined in objective technical or economic terms and for which it would be possible to formulate concrete countermeasures. The subjective side of long term energy policy and government commitment to nuclear power has now become a major concern to financing institutions, as decisions to complete and operate nuclear power plants have been changed in some cases.

On the basis of a detailed analysis of the present situation with regard to the identified requirements and constraints, it is clear that the IAEA has an important role in assisting its developing Member States to plan and execute nuclear power programmes.

The IAEA already has an extensive programme in this area, based on many years of technical co-operation activities. Nonetheless, some recommendations can be made for achieving greater effectiveness, either by strengthening existing activities or by initiating new ones. These recommendations are presented below.

RECOMMENDED ACTIONS BY THE IAEA

Energy and nuclear power planning

Over the years, the IAEA has developed a comprehensive framework of information, tools, methodologies and expertise to assist its developing Member States

in energy and nuclear power planning. These provide the necessary basis for a strengthened programme of assistance in this domain. It is recommended now that the IAEA should:

(1) *Offer an integrated package of assistance,* with training in the use of IAEA methodologies as a basic component, for studying the needs for energy, electricity and nuclear power within the overall context of economic development of a country, for analysing the economically optimized choices of energy options, and for assessing the required local infrastructures and the plans for their development. The environmental and other impacts of energy options should be included in the analysis.

(2) *Promote and facilitate regional co-operation and the exchange of information and results in relation to energy and nuclear power planning studies.* These activities could include the exchange of experience, sharing of databases and comparison and co-ordination of studies. In this connection, the work under the regional co-operation agreements (e.g. RCA[a] for Asia and the Pacific and ARCAL[b] for Latin America) can help to support nuclear power planning capabilities, as for example in the case of the RCA workshops for regional users of the IAEA's energy planning models (the Wien Automatic System Planning Package (WASP) and the Model for Analysis of Energy Demand (MAED)). Regional agreements could also be used to promote co-ordinated nuclear power and electricity supply policies from which benefits could be drawn through joint efforts in, for example, manpower development, use of available industries, and establishment of larger grids through interconnection. Efforts by organizations in regard to regional grid interconnection and integration, such as the Commission of Regional Electrical Integration (CIER) in Latin America and the Union of Producers, Conveyors and Distributors of Electric Power in Africa (UPDEA) in West Africa, should be followed as these could facilitate future nuclear power introduction. Co-ordination with the related activities of regional economic commissions (e.g. the Economic Commission for Europe (ECE), the Economic Commission for Latin America (ECLA) and the Economic and Social Commission for Asia and the Pacific (ESCAP)) and the regional development banks should be promoted.

(3) *Promote closer co-operation with the World Bank,* through joint projects where appropriate, in energy and power sector planning and project preparation studies, including technical assistance to strengthen the capabilities in this domain in the developing countries. Existing IAEA–World Bank co-operation, such as in the

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[a] RCA: Regional Co-operative Agreement for Research, Development and Training Related to Nuclear Science and Technology.

[b] ARCAL: Regional Co-operative Arrangements for the Promotion of Nuclear Science and Technology in Latin America.

United Nations Development Programme financed energy planning project for European and Arab countries, should be strengthened.

Public acceptance

The acceptability of nuclear power has become an important concern for the general public, and also for professionals and decision makers. The primary means to allay the concern that is felt is the timely provision of information, and the IAEA should take a more active role in this regard. In particular, it should:

(4) *Organize short information seminars* on the basic issues and general requirements of nuclear power programmes for political leaders, other decision makers and the specialists who help to prepare decisions in developing Member States.

(5) Increase activities to *systematically develop and make available information* concerning the questions most frequently raised in relation to public acceptance. This information could be provided to the public and used as reference material in schools and also by industry and government professionals who have to deal with questions raised by the public.

Project preparation and implementation

The preparedness and capabilities of a country, in terms of its key infrastructures, organizations and manpower, are important for the technical, economic and financial viability of nuclear power programmes and projects. It is recommended that in order to assist developing countries in these matters, the IAEA should:

(6) *Strengthen assistance and involvement in nuclear power project feasibility studies* in developing countries (including financial feasibility), with the co-operation of the World Bank where possible.

(7) *Play a stronger role in assisting developing Member States to assess infrastructures* (manpower, industrial support, ability to absorb transferred technology, etc.) and in drawing up development plans for them, building as far as possible on a country's experience with nuclear techniques and research reactors. The IAEA's manpower development assistance should be systematic and continuous, from the very early stages of nuclear research through the developing nuclear power programme, and should include assistance to strengthen and upgrade local capabilities for project management and implementation.

(8) *Encourage the development of and promote information exchange on methods for reducing costs and construction times* of nuclear power plants without compromising their safety and reliability.

(9) *Continue and strengthen support for nuclear power plant operation* in order to achieve (and to document and publicize) a 'record of excellence' for nuclear power, through the exchange of information, experience and reports on operating performance.

(10) *Continue efforts to find partners in order to implement and finance a feasibility study* for a nuclear power plant of existing design in the small and medium power reactor (SMPR) range.

(11) Strengthen and make more systematic its activities to *assist developing Member States in establishing national legislation* as a basis for radiation protection and safety standards. Assistance in establishing a regulatory organization and collaboration in safety studies in the first phases of a project would be very helpful.

Nuclear power financing

The financing of nuclear power projects involves complex issues which need to be fully understood by all the parties involved. The IAEA should initiate actions to enhance its capabilities to advise and assist its developing Member States with regard to the financing issues. In particular, it is recommended that the IAEA should:

(12) *Promote information exchange between the buyers, suppliers, financing organizations and export credit insurers* to achieve at an early stage a better understanding by all parties of the special requirements, complexities and possibilities of nuclear power financing, in particular for projects in developing countries.

(13) *Assist, in conjunction with the World Bank, in strengthening and supporting local government and utility capabilities for financial planning* (installation of appropriate tariff structures, project finance and debt management) in the electric power sector, in order to help improve the availability of financing for nuclear power.

(14) *Encourage involved Member States to review the Sector Understanding on Export Credits for Nuclear Power Plants, which is part of the OECD 'Consensus'*, with a view to improving the loan conditions for the supply of nuclear power plants.

(15) *Study and promote the exchange of information on schemes for nuclear power financing* (e.g. the build–operate–transfer model and countertrade arrangements).

(16) *Encourage other international organizations,* in particular the World Bank, *to include nuclear power among the possible options* in long term power sector planning in individual developing countries, when appropriate.

1. BACKGROUND

For more than two decades the International Atomic Energy Agency has assisted developing Member States with the introduction of nuclear power, and in the process has developed an in-house capability to advise these Member States on long term energy, electricity and nuclear power planning and on the development of the infrastructures necessary for successful nuclear power implementation.

Through these assistance activities, the IAEA has been in a position to follow the development of nuclear power programmes and projects in its developing Member States. The experience gained has been used to achieve a better definition of the problem areas in which international assistance is needed and also of the criteria for use in assessments. The following basic criteria are fundamental to the IAEA's programme planning and development assistance:

(1) Nuclear power should be considered only when it is technically feasible and when it would be part of an economically viable long term energy and electricity supply expansion strategy, considering all alternatives and relevant factors.

(2) A nuclear power programme should be launched only when it — and in particular, the first project — has a definite likelihood of being successful, i.e. it can be executed within the planned schedule and predicted financial limits and can be operated safely and reliably once in service.

(3) A nuclear power project should be finally committed only on the basis of comprehensive planning, and after steps have been taken to meet all necessary supporting infrastructure requirements, including assurance of financing.

The application of these criteria assures that decisions taken on a nuclear power programme are coherent with an overall national energy policy, and that the programme can be supported by the government.

Notwithstanding the efforts made so far, and in spite of the fact that the nuclear power option could make a very useful contribution to energy supplies in a number of developing countries, nuclear power has been introduced only to a small extent in a few of these countries.

During the IAEA General Conference in September 1985, a number of delegates urged the IAEA to initiate action designed to further assist developing countries with nuclear power planning and implementation, and in particular to undertake an examination of the problems of nuclear project financing and infrastructures. Also in September 1985, the Third Review Conference of the Parties to the Treaty on the Non-Proliferation of Nuclear Weapons made proposals along similar lines for consideration by the IAEA. In December 1985, members of the Scientific Advisory Committee expressed the view that the IAEA could play a useful role in helping to address the major problems which have to be resolved before

developing countries can benefit from nuclear power, including problems related to infrastructures, electric grids, financing and the training of personnel. Lastly, Egypt requested the inclusion of an item entitled "Initiation of an expert group study on mechanisms to assist developing countries in the promotion and financing of their nuclear power programmes" in the agenda of the February 1986 session of the IAEA Board of Governors, having made a proposal to that effect during the December 1985 session of the Board's Technical Assistance and Co-operation Committee.

The Director General proposed to the Board the convening of a Senior Expert Group (SEG) on Mechanisms to Assist Developing Countries in the Promotion and Financing of Nuclear Power Programmes. This proposal received unanimous support from the Board.

The Senior Expert Group was asked:

(a) To identify and analyse the problems of and constraints on nuclear power introduction/expansion in developing countries, with particular attention being paid to the problems of financing nuclear power projects;
(b) To study mechanisms for dealing with the identified problems and constraints in order to assist developing countries with the promotion and financing of their nuclear power programmes, and to determine the role of the IAEA in this context.

The SEG met twice in 1986 and once in 1987. The experts who participated in each meeting are listed at the end of the report.

During its first meeting (1–3 July 1986) the SEG recognized that financing represents one (but not the only) major constraint to nuclear power development in developing countries. Therefore, the SEG recommended that a subgroup on financing be established to study the following four issues:

(1) The circumstances specific to financing of nuclear power projects;
(2) The present schemes of export finance and the extent to which they are responsive to the needs of developing countries for financing nuclear power projects;
(3) Methods of improving the present export finance schemes to make them more responsive;
(4) Other methods which could be used to alleviate the problems of financing nuclear power projects.

The subgroup on financing met once in 1986 and once in 1987. The experts who participated in each meeting are listed at the end of the report.

2. THE NEED FOR ENERGY AS A BASIS FOR ECONOMIC DEVELOPMENT OF DEVELOPING COUNTRIES: THE ROLE OF NUCLEAR ENERGY

The availability of a reliable and economical energy form is one of the important prerequisites for economic and social development, as clearly demonstrated by the close relationship between energy consumption and economic growth in industrialized countries and between the persistent energy deficiency and low standard of living in many developing countries. This is confirmed by statistical data and by projections of future energy demand.

In 1985, the United States of America, with less than 5% of the world population, consumed around 25% of the total world energy production; the per capita consumption was around 320 GJ[1], compared with an average of about 200 GJ for all industrialized countries. In the same year the entire developing world, with 75% of the world population, consumed only about the same amount of energy as the USA, corresponding to an average consumption of less than 25 GJ per capita.

There is general agreement that the large disparity between developing and industrialized countries in economic development and also in energy and electricity consumption needs to be reduced, but it is recognized that this will be a gradual process for which a long term outlook is needed. According to realistic scenarios the disparity is not expected to be fully eliminated within the next fifty years.

Nevertheless, up to the year 2030, even if the per capita consumption in developing countries were to increase only to 75 GJ and the per capita consumption in industrialized countries remained constant at about 200 GJ, the worldwide requirement for energy would increase from the present 320 EJ[1] to 750 EJ by the year 2030. Some 60–65% of the world's energy production would then be needed for the approximately 6000 million inhabitants expected to be living at that time in the countries which today are classified as developing.

Energy in all available forms will be needed to facilitate economic growth and improvements in the quality of life in the developing world, and its increasing use in the form of electricity produced in bulk will be essential.

Statistical data on energy and electricity usage and socio-economic development show clearly (Fig. 1) the linear relation between growth in GDP[2] and increase

[1] 1 EJ (exajoule) = 10^9 GJ (gigajoules) = 23.9 million tonnes of oil equivalent (mtoe).

[2] Gross domestic product (GDP): the total final output of goods and services produced by an economy, i.e. by residents and non-residents, regardless of the allocation to domestic and foreign claims.

Gross national product (GNP): the total domestic and foreign output claimed by residents. It comprises gross domestic product adjusted by net factor income from abroad. Factor income comprises receipts that residents receive from abroad for factor services (labour, investment and interest) less similar payments made to non-residents abroad.

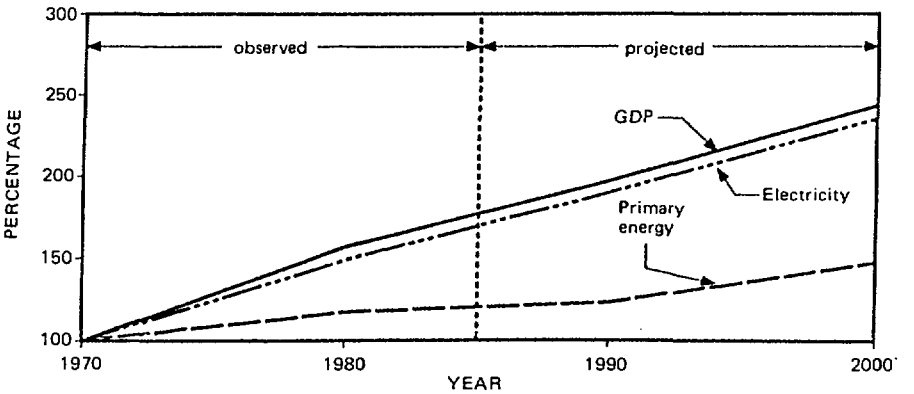

FIG. 1. Trends in gross domestic product, primary energy consumption and electricity consumption in OECD countries. Source: IAEA Energy and Economic Data Bank.

in electricity consumption. The strong connection between electricity demand and GDP was maintained even after the oil price shocks in 1973 and 1979 (although there was a significant decoupling of the relation between primary energy consumption and GDP), and this connection is likely to continue. To ensure the required economic growth in developing countries, the electricity consumption in these countries must grow at rates above those of their economic growth and total energy consumption, probably even at rates higher than those experienced in industrialized countries at similar stages of development.

On the basis of the above considerations, the total electricity generation of all developing countries is projected to increase from the present level of around 1700 TW·h[3] to around 12 500 TW·h by the year 2030. This projected electricity generation is based on an increase of the average per capita electricity consumption from the present 500 kW·h to around 1800 kW·h, compared with a present average of 7000 kW·h in industrialized countries.

The electricity requirements of the developing countries can only be met through a more extensive use of conventional thermal and hydro power sources together with the introduction of nuclear power programmes in additional developing countries and increased use of nuclear power in those countries which have already introduced it. In this context it is significant that nuclear power programmes are already under way in the ten developing countries which presently generate around 60% of the total electricity production of all developing countries. However, nuclear power in developing countries today contributes only about 3% of their total electricity production, compared with about 18% for industrialized countries.

The expanded use of nuclear power in industrialized countries could also ease the energy problem in developing countries by reducing world demand on fossil fuel

[3] 1 TW·h = 10^9 kW·h.

supplies. During 1986, nuclear power plants produced more than 1500 TW·h of electricity, or about 15.5% of the total electricity generated worldwide. To generate this amount of electricity by other means would require substantial resources — for example, 580 million tonnes of coal, which is approximately equivalent to the annual coal production of the USA; or 300 million tonnes of oil, the equivalent of Saudi Arabia's 1982 oil production. This equivalent oil requirement corresponds to a production rate of 7 million barrels per day, which is about two thirds of today's idle oil production capacity. It is clear that if these additional amounts of fossil fuels were being required for electricity generation, the upward pressures on coal and oil prices could have a significant impact, particularly on developing countries.

In contrast to the proven status of nuclear power, the present technical and economic uncertainties surrounding solar power, wind power, biomass, etc., do not permit dependence on them for large scale electricity generation in the foreseeable future, although they could play a role in supplying electricity in villages and remote areas not connected to a centralized grid.

Only nuclear power with the highest practical reliability and safety standards and coal based power with suitable environmental protection standards could become significant substitutes for oil in the generation of the large amounts of electricity necessary for general socio-economic development in developing countries. The task of energy planners is to determine the appropriate mix of the various energy sources (nuclear, coal, oil, gas, hydro and renewables) to satisfy the growing energy needs at minimum cost and with an acceptable environmental impact.

Thus, it is clear that the developing countries will require more energy, in particular electricity, and that there is a need for nuclear power in some developing countries. Experience has shown that nuclear energy generation is in many situations economically competitive with other sources of energy, and that, notwithstanding the Three Mile Island and Chernobyl accidents, nuclear power is a proven and acceptably safe technology, available for meeting growing electricity needs in both industrialized and developing countries, with minimal environmental impacts during operation.

The following sections of this report explore the key requirements which must be met in order to promote and ensure successful nuclear power programmes, and the mechanisms which could be used to assist developing countries to meet those requirements.

3. GENERAL REQUIREMENTS FOR THE INTRODUCTION AND EXECUTION OF A NUCLEAR POWER PROGRAMME

In order to identify the constraints that developing countries might face in the introduction and execution of a nuclear power programme, it is necessary to define

TABLE I. REQUIREMENTS FOR NUCLEAR POWER INTRODUCTION AND IMPLEMENTATION

A. Requirements which must be met at the national level before the introduction of nuclear power

A.1. Long term policy reasons for nuclear power

A.2. Government/national commitment to a nuclear power programme

A.3. National legislation to create the organizational and regulatory basis for radiation protection and nuclear safety, provide for enforcement of such regulations and define nuclear liability

A.4. An electric grid with adequate size and characteristics for accepting a series of units, which at the time are likely to be the largest units on the grid and should be operable at a high load factor

A.5. Acceptability of the nuclear power option from the viewpoint of:
— those who prepare and take decisions
— the public

B. Requirements which must be met for the successful implementation of a programme

B.1. Feasibility study covering the technical and economic viability of a project and the national infrastructures to support it, as a basis for the decision to be taken on the project

B.2. Qualified manpower for all activities which are either required (e.g. planning, project management, operation and regulation) or desired within the country

B.3. A general level of technical and scientific development which can effectively support the operation and maintenance of a nuclear plant, including, e.g., support in scientific and technical problem diagnosis

B.4. An industrial support structure capable of meeting the desired level of participation in project execution, operation and maintenance, and meeting specified levels of quality

B.5. An organizational structure with entities which have clearly defined tasks and responsibilities for planning, project execution, ownership and operation of the plant, and regulation

B.6. A national quality assurance/quality control system at different levels to meet regulatory safety requirements and to serve as a management tool to ensure good operating performance of the project

C. Requirements necessitating international action for the successful launching of a project

C.1. An international, intergovernmental agreement structure to provide the basis for supplies and transfer of technology

C.2. Establishment of contractual arrangements for supplies of equipment, fuel, services, spares and technology on a continuing basis

C.3. Definition of the most effective channels for technical assistance and technology transfer for each area of weakness or deficiency

TABLE I. (cont.)

D.	**Requirements for maintaining the programme**
D.1.	A long term policy for assuring supply of fuel, equipment and technology
D.2.	A long term policy for waste management and disposal
E.	**Requirements for financing the projects**
E.1.	Adequate and supportable financing for each project
E.2.	Financing schemes responsive to the needs of developing countries in terms of interest rates, periods of grace and repayment profiles

the general requirements which need to be fulfilled for a successful programme. This approach is not inherently limited to developing countries, and lessons may be drawn from experiences in both industrialized and developing countries. The list of requirements shown in Table I was elaborated from information provided by the SEG participants and also from information from a number of additional countries about the importance attached, as a result of experience, to each requirement as a real constraint. As each country represents a unique situation, any list of general requirements results in a different definition of constraints for each country, and these may come into play at different stages of the development of the country's nuclear power programme.

3.1. THE CHARACTER OF THE REQUIREMENTS AND THEIR IMPORTANCE AS CONSTRAINTS

The identified general requirements (Table I) were divided into five groups for the purposes of further analysis, taking into account experience which had been reported in answers to a questionnaire from a number of developing Member States. The first four groups (items A–D) are discussed in this section and Section 4; the financing issues (item E) are discussed in Sections 5 and 6.

3.1.A. Requirements which must be met at the national level before the introduction of nuclear power

The requirements in this group include those for which the national government will have the main responsibility of ensuring that proper assessments are made and that appropriate actions are taken in a timely manner.

A.1. Long term policy reasons for nuclear power

Experience in a number of countries, both developing and industrialized, has shown the importance of a study to identify and justify the role of nuclear power in a national energy plan. Inadequacies in planning can create a serious constraint in relation to the formulation and effective execution of a sound government energy policy.

The planning effort must consider opportunities for demand management as well as supply options and must place energy (in particular electric energy) needs and strategies in the context of overall national development plans, resource assessments and potential uses of resources. Economic planning should be one basis for policy formulation, but the planning must not be too narrow and should take into account the environmental impacts and perceived risks of different supply options and the total costs of building up new supply structures. The coal option will, for example, involve a consideration of future prices for imported coal, or, if indigenous resources are used, the total cost of resource development, and investments in facilities for the production, transport and handling of large quantities of coal. Consideration of the desirability of diversification and security of energy supplies will also have to be given weight in the planning process, as well as the availability of raw materials, environmental considerations and technical and scientific development. Although it is clear that the nuclear option must show promise of economic viability in order to be chosen, the long term advantages of stable generation costs, diversity of supply, etc., must also be recognized.

A.2. Government/national commitment to a nuclear power programme

Government commitment to a nuclear power programme is extremely important, but the nature and extent of the commitment must be well understood. Although the initial commitment will relate to a decision on a specific project, this decision must be taken in the context of a longer term commitment to a nuclear power programme involving a number of consecutive units. Even though the nuclear option may have highly favourable lifetime generation costs in comparison with the alternatives, the investment requirements of consecutive plants within a programme will impose large cash flow demands. A strong commitment to conclude each project on schedule is considered to be a necessity for international financing, which has been a serious constraint in several cases. It is essential that there be strongly committed organizations and leadership to implement and guide the programme, as interruption in programme and project implementation would lead to longer plant construction times and very much higher costs.

A.3. National legislation

The national legislation is usually introduced by a radiation protection law and the establishment of a radiation protection authority or service. This is then supplemented with nuclear safety legislation and the establishment of a regulatory body for reactor safety. These laws also define the conditions for ownership of nuclear facilities and materials, and regulate the question of third party liability in the operation of the plants. The relationship between the regulatory authority and the plant owner/operator must be carefully defined. It must give the regulatory body adequate independence so that the basic objective of ensuring safety is not lost, but it must on the other hand be based on the existing situation and not permit irrelevant requirements to impede the development of the programme.

A.4. Electric grid size and characteristics

The size and quality of the electric grids in many developing countries pose a serious constraint on the introduction of the large (generally over 600 MW) nuclear power units which are now available from international suppliers. While conservatism and caution are advisable on this point, general rules often do not apply. It has in several cases proved possible to operate units which are much bigger than 10% of the total generating capacity in the grid. It is clearly not only the grid size but also the 'quality' and reserve capacity which are important. Interconnection with grids in neighbouring countries may be a solution, and it is noted that interconnections are becoming much more common in developing regions. Finally, it should be noted that demand growth and grid expansions are often such that in a fairly short time the grid will be built up sufficiently to accommodate larger plants. The availability of smaller nuclear reactor power plants (SMPRs, see Section 4.3) would help to solve the grid problem. However, grid–plant interaction still represents a basic problem which must be taken into account in specifying both grid development and plant operation; recognition of the technical problem at an early stage can decrease its significance as a constraint. It will always be most important for the first plant and tend to decline in significance for later ones.

A.5. Acceptability of the nuclear power option

Nuclear power acceptability has been a major issue in several countries, including some developing countries. The Chernobyl accident in particular caused a strong reaction, although public concern now seems to be declining. Acceptability should be seen not only as a problem of public acceptance but also in terms of its reflection in the decision making process. People who are well informed about nuclear energy are needed both among political leaders at the ministerial level and among those who help to prepare the decisions in the ministries. These persons can

also help to influence public opinion. Therefore, information about nuclear power needs to be provided at all levels of the debate. The primary actions must consist of providing authoritative, objective and relevant information to all concerned parties, both locally around the future plant site and nationwide. Public acceptance is closely connected with government commitment but it also has an international perspective in that public opposition movements have spread from one country to others and one government's declared attitude can influence public opinion in neighbouring countries.

While most other requirements are more difficult to meet for the first project, the acceptability issue may require actions throughout the lifetime of a nuclear power programme.

3.1.B. Requirements which must be met for the successful implementation of a programme

B.1. Feasibility studies

The technical, economic and financial viability of a project, demonstrated through a careful feasibility study, is an absolute prerequisite for a successful programme. In some developing countries, coal fired plants are now built without sulphur dioxide cleanup equipment. Such plants, when built at coastal locations with minimal infrastructure requirements for handling imported coal, can have very low capital costs. Together with the uncertainties surrounding nuclear plant capital costs, this can lead to difficulties in some cases in proving that nuclear plants will produce electricity more cheaply than coal fired plants. There is, however, an increasing awareness that an 'optimal' energy system must be not only low cost but also environmentally sound. International agencies, such as the World Bank (International Bank for Reconstruction and Development, IBRD), are stressing this issue in their assessments of energy projects. Therefore, it can be expected that the costs of coal fired power plants will increase as a result of the additional costs of installing and operating environmental protection equipment.

In this respect, recent studies (e.g. that by the Nuclear Energy Agency of the Organisation for Economic Co-operation and Development[4]) of electricity costs from nuclear plants in industrialized countries compared with those from coal fired plants equipped with flue gas desulphurization systems generally show that in large unit sizes nuclear power generation has a cost advantage, except in some specific locations such as near coal mines in the USA and Canada. Nonetheless, it is clear that uncertainties about economic and financial viability can lead to serious constraints, not only on the introduction of nuclear power but also on the continua-

[4] Projected Costs of Generating Electricity from Nuclear and Coal-fired Power Plants for Commissioning in 1995, report by an expert group, OECD/NEA, Paris (1986).

tion of well established nuclear power programmes. It is therefore essential that these questions be thoroughly addressed in feasibility studies.

The Senior Expert Group made three main points about feasibility studies:

(a) Feasibility studies must be integrated into the decision making process, and must go well beyond the pure economic and technical viability of a plant at a specified site. The studies must also take into account the necessary infrastructures and overall optimization of the energy supply system, as well as questions of national importance such as the diversity and independence of energy supplies.

(b) The studies should be carried out by trained local staff, with consultants as necessary, in order that the decision makers in the government and local organizations are fully informed and committed to the findings. The government or national authorities should demonstrate their commitment by providing at least a substantial part of the financing for the feasibility study.

(c) Participation of the IAEA in the feasibility study or at least the review of it could be decisive for its credibility to financing institutions and would have a strong positive influence by increasing confidence on the part of the lenders that the project is technically and financially sound.

B.2. Qualified manpower

Once a programme is launched, the availability of qualified manpower at different levels and for very different functions is fundamental for successful implementation. Some functions must be adequately filled by national manpower, such as planning, regulation, acquisition, project management, project safety supervision, quality assurance (QA) and operations. For other functions, it may be a question of whether it is desirable to delegate them to either a main contractor or hired consulting engineers. The nature of the manpower requirements has often been misunderstood. Scientific staff of different disciplines are needed, but there is a critical requirement for management staff, engineers and technicians with experience of large projects.

The exact manpower requirements will depend upon the contractual arrangements for a project, and much can be gained by paying special attention to this aspect in the contract with the supplier and with an experienced utility in the supplier country.

Experience has indicated that IAEA assistance in meeting this requirement, particularly in the preparatory phase, can be very important.

B.3. General level of technical and scientific development

A generally high level of scientific and technical development is needed and it becomes a significant requirement and potential constraint in respect to increasing

the level of local participation. The need is not only for qualified engineers and scientists, but also for institutions (e.g. nuclear R&D organizations and industry research institutes) which can advise on nuclear safety and radiation protection matters and on industrial standards as well as help in diagnosing and solving problems during the construction and operation of a plant.

It is possible to overcome local deficiencies to a great extent through outside consultants and architect-engineering firms and through the services which can be offered under a turnkey contract, customary for the first plant in a country.

B.4. Industrial support structure

For the construction and in particular the operation and maintenance of a nuclear power plant there is a need for an industrial support structure, which can be based in part on experience from conventional power plants. The detailed requirements will depend on both the contractual terms and the desired level of domestic participation in the project, and it is not possible to define a minimum general level of industrial support. It is important to assess carefully the existing industries and how they can be developed and strengthened to meet the QA and other requirements for a nuclear project in accordance with local participation plans. It is of fundamental importance that there be government commitment to support and finance the development of the industrial support structure.

B.5. Organizational structure

An organizational structure must exist with entities which have clearly defined tasks and responsibilities for planning, project execution, ownership and operation of the plant, and regulation. The organizational requirements are clearly very important; however, it has been possible to create adequate structures from existing organizations in most cases. It is interesting to note that very different structures have worked very well; for example, the plant owner/operator organization can be an established atomic energy commission, a new nuclear power authority or a national utility. There are no general solutions which can be recommended, but each country's government must assess the situation and establish the structure which is most suitable for the prevailing conditions. Clear definition of the responsibilities of all involved organizations is particularly important in the case of a nuclear power project, owing to its large size and complex nature in relation to other industrial projects.

B.6. National quality assurance/quality control system

The establishment of a national quality assurance/quality control (QA/QC) system is very important for safe, reliable and economic operation of the nuclear

power plant. The QA/QC system is needed not only to meet regulatory requirements but even more to serve as a management tool for the plant owner in controlling the project execution as well as operation and maintenance. The QA/QC system must be established also in the national industries as an essential preparation for industrial participation. The responsibility for QA and safety cannot be delegated but many of the functions in the programme can be carried out by hired staff or contracted organizations. The owner's QA organization need not be large but it must be well qualified. This requirement has not been a constraint in the past and it is not likely to be one in the future if it is properly recognized and steps are taken to set up the system.

3.1.C. Requirements necessitating international action for the successful launching of a project

C.1. International and intergovernmental agreements

Intergovernmental agreements are needed to provide the basis for supplies and transfer of technology. They have also provided for assurances of non-proliferation or peaceful uses in connection with supplies and transfers. The Tlatelolco Treaty and in particular the Non-Proliferation Treaty now give a general framework for broader non-proliferation assurances. They are the preferred instruments to many supplier States, but they are not accepted by all States. They do not replace the bilateral agreements, which often contain non-proliferation conditions over and above those of the Treaties.

The non-proliferation conditions of several supplier States changed during the 1970s and the bilateral supply and transfer conditions then became constraints for several recipient States. They have in some cases been difficult to overcome. This can thus be a serious problem, which must be resolved primarily through bilateral negotiations. The IAEA Board of Governors in 1980 set up a Committee on Assurances of Supply (CAS) to discuss the intergovernmental aspects of the supply assurance problem.

Regional co-operation agreements can supplement the bilateral transfer agreements, particularly in helping to strengthen infrastructures in the early stages and later also through joint projects in which resources can be pooled.

Regional co-operation agreements, either intergovernmental (bilateral and/or multilateral) or between utilities, offer opportunities for:

- Joint planning of electricity generation systems and joint projects;
- Joint planning and implementation of the expansion or development of the interconnected grids;
- Joint planning and development of the industrial infrastructure and strengthening of the local participation in deliveries of services and equipment based on regional division of labour;

— Co-operation in manpower training and exchange of experts;
— Scientific and technological development;
— Co-ordination of fuel supplies and co-operation in back end fuel cycle activities.

C.2. Contractual arrangements

There is a general constraint in that a bilateral intergovernmental agreement is invariably required before any plant supply contract can be concluded. In addition, supply contract negotiations will include the major constraint of financing and can sometimes run into country specific problems such as inflation. In the present difficult financing situation it has been a major constraint to find adequate contract terms for the construction of an imported plant.

For plant equipment and fuel cycle technologies, licensing agreements or contracts of a commercial nature are normally needed and have generally functioned well. For some limited sectors, such as fuel fabrication technology, the IAEA has been able to provide the complete technology transfer but even in these cases bilateral agreements have been required.

C.3. Effective channels for technical assistance and technology transfer

The availability of an effective channel for technical assistance to overcome identified weaknesses, although a very important point to be taken into account during contract negotiations, should not pose any constraint as there are many sources to choose from once the agreement structures are in place. The IAEA can play a useful role in helping to identify such sources and facilitating the arrangements for technical assistance.

Technology transfer can generally be arranged only if there exists a bilateral intergovernmental agreement. This agreement can in itself serve as an essential instrument for transfer in non-commercial sectors, notably general manpower development, establishment of capabilities in safety evaluation and regulation, and radiation protection. Weaknesses in a country's capability to absorb the transferred technology can create constraints in this domain.

A turnkey contract is normal for the first plant in a country. It can help to assure that the plant is constructed within the time schedule and overall budget, but it can also serve as an effective tool of technology transfer through the local participation it most often specifies and through the technical services it should offer.

3.1.D. Requirements for maintaining the programme

D.1. Long term policy for assuring supply of fuel, equipment and technology

The introduction of stricter non-proliferation conditions for supply by several supplier countries in the late 1970s and consequent renegotiation of bilateral agreements have raised concerns about continuing assurances of supply of fuel, equipment and technology in countries planning or actually executing nuclear power programmes.

In considering the intergovernmental aspects of the problem, the CAS focused its attention initially on a discussion of a set of principles for international co-operation in nuclear energy, but it has not been possible to achieve agreement on this owing to definite differences on a few main issues. While the CAS has agreed on some more practical questions, namely backup mechanisms for supply and revision mechanisms for bilateral agreements, it has not been possible to conclude its work. The same was true for the United Nations Conference on the Promotion of International Co-operation in the Peaceful Uses of Nuclear Energy (UNCPICPUNE), held in March–April 1987.

It is unlikely that a solution will be found multilaterally in the near future, and thus bilateral agreements are for the time being the basis for supply assurances. In the present buyer's market for both power plants and front end fuel cycle supplies there are also possibilities to achieve an improved level of supply assurance by diversification of suppliers, especially in relation to the fuel cycle. Several developing countries have also in this situation established domestic capabilities (e.g. fuel fabrication plants) to produce consumables needed for operation of their nuclear power plants.

It is necessary to make a distinction in this context between assurances that consumables needed for operation will be supplied and assurances that a plant contracted for will be completed. There have been examples of supply interruptions in the latter respect, though not in recent years.

The present situation means that the buyer or his authorities must at an early stage develop a policy for the supply of fuel and fuel cycle services. It will be based on perceptions of the availability of uranium and services, and of assurances of fuel supplies in the long term. The policy must be defined at an early stage, as it may influence the choice of reactor type.

D.2. Long term policy for waste management and disposal

There are well defined technical concepts and procedures for the management and disposal of all categories of radioactive waste. They have also been proven in practice except for the case of ultimate disposal of high level or alpha bearing wastes.

Nevertheless, waste management and disposal have become central to the question of acceptability of nuclear power in many countries.

High level waste management should not become a technical constraint, since capacity exists at nuclear power plants to store spent fuel for many years, and the technology for storing spent fuel for 30–50 years in intermediate storages preparatory to a decision about reprocessing or disposal has been developed and is being demonstrated. For acceptability reasons, however, many governments have required that a high level waste management and disposal concept be presented and approved before an operating licence for a nuclear power plant is granted. The concepts and designs available in a number of countries should make it possible to preclude this issue from becoming a constraint as long as discussion of it remains objective.

The procedures and methods needed for management of low and intermediate level wastes from nuclear power plant operation are well known and can be adopted.

3.2. GENERAL DISCUSSION OF CONSTRAINTS

It is clear that many of the requirements are interrelated. For example, it can be expected that availability of qualified manpower and industrial support will be interdependent. The size and in particular the quality of the electric grid will in many countries reflect the general level of industrial development. The government's commitment to and support of a nuclear power programme will be closely coupled to the country's overall long term economic development and energy supply policies. Financing and contractual arrangements will be interrelated. Nevertheless, every country represents a unique situation and this makes it impossible to generalize, so it has not been possible to simplify the list of requirements further. The importance of each one as a constraint must be assessed in each country so that the best ways of overcoming the problems may be chosen.

It is also clear that the general world situation has recently changed and influenced the importance of the constraints in a fundamental way. Most apparent is, of course, the changed economic situation in a number of developing countries, which has diminished the possibilities of finding financing and has not only blocked the introduction of nuclear power in some countries but also stopped or delayed viable nuclear power programmes. Among other general influences are the following:

(a) The size of nuclear power plants being built in industrialized countries and offered for export has increased rapidly. Although 600 MW plants are still being offered, the plants recently completed or now under construction in most industrialized countries are generally in the size range of 900 MW and above. These units are too large for use in the power grids of many developing countries.

(b) The restrictions associated with non-proliferation, as imposed by several supplier countries, were tightened during the 1970s, sometimes requiring renegotiation of existing contracts.

(c) There has been a general increase in the capital costs of nuclear plants, in part owing to increasing safety and regulatory requirements. This has been paralleled by increasing costs also for the alternatives, owing to added environmental protection requirements. Although nuclear power continues to have an economic advantage in many locations, the advantage is not as great as it was. It must be noted, however, that nuclear power's advantages of low fuel costs and stable generation costs remain valid.

(d) Concerns about reactor accidents and waste disposal have caused public acceptance to become a more widespread issue. This has in some cases caused uncertainties about government commitments and policies, and in turn had a negative effect on the general climate concerning the financing of nuclear power projects.

Most of these general changes have influenced nuclear power programmes in industrialized as well as in developing countries and the means of overcoming the resulting constraints should to a great extent be the same.

Some of the constraints which have become important have a subjective background. This is particularly true in regard to acceptance by the public and, through its impact on political movements, by the government and authorities. This type of constraint could be more difficult to overcome than those which can be defined in objective technical or economic terms and for which it would be possible to formulate concrete countermeasures. The subjective side of long term energy policy and government commitment to nuclear power has now become a major concern to financing institutions, as decisions to complete and operate nuclear power plants have been changed in some cases.

4. WAYS OF ALLEVIATING CONSTRAINTS ON MORE WIDESPREAD USE OF NUCLEAR POWER

4.1. IMPORTANCE OF REQUIREMENTS AS CONSTRAINTS

Members of the SEG from Argentina, China, Czechoslovakia, Egypt, India, the Republic of Korea and Yugoslavia completed a questionnaire indicating the importance they attached, as a result of experience, to the requirements (listed in the first column of Table II) considered as constraints on the introduction of nuclear power and, when applicable, later generations of reactors. In addition, responses were obtained from General Conference delegations from Malaysia, Morocco, Pakistan and the Philippines.

TABLE II. MAIN ACTORS INVOLVED IN OVERCOMING CONSTRAINTS, AND ACTIONS TO BE TAKEN

Requirements	Likely importance as constraint	Government and authorities	Owner organization	Bilateral agreement(s)	Regional co-operation	Multilateral organizations	Notes
A. Requirements for nuclear power introduction							
A.1. Long term policy reasons	High Decreasing	×			Co-ordination when feasible	IAEA–World Bank: seminars	
A.2. Government/national commitment	High Decreasing	×				IAEA–World Bank: seminars	
A.3. National legislation	Low Decreasing	×				IAEA: assistance	
A.4. Electric grid	High Decreasing		×[a,b]		Inter-connection		[a] Assistance from consultants [b] Availability of SMPRs
A.5. Acceptability	High Increasing	×	×			IAEA: provision of information	
B. Requirements for programme implementation							
B.1. Technical and economic feasibility	High Stays high		×[c]			IAEA: advice World Bank: advice	[c] Assistance from consultants
B.2. Qualified manpower	High Increasing/ decreasing	×	×	×	×	IAEA	
B.3. General level of technical and scientific development	High Decreasing	×				IAEA: advice	

B.4. Industrial support structure	Medium Decreasing	×[d]	×[d]		×	IAEA: advice	[d] Assistance from consultants
B.5. Organizational structure	High Decreasing	×	×				
B.6. National QA/QC system	Low Decreasing		×[e,f]			IAEA: training standards	[e] Assistance from consultants [f] Technical support from contractors
C. Requirements necessitating international action							
C.1. International, inter-governmental agreement structure	High Stays high	×	×	×	×	IAEA: safeguards	
C.2. Contractual arrangements	Medium Stays medium	×	×	×			
C.3. Channels for technical assistance and technology transfer	Low Decreasing		×[g]	×	×	IAEA: technical co-operation	[g] Technology transfer from foreign utilities
D. Requirements for maintaining programme							
D.1. Long term policy for assuring supply of fuel, equipment and technology	High–medium Increasing	×	×	×		IAEA: CAS	
D.2. Long term policy for waste management and disposal	High-low Increasing	×	×			IAEA: technical co-operation	

The questionnaire responses showed great differences between countries. It was notable that those developing countries which started their first nuclear power project with initial operation in the period 1969–1977 felt the constraints to a much lesser extent than those which are now trying to launch nuclear programmes. The constraints felt in that period were objective ones, such as grid size and characteristics and manpower availability. It is, however, also to be noted that the countries concerned all had prestigious nuclear authorities and a long tradition in nuclear research. For those which are now trying to launch programmes, the constraints tend to be felt more in financing and in subjective factors, notably the acceptability of the nuclear option.

Some general conclusions could be drawn about the relative importance of the constraints and how this has changed with time or with the development of a programme. In Table II, the second column indicates the most probable present situation and the trend in the evolution of each requirement in terms of its importance as a constraint.

4.2. MAIN ACTORS INVOLVED IN OVERCOMING CONSTRAINTS, AND ACTIONS TO BE TAKEN

4.2.A. Constraints on nuclear power introduction

The preparation of national legislation is not likely to be a constraint as advice is available from the IAEA and the basic protection legislation should have been in existence since the inception of nuclear research. Governments would take action corresponding to their policies and commitments.

In all cases except problems concerning the electric grid, the national government and its authorities would be the main actors in defining and carrying out the nuclear power policy. They can rely on advice and assistance from the IAEA for planning and assessment efforts and on information as a basis for decision making. The IAEA, in giving advice, should work together with other organizations, in particular with the World Bank, through joint projects where possible, to assure that the nuclear policy will be compatible with general energy and economic policies. Co-operation with the United Nations Industrial Development Organization (UNIDO) should also ensure compatibility with industrial development policies and capabilities.

The IAEA should strengthen its role in giving assistance to overcome primary constraints. Specific mechanisms should be:

(a) Seminars for the decision makers and those who help to prepare decisions in order to provide a sound information base;

(b) An integrated planning framework which not only determines an economically optimized expansion plan for the electricity supply system, as part of long term socio-economic development plans, but also assesses national infrastructures, identifies potential constraints and reviews means to overcome them.

In regard to this last point, nuclear power planning should also include assessment of the environmental impacts of nuclear power and of the alternatives, as these have an important influence on the choice of the 'optimum' energy system, in addition to cost optimization. Planning should include consideration of the future stability of fuel prices and generation costs, diversity of energy supplies, etc.

Regional co-operation should be sought whenever feasible to obtain co-ordinated nuclear power and electricity supply policies from which benefits could be drawn through joint efforts in, for example, manpower development, use of available industries and the establishment of larger grids through interconnection.

With respect to the electric grid the plant owner must be the main actor, in co-operation with electric utilities if they are not the same organization. The problem of grid size and characteristics often arises as a result of investment in the transmission system not keeping pace with expansion of the generating system. There are short term and low cost measures which can and should be taken to improve load dispatching and grid protection systems, but larger investments to expand and strengthen the transmission grid must also be planned in the overall programme.

Interconnection of neighbouring national grids can contribute to the solution in some cases. However, interconnection is a major endeavour involving political and technical problems and investments which can be quite substantial for new transmission lines, higher transmission voltage and control equipment. Effective interconnection can be a means to meet short term needs, such as during periods of peak demand or unexpected unit outages, and also offers opportunities for a permanent and dependable interchange of energy and sharing of system reserves.

Efforts by organizations in regard to regional grid interconnection and integration, such as the Commission of Regional Electrical Integration (CIER) in Latin America and the Union of Producers, Conveyors and Distributors of Electric Power in Africa (UPDEA) in West Africa, should be followed as these could facilitate future nuclear power introduction. Co-ordination with the related activities of regional economic commissions (e.g. the Economic Commission for Europe (ECE), the Economic Commission for Latin America (ECLA) and the Economic and Social Commission for Asia and the Pacific (ESCAP)) and the regional development banks should be promoted.

Availability of small and medium power reactors (SMPRs) has often been quoted as a possible means to alleviate grid problems as well as other constraints (see Section 4.3).

The acceptability of nuclear power has become a major issue in public debates, and concerted action by the government, its authorities and the plant owner will be

needed to prevent this from becoming a serious constraint on nuclear power introduction. The primary means to overcome this constraint is through timely provision of information, and the IAEA should take a more active role to assist developing countries in this process by developing and making available information packages, including television films, for public education. The information packages should deal with the basic questions most frequently raised in relation to public acceptance.

Neutral IAEA reviews in the form of, for example, assistance in safety analysis report reviews, Operational Safety Review Teams (OSARTs) and Radiation Protection Advisory Teams (RAPATs) are important as confidence building measures.

4.2.B. Constraints on nuclear power programme implementation

The main actor in this category is generally the plant owner. In addition, the government and its authorities have important supporting functions in assuring the execution of its policy by making funds available, establishing the organizations and co-ordinating them. In some cases outside assistance can be sought bilaterally, regionally and from the IAEA. It is important that the decisions reflect a realistic assessment of the national infrastructures, in particular as concerns manpower and industrial support, and possibilities to overcome or compensate for any identified weaknesses.

Thus, the owner must initiate assessments of infrastructure status and establish necessary manpower development and industry upgrading programmes. An integrated and systematic programme of IAEA planning assistance could be significant here.

The availability of qualified manpower can increase in importance as a constraint when increasing local participation is sought for subsequent nuclear power projects. This should be recognized from the beginning in manpower development planning, since a long time (ten years or more) is needed for building up the essential manpower. The IAEA could well play a more active role in making its manpower development assistance systematic and continuous, from the very early stages of nuclear research through the developing nuclear power programme, while it is recognized that in the later stages bilateral agreements and contracts will be far more important than IAEA assistance for educating and training the large numbers of specialists needed.

The feasibility study should be the first major effort of the plant owner towards realization of the first project. It will mean an expenditure of the order of millions of US dollars and will probably require the help of outside consultants, unless the country has taken the necessary steps for developing the nuclear planning staff. It is of the greatest importance that the owner organization takes the lead in the execution of the study with a small group of qualified full time staff, and, as a demonstration of commitment to the project, also provides financial support to the study.

Association of the IAEA with the study, from its initial organization up to the final review, would be decisive for the credibility of the study for financing institutions.

4.2.C. Constraints necessitating international action

Bilateral supply agreements have become the source of some constraints through the restriction of non-proliferation conditions which several supplier States imposed in the 1970s. The governments are obviously the main actors and their negotiators have to be very well informed about the present international policy developments. Bilateral supply agreements will generally be coupled with a safeguards agreement with the IAEA.

Regional co-operation agreements have been of significant assistance in research and development efforts and are promoted by the IAEA. Regional co-operation agreements can supplement the bilateral transfer agreements, particularly in helping to strengthen infrastructures in the early stages and later also through joint projects in which resources can be pooled.

Once international agreements have been set up by the governments concerned, the contract negotiations between owner and supplier may be difficult, but they are hardly a constraint. Prospective owners should, however, explore possible new types of arrangement, such as 'build, operate and transfer' (BOT), or longer term arrangements to build up the domestic industry.

In regard to technical assistance from the supplier country it should, in particular, be borne in mind that utilities operating a similar plant can often provide extensive practical assistance, and their co-operation should be sought in addition to that available from the supplier.

4.2.D. Constraints on maintaining a programme

Experience indicates that the chief constraint in this category would be in financing (see Sections 5 and 6). Problems with assurances of supply can be a major constraint but the present buyer's market offers diversification possibilities which can help to overcome this. For the longer term, the main actions will have to be by national governments and will reflect their perceptions of the future supply situation. The efforts made by the CAS could help to overcome this constraint if practical conclusions were reached.

Public opposition movements could become a constraint if not dealt with properly and in a timely manner. Continuously informing the public on developments in nuclear power and related issues could help to allay public concerns.

4.3. SMALL AND MEDIUM POWER REACTORS (SMPRs)

Smaller power reactors have been seen as one possible means to overcome both grid and financing constraints. A recent study[5] by the IAEA has shown that several SMPR designs in the size range 100–500 MW could be offered to developing countries but most often there are no recently built reference plants. In general, the price of the generated electricity would be expected to be higher for smaller power plants than for larger plants. There is furthermore no recent capital cost experience concerning exported plants on which to base economic assessments. Thus, the economic viability of SMPRs as compared with conventional power plants is much more difficult to demonstrate than it is for larger nuclear power plants.

There is nevertheless a very large body of experience available from the construction and operation of plants in the power range below 600 MW, most recently in India and in countries constructing the 440 MW pressurized water reactor (PWR) plant of Soviet design.

Potential general advantages of SMPRs are as follows:

(a) A nuclear power programme can be launched earlier than in the case of larger plants;
(b) Smaller power outputs offer a better fit to low load growth rate situations;
(c) Lower absolute capital cost, with smaller financial burden for each plant;
(d) Distribution of economic risk through several smaller plants;
(e) Possibly a higher degree of shop fabrication and an improved potential for series production, offering potential for shortening of the construction schedule;
(f) A better controlled construction schedule as a result of less on-site work and the smaller size of many components;
(g) Lower heat rejection for each plant, which could extend the number and location of possible sites, allowing more optimal siting in respect to consumption centres for heat and power.

It has to be recognized that most of these advantages would apply also to smaller fossil fuel fired plants and they are thus in no way unique to SMPRs.

On the basis of the IAEA SMPR Project Initiation Study, some five SMPR plant designs can be considered technically proven and could be used in developing countries, but a detailed feasibility study would be required with the participation of both the potential seller and buyer in order to obtain a firmer grasp of the economics of such a plant. The IAEA has offered such a study as a 'footnote-a/' technical

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[5] INTERNATIONAL ATOMIC ENERGY AGENCY, Small and Medium Power Reactors: Project Initiation Study, Phase I, IAEA-TECDOC-347, Vienna (1985).

co-operation project[6] since 1986, but it has found no interest among developing countries. The main reasons are probably as follows:

(1) Potential buyers have lost confidence as for many years no SMPR designs were offered by suppliers and because the economics of the present designs appear to them to be too uncertain;
(2) Many of the potential buyer countries have had to set different priorities as a result of their debt situation;
(3) A buyer country's main input to the feasibility study would be qualified manpower, but this may not be available;
(4) A recognized weakness in many essential infrastructures exists in the potential buyer countries;
(5) Doubts have arisen in several potential buyer countries about the acceptability of nuclear power.

A feasibility study for a plant of proven design as proposed by the IAEA could certainly be an important next step but it will require credible information from suppliers about the costs, construction schedule, operability, availability and safety characteristics. Providing this information requires development and engineering work by the suppliers, but the uncertainties about the magnitude of the potential market do not encourage suppliers to allocate much money to such work. Thus, there seems to be an impasse in which buyers wait for proof of economic viability and suppliers wait for proof of a potential market. To break from this situation would require concrete steps towards a project, with potential sellers accepting a high financial risk in order to capture what is now seen as only a possible market of uncertain size.

It can be expected that additional SMPR designs will become available. Some industrialized countries are interested in power plants in the power range of 600 MW and below, including enhanced safety and reliability obtained through both evolutionary designs (e.g. advanced light water reactors (LWRs)) and novel designs (e.g. the process inherent, ultimately safe reactor (PIUS) and the intrinsically safe and economic reactor (ISER)).

The IAEA will certainly continue to follow any developments in this area, including the experience gained in recent construction and operation, but it has been difficult to define specific actions in the absence of concrete expressions of interest from potential buyer countries.

During the 30th IAEA General Conference in 1986, the Mexican delegate suggested that a solution could perhaps be the creation of an international enterprise, tied formally and operationally with the IAEA. This enterprise, conceived as a self-sustained unit, would dispose of technical and financial means adequate for design

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[6] Footnote-a/ projects are projects approved by the IAEA Board of Governors for which no immediate funds are available.

and construction of SMPRs over the long term. Questioned about the feasibility of this proposal, the SEG concluded that it goes far beyond the framework of IAEA activities as specified in the Statute.

5. PARTICULAR ISSUES AND PROBLEMS RELATED TO FINANCING OF NUCLEAR POWER PROJECTS IN DEVELOPING COUNTRIES

5.1. SPECIAL CIRCUMSTANCES RELATED TO FINANCING OF NUCLEAR POWER PROJECTS

The SEG subgroup on financing identified three principal characteristics specific to nuclear power projects which make financing difficult:

(a) *High investment costs of nuclear power plants*

The investment cost of a nuclear power plant will be of the order of 1000–2000 million US dollars, depending on the plant size, construction time, interest rates and other factors. This large capital requirement may approach or even exceed the available credit limits identified by bankers for individual developing countries. Lenders are probably reluctant to concentrate their financial risk in a single project of this magnitude.

(b) *Long duration of construction*

Construction periods in various countries have ranged from 6 to 14 years. It was recognized that the longer periods were usually due to a variety of non-technical problems. It was judged that for planning purposes a value of about 8 years should be used for the construction period in a developing country, especially in the case of the first nuclear power plant. Also, site preparation and development of local infrastructures (construction of roads, a harbour for transport of heavy equipment, development of housing for workers, etc.) may take more time in developing countries than in an industrialized country.

During the construction period the owner is confronted with two complementary problems, which are more severe for nuclear power projects than for other kinds of project owing to the longer construction time:

(i) Lack of revenue from the project, as the plant under construction is not yet producing electricity;

(ii) The requirement to pay interest during construction: for example, for a duration of 8 years and with an interest rate of 7–10% per year, the interest during construction will amount to some 30–45% of the plant investment cost.

(c) *High degree of uncertainty*

Owing to the large amount of money invested and the long construction time, as well as uncertainties about the eventual outcome with respect to both factors, lenders generally consider that financing of nuclear power projects is a highly complex undertaking. Experience in various countries has indicated that construction of a nuclear power plant may face many uncertainties which can lead to longer than expected construction periods and, as a consequence, to large cost overruns and to higher and protracted financing requirements. Unpredictable additional costs due to escalation can also be a problem, in particular when supplies come from countries with high inflation rates.

5.2. PRESENT SCHEMES OF EXPORT FINANCE

There are three ways in which export credits are normally arranged, namely as supplier's credit, buyer's credit and aid credit. Supplier's credit will not function for nuclear power plants because of the size of the project and the negative effect that such a credit would have on the supplier's balance sheet. Under the terms of an OECD agreement, aid credits, which are often on concessionary terms, are ruled out for the financing of nuclear power plants.

For buyer's credit, the credit insurance organizations of the supplier countries play a decisive role, reflecting the export policies of the supplier States with respect to their trading partners. The credit insurance will determine the availability of capital from the main export credit institutions and also from the commercial banks. Normally, the export credit insurance organizations limit their coverage to no more than 85% of the import value of the plant. Thus, the remaining 15% of the import value to be made as cash payment, as well as interest during construction and all local costs, will have to be funded by the buyer from other sources. Even if an amount of local cost equivalent to the cash payment (i.e. 15% of the import value) is included in the export credit, which often can be the case, there will still remain a substantial requirement to be covered either by the buyer or through commercial banks. It depends on the size of this remaining requirement and on the credit worthiness of the buyer as to how this money may be raised, and whether the commercial banks will have to form a consortium with a large number of partners in order to spread the financial risk. All these considerations contribute to the complexity of nuclear project financing.

The present schemes of export credits and commercial financing do not adequately meet the needs of nuclear power financing in terms of repayment periods and profiles, or in terms of flexibility to meet delays and cost overruns. In particular, the profile of the required repayment schedule (equal instalments on principal, plus the interest payments) imposes a high annual capital charge requirement. Furthermore, some of the conditions on interest rates and exclusion of aid credits, as specified in the export credit schemes, tend to disfavour nuclear projects in comparison with conventional projects.

5.3. WAYS TO IMPROVE THE PRESENT EXPORT FINANCE SCHEMES

The subgroup on financing extensively discussed the financing issues, giving particular attention to the Sector Understanding on Export Credits for Nuclear Power Plants, which is part of the broader OECD 'Consensus' on export credits in various fields. The current terms of the export credits for nuclear power stations and nuclear equipment, materials and services were approved on 18 August 1984.

The agreement limits the repayment period to a maximum of 15 years after commissioning of the nuclear power plant. Three officially supported interest rates ('matrix rates') are indicated in relation to the economic level of the buyer country. Every six months, on 15 January and on 15 July, these rates of the OECD Consensus are reviewed as a function of variations in the borrowing costs of the governments of five OECD countries[7], whenever these costs have varied by at least 0.5%. For export credits for nuclear power plants, the sectoral agreement stipulates that the interest rate should be *1% higher* than the matrix rates of the consensus.

Financing may be offered (by any exporter) at lower rates of interest in those currencies where such lower rates are offered in the financial markets. Such financing may be officially supported by any government on behalf of its exporter. The minimum interest rates for these currencies are called CIRRs (commercial interest reference rates), and the special, slightly higher rates which apply to nuclear power plants are called SCIRRs (special commercial interest reference rates). CIRRs and SCIRRs are based on government bond yields or some other index of actual financial market conditions for a particular country.

It should be noted that the gap between the consensus and the market rates has been decreasing owing to the falling interest rates in the reference countries and the weighting mechanism used to calculate the matrix rates under the consensus.

Nonetheless, the conditions established were considered by the subgroup to be one of the key constraints on nuclear project financing. Therefore, the subgroup suggested some areas of the sector understanding which should be reviewed and

[7] France, the Federal Republic of Germany, Japan, the United Kingdom and the United States of America.

improved, at least to eliminate terms which are unfavourable to nuclear projects as compared with fossil fuel projects.

The subgroup identified five major areas for discussion and, if possible, for improvement of the OECD Consensus:

(a) *Interest rate*

Although it was recognized (Section 5.1) that, compared with investments in other industrial projects, financing of nuclear power projects represents risks of a different degree for lenders (in particular, large capital requirement, long construction period, long repayment period and risks of cost overruns), the fact that nuclear power plant financing is charged an additional 1% of interest above the general rate of the consensus matrix represents a significant economic burden for nuclear plants relative to alternative types of power plant (which are charged the matrix rate).

(b) *Use of soft loans and aid funds*

The present terms of the consensus rule out the use of bilateral soft loans, such as aid funds for equipment and services, pertaining to that part of the project 'inside the security fence'. This ban on mixed credit penalizes nuclear plants in comparison with fossil fuel plants, since the ban does not apply to the latter.

(c) *Financing of interest during construction*

Interest on export credits during construction will represent a substantial foreign exchange requirement on the part of the owner, and will normally have to be met from commercial lending sources. It would be highly desirable for export credit agencies to recognize this interest as part of the project cost in determining the loan amount, and to finance the same proportion of interest during construction as for other project costs.

(d) *Starting point of repayments (grace period)*

The starting date of the repayment period is specified in the contract as the date of provisional acceptance of the project, with some latest date specified as a limit. It would seem suitable to introduce more flexibility in order to take into account possible delays during construction. Although the repayment schedule can usually be renegotiated when delays occur, buyers would be interested to have the conditions and limits of this flexibility included in the initial contract.

(e) *Repayment profile*

Although it is recognized that raising money for a long repayment period is not an easy task, borrowers would like lenders to study new mechanisms which could ease the repayment burden in the early years of project operation. A possible mechanism would be to allow alternative repayment profiles, such as constant annual payments (instead of equal instalments on principal) over the repayment period or lower principal payments in the initial years followed by higher payments in later years. Extending the maximum duration for repayment beyond the present limit of 15 years after plant commissioning could also be of some help.

The subgroup recommended that these points be brought to the attention of the IAEA Member States which participate in the negotiations of the consensus.

6. OTHER POSSIBLE WAYS TO ALLEVIATE PROBLEMS IN FINANCING OF NUCLEAR POWER PROJECTS

In addition to points related to the present financing schemes and possible ways to improve them, as discussed in Section 5, the subgroup gave extensive consideration to the overall complexities of nuclear power projects and how these complexities affect nuclear power financing. In particular, the subgroup emphasized that it is essential that every effort be made, by all parties involved in the development of nuclear power, to reduce the uncertainties linked to such large investments and long project times. Reduction of uncertainties was seen as being essential to improving the overall climate for financing of nuclear power projects.

The subgroup attempted to identify the main issues affecting the financing of nuclear power projects and suggested specific actions that each party involved (lenders and export credit agencies; suppliers and investors; multilateral organizations; developing countries) could undertake in order to reduce economic and financial risks and to make a nuclear project more predictable.

The subgroup proposed a matrix of actions as shown in Table III. Each row of the matrix is related to a specific issue and each column to an actor. The various issues were grouped into five major domains: programme/project related factors, investment climate, financing plan, export credits and credit worthiness.

6.1. PROGRAMME/PROJECT RELATED FACTORS

The members of the subgroup were unanimous that all possible efforts should be made to reduce as far as possible the uncertainties surrounding the cost and schedule of a nuclear power project. The subgroup considered that the buyer's

government's commitment to and demonstrated backing of the nuclear power programme was essential in this respect. The government should take early and strong actions to put in place the legal and institutional arrangements which are required for the programme.

The owner organization, together with other relevant organizations in the buyer country, should carry out long term energy and power sector studies to determine the role appropriate to nuclear power in the national energy plan. Feasibility studies for the nuclear power project should include exploration of financing possibilities and determination of the financial feasibility of the project.

Manpower development programmes should be established at an early stage in preparation for project execution. The exact manpower requirements will depend upon the contractual arrangements for a project, and much can be gained by paying special attention to this aspect in the contract with the supplier and with an experienced utility in the supplier country. It is possible to overcome local deficiencies to a great extent through outside consultants and architect-engineering firms and through the services which can be offered under a turnkey contract, which is the customary form of contract for the first plant in a country.

The IAEA could have an important role in strengthening and assisting local capabilities for energy and power sector planning, project feasibility studies, manpower development and other infrastructure developments. Objective information on nuclear power provided by the IAEA, for example through seminars for decision makers, could make a positive contribution to government commitment as well as to public attitudes towards nuclear power.

6.2. INVESTMENT CLIMATE

Considering the complexities of nuclear power financing, it is very important that the investment climate surrounding a nuclear power project be favourable. The investment climate can be enhanced if the government and owner organization of the buyer country establish a record of consistent and fair dealings with lenders and investors, as well as an electricity tariff structure adequate for the financial strength of the utility.

The IAEA and World Bank could play a useful role by assisting the buyer organizations to determine tariff structures which would be appropriate to meet the needs of investment programmes, for instance on the basis of long run marginal costs of generation.

6.3. FINANCING PLAN

The financing plan must be designed to meet the special needs of nuclear power project financing (Section 5.1), such as a long construction time, a large capital

Text cont. on p. 48.

TABLE III. ISSUES AFFECTING FINANCING OF NUCLEAR POWER PROJECTS, AND ACTIONS PROPOSED FOR VARIOUS ACTORS

	Issues	Lenders and export credit agencies	Suppliers/investors	Multilateral organizations	Developing countries	
					Government and authorities	Owner organization
PROGRAMME/PROJECT RELATED FACTORS	Pre-project studies and project preparation	Explore financing possibilities; co-operate in studies of financial feasibility of project; in later phase, arrange offers of financing packages Arrange bilateral soft loans to finance feasibility studies and site studies	Assist in investigating local infrastructures and industrial capabilities for project participation Ensure that environmental requirements and local conditions are properly considered in design	IAEA–World Bank: assist and/or finance long term energy and power sector studies and feasibility studies; include studies of project financial feasibility IAEA: assist in establishing manpower development and training programmes IAEA: assist in establishing licensing procedures/requirements IAEA (with World Bank financial assistance if necessary): ● assist in site studies; ● assist in providing objective information for public and decision makers	Prepare long term energy planning studies; establish sector policies and make commitment to sector development programmes, including nuclear power Make commitment for continuity of power programmes Assess local infrastructures and domestic participation possibilities Explore/define financing possibilities; feasibility to finance project Establish institutional and legal infrastructures, including licensing authority, procedures and requirements	Carry out long term supply and demand studies for power sector, with participation of relevant national authorities Explore and define financing possibilities; determine feasibility to finance project Prepare and execute manpower development and training programmes at early stage Prepare feasibility studies, with participation of relevant national authorities Select site and carry out extensive site studies

				Make land, land rights available before start of project Approve site before start of project Issue generic licences of standardized designs	Prepare site infrastructures Prepare environmental studies before start of project Provide timely information to relevant authorities and public
Project management during construction and operation		Provide strong management team with authority appropriate to responsibilities for project	IAEA: assist in strengthening and upgrading national project management capabilities (IAEA–World Bank co-operation)	Provide approvals and import licences on schedule to avoid delays in delivery of equipment Eliminate or minimize customs requirements on project Give utility managers proper authority	Co-operate with consultants, including suppliers and utilities with nuclear experience, as appropriate to needs of utility and phase of project
Government commitment to nuclear projects; justification for nuclear power versus fossil fuels			IAEA: hold nuclear power seminars for decision makers IAEA–World Bank: assist and/or finance long term energy and power sector studies IAEA: provide objective information on economic performance of nuclear power	Show evidence of strong national government support of nuclear power by: • strong and consistent support of nuclear power agency • including nuclear power in national and power sector plans • appropriating required funds and approving guarantees and foreign exchange borrowing	Prepare long term expansion plans for generation system, including nuclear power programme

TABLE III. (cont.)

	Issues	Lenders and export credit agencies	Suppliers/investors	Multilateral organizations	Developing countries	
					Government and authorities	Owner organization
PROGRAMME/PROJECT RELATED FACTORS	Delays/cost overruns (project completion risk)	Assume share of completion risk through commitment to reschedule repayments (extend grace period) and finance cost overruns	Ensure timely issuance of export licences and continuity of contracts and licences Assume liability for completion risks when fault lies with supplier Ensure that detailed design is complete before start of construction; provide strong justification for any changes Establish realistic project schedules	IAEA: assist in establishing strong and effective project management	Establish consistent and clearly understood policies and procedures Make commitment to finance local share of cost overruns Ensure timely issuance of import licences Ensure timely funding Ensure appropriate licensing procedures, to avoid subsequent need for design changes, as far as possible	Avoid interruptions in project management (minimize disruptive reorganizations) Fix design as early as possible Establish procedures for rapid examination and decision on any proposal for design change

INVESTMENT CLIMATE	Long delay/high risk on returns to equity investors		Compound equity Use convertible debentures	Finance early costs (e.g. feasibility studies, site studies, site preparation)	Invest government funds early; cover down payments and other early costs	Seek supplementary equity investors in later stages of construction
	Political risks	Utilize existing insurance schemes		Utilize existing insurance schemes Promote new insurance schemes (e.g. MIGA[a])	Enact clear, consistent and fair investment code; establish record of equitable treatment of investors (including fair compensation in the event of expropriation) Take necessary actions to make operative MIGA[a] and bilateral investment insurance programmes (e.g. COFACE[b], OPIC[c])	
	Tariff structures/ fair returns in power sector			IAEA–World Bank: encourage/require realistic tariff structures as essential condition in project feasibility evaluations	Establish record of satisfactory tariffs; make commitment to long term tariffs adequate to contribute to financial strength of utility; and commitment to allow transfer of interest/dividends	Establish record of satisfactory tariffs; make commitment to long term tariffs adequate to contribute to financial strength of utility; and commitment to allow transfer of interest/dividends

[a] MIGA: Multi-Investor Guarantee Agency.
[b] COFACE: Compagnie française pour le commerce extérieur.
[c] OPIC: Overseas Private Investment Corporation (USA).

TABLE III. (cont.)

	Issues	Lenders and export credit agencies	Suppliers/investors	Multilateral organizations	Developing countries	
					Government and authorities	Owner organization
FINANCING PLAN	Long period of construction	Provide appropriate schemes for financing (grace period, financing of interest during construction, schedules for repayment, etc.)	Make available as early as possible all information on design and licensing Clearly establish responsibilities for project execution (single-responsibility contract)	IAEA: stimulate study of economical and standardized designs, including SMPRs IAEA–World Bank: assist in strengthening and upgrading local project management capabilities	Establish streamlined and effective licensing and design approval procedures Establish rapid administrative procedures (customs clearance, etc.)	Construct multiple units at site, where possible Select standard and proven design Make contract with clear responsibilities Establish incentives for timely completion Establish effective project management
	Large capital requirements at extraordinary terms	Arrange appropriate consortium of financing sources Review and revise financing terms under OECD Consensus	Search for sources of equity financing	IAEA–World Bank: assist in strengthening local capabilities for financial planning and debt management World Bank with International Finance Corporation: participate in financing	Make available local loans and equity	Search for equity partners Set up suitable financing plan, including self-financing, foreign and local borrowing and budget funds Contract for all financing required Provide for adequate financial planning and debt management

FINANCING PLAN	Availability of local financing	Agree to finance local expenses and interest during construction	Attract local lenders and equity investors	World Bank: assist in alleviating problems of local financing	Guarantee reimbursement of local expenses Approve tariffs which will provide internal cash generation for investment programmes Facilitate access to local debt/equity markets	Access local debt/equity markets
	Financing for cost overruns	Make provisions for financing cost overruns	Make careful advance analysis of project schedule and requirements Establish effective control of construction schedule to minimize delays and cost overruns	IAEA–World Bank: assist in strengthening local capabilities for project planning, management and control	Avoid overly ambitious plans for local participation, in particular for a first nuclear power project Assume responsibility for financing local cost overruns	Improve and strengthen planning and project management capabilities Establish flexible provisions allowing change from local to foreign suppliers when appropriate to avoid delays and cost overruns
	Participation of multilateral lending agencies			World Bank and other multilateral lending agencies: participate in project financing	Take action to request participation of World Bank and other multilateral lending agencies	

TABLE III. (cont.)

	Issues	Lenders and export credit agencies	Suppliers/investors	Multilateral organizations	Developing countries	
					Government and authorities	Owner organization
EXPORT CREDITS	Repayment profile	Revise terms of OECD Consensus Establish repayment profiles which alleviate cash requirement burden in early years of plant operation (e.g. levellized payments instead of equal instalments on principal)		IAEA: stimulate review of OECD Consensus		
	Financing local costs and interest during construction	Examine possibilities for capitalizing interest during construction		World Bank: advise and assist on schemes for financing local costs	Provide access to local finance market	Seek local sources for financing
	Interest rates	Review OECD Consensus, with aim to reduce or eliminate higher interest rates for nuclear power projects		IAEA: stimulate review of OECD Consensus regarding terms of financing for nuclear power projects		

EXPORT CREDITS	Mixed credits/ soft loans/grants	Review OECD Consensus, with aim to achieve consistency of policies for nuclear and fossil fuel power plants		IAEA: stimulate review of OECD Consensus regarding terms of financing for nuclear power projects		
	Limitations on credit guarantees	Share loans among various credit guarantee agencies Establish multinational sources of financing (financial consortia)	Develop multivendor projects (multinational sources of supply and credits)	Involve MIGA[a] IAEA: promote/ stimulate economical and standardized SMPR designs	Accept multinational projects: ● multivendor sources of supply ● multibuyer projects (regional co-operation)	Investigate possibilities for regional co-operation between utilities in nuclear power project

[a] MIGA: Multi-Investor Guarantee Agency.

TABLE III. (cont.)

	Issues	Lenders and export credit agencies	Suppliers/investors	Multilateral organizations	Developing countries	
					Government and authorities	Owner organization
CREDIT WORTHINESS	Magnitude of risk on single project (large investment cost)	Diversify financing sources and utilize existing credit insurance schemes	Develop multivendor project; diversify sources of supply and credit (multinational sources) Ensure sound project management	World Bank: establish and promote use of institutions for guarantees related to multilateral financing (e.g. MIGA[a]) IAEA: promote development of SMPRs IAEA–World Bank: promote/assist regional power sector planning studies; assist development of multinational projects	Promote regional co-operation in multinational projects	Investigate possibilities for sharing project with utilities in adjacent countries Select appropriate unit size
	Credit limits of commercial banks and export credit agencies	Establish multisource financing	Establish co-financing with multilateral financing institutions Arrange multisupplier credits	Establish co-financing with multilateral financing institutions	Establish sound economic policies and debt management programmes Use expert advisers (World Bank, IMF, IAEA) Promote multinational projects	Establish sound tariff and debt management policies

CREDIT WORTHINESS	Developing country borrowing capacity			World Bank, IMF: advise countries on sound economic and debt management policies	Establish sound economic policies and debt management programmes Use expert advisers (World Bank, IMF, IAEA) Promote multinational projects	Establish sound tariff and debt management policies
	Project finance/ risk sharing	Ensure appropriate sharing of risk	Ensure appropriate sharing of risk	IAEA–World Bank: guide and advise on project financing schemes	Adhere to principles of project financing model, with risk sharing	Establish sound tariff and debt management policies

[a] MIGA: Multi-Investor Guarantee Agency.

requirement at terms which are extraordinary in comparison with other projects, and the likelihood of cost overruns.

The subgroup considered that all possible actions should be taken to alleviate the special needs of a nuclear power project, such as taking steps to shorten project times and reduce costs as well as minimizing the likelihood of delays and cost overruns.

In this regard, the IAEA and World Bank could have an important role by providing assistance to strengthen and upgrade local project management capabilities. The IAEA and World Bank could also give assistance in strengthening local capabilities for financial planning and debt management.

Economical and standardized designs for nuclear power plants, including SMPRs, could be promoted and stimulated by the IAEA as a means to shorten construction times and reduce costs. However, the main efforts in this domain would have to come from the supplier countries.

6.4. EXPORT CREDITS

The present scheme of export credits is governed by the terms of the OECD Sector Understanding on Export Credits for Nuclear Power Plants (Section 5.2). Suggested improvements to this sector understanding were covered in Section 5.3.

Members of the subgroup were of the opinion that some specific steps could be taken to alleviate the problems of export credit. In particular, opportunities for multivendor and multibuyer projects should be investigated and where appropriate promoted as a means to overcome limitations on export credit guarantees and distribute the financial risk.

6.5. CREDIT WORTHINESS

Members of the subgroup considered that doubt about the credit worthiness of the buyer country was a very serious obstacle to nuclear project financing. Indeed, it is unlikely that any scheme could be found to finance nuclear power projects in countries with very poor credit worthiness, especially in view of the large investment cost of nuclear power plants. However, for countries with generally acceptable credit ratings, some steps could be taken to improve possibilities for financing a nuclear power project, for example in terms of economic policies, debt management and project risk sharing. The IAEA and World Bank could help in promoting and strengthening these steps.

6.6. THE BUILD-OPERATE-TRANSFER (BOT) MODEL FOR NUCLEAR PROJECT FINANCING

Workable arrangements to share the economic and financial risks would be very helpful in obtaining financing for a nuclear project. Various contract arrangements were suggested, such as multisupplier and multibuyer projects, and co-financing with multilateral financing institutions (e.g. the World Bank). The build-operate-transfer (BOT) approach, as proposed by Turkey and now being studied by some other developing countries, was discussed extensively and is reviewed here.

The BOT model would make use of project financing for part of the investment requirements, but would also involve equity investors in the project. A distinctive feature of the model is the inclusion of foreign investors in the ownership and management of the nuclear power station.

A 'joint venture utility' (JVU) would be established with equity participation by the concerned utilities and other organizations in the buyer country, as well as by foreign suppliers and financing institutions. The JVU would be responsible for financing, building and operating the nuclear power plant until all the debts were serviced.

The buyer country would provide guarantees to purchase the energy produced at a price to cover the debts and the operating costs, including a reasonable return on invested equity, as well as transfer guarantees for repayments, profit and equity. In this regard, it must be noted that electricity tariffs to customers in developing countries are generally controlled by the governments and in many cases are below levels which would be required to fully cover costs of a BOT project. Therefore, special arrangements would be needed in order to provide adequate purchase price guarantees to the JVU.

The BOT model could help to assure foreign financial institutions that the project would be executed successfully, as the local capabilities could be strengthened and supported by foreign capabilities, both technical and financial. This could facilitate the allocation of loans for nuclear power projects in developing countries.

A part of the required financing would be provided as foreign equity investment, which could partially contribute to covering local cash requirements. Additionally, encouragement of foreign equity investment in power sectors could reduce the foreign debt of developing countries.

Close co-operation of local and foreign manufacturers within the JVU could pave the way for co-operative projects in other developing countries through transfer of know-how, and could offer possibilities for covering part of the required foreign financing through the income of the local parties involved. This could contribute to improving the foreign balance of payments.

It must be emphasized that while the BOT model might offer an alternative financing scheme for countries which have a generally acceptable credit worthiness,

it does not in itself overcome the basic problems of credit worthiness. The contractual arrangements which would be necessary for identifying the responsibilities and risks for the various parties in the JVU are very complex and can, in themselves, introduce new uncertainties into the project. The considerations must be examined carefully.

To date, no nuclear power project has been implemented using the BOT model. However, some countries (e.g. Turkey and Indonesia) are in the process of negotiating or studying the feasibility of BOT projects. The results of these efforts could give an indication of the potential for this model to be applied to other projects.

7. RECOMMENDED ACTIONS BY THE IAEA

On the basis of a detailed analysis of the present situation, it became clear that the IAEA has an important role in assisting its developing Member States to plan and execute nuclear power programmes.

The IAEA already has an extensive programme in this area, based on many years of technical co-operation activities. Nonetheless, some recommendations can be made for achieving greater effectiveness, either by strengthening existing activities or by initiating new ones. These recommendations are presented below.

7.1. ENERGY AND NUCLEAR POWER PLANNING

Over the years, the IAEA has developed a comprehensive framework of information, tools, methodologies and expertise to assist its developing Member States in energy and nuclear power planning. These provide the necessary basis for a strengthened programme of assistance in this domain. It is recommended now that the IAEA should:

(1) *Offer an integrated package of assistance,* with training in the use of IAEA methodologies as a basic component, for studying the needs for energy, electricity and nuclear power within the overall context of economic development of a country, for analysing the economically optimized choices of energy options, and for assessing the required local infrastructures and the plans for their development. The environmental and other impacts of energy options should be included in the analysis.

(2) *Promote and facilitate regional co-operation and the exchange of information and results in relation to energy and nuclear power planning studies.* These activities could include the exchange of experience, sharing of databases and comparison and co-ordination of studies. In this connection, the work under the regional co-operation

agreements (e.g. RCA[8] for Asia and the Pacific and ARCAL[9] for Latin America) can help to support nuclear power planning capabilities, as for example in the case of the RCA workshops for regional users of the IAEA's energy planning models (the Wien Automatic System Planning Package (WASP) and the Model for Analysis of Energy Demand (MAED)). Regional agreements could also be used to promote co-ordinated nuclear power and electricity supply policies from which benefits could be drawn through joint efforts in, for example, manpower development, use of available industries, and establishment of larger grids through interconnection. Efforts by organizations in regard to regional grid interconnection and integration, such as the CIER in Latin America and UPDEA in West Africa, should be followed as these could facilitate future nuclear power introduction. Co-ordination with the related activities of regional economic commissions (e.g. the ECE, ECLA and ESCAP) and the regional development banks should be promoted.

(3) *Promote closer co-operation with the World Bank,* through joint projects where appropriate, in energy and power sector planning and project preparation studies, including technical assistance to strengthen the capabilities in this domain in the developing countries. Existing IAEA–World Bank co-operation, such as in the United Nations Development Programme financed energy planning project for European and Arab countries, should be strengthened.

7.2. PUBLIC ACCEPTANCE

The acceptability of nuclear power has become an important concern for the general public, and also for professionals and decision makers. The primary means to allay the concern that is felt is the timely provision of information, and the IAEA should take a more active role in this regard. In particular, it should:

(4) *Organize short information seminars* on the basic issues and general requirements of nuclear power programmes for political leaders, other decision makers and the specialists who help to prepare decisions in developing Member States.

(5) Increase activities to *systematically develop and make available information* concerning the questions most frequently raised in relation to public acceptance. This information could be provided to the public and used as reference material in schools and also by industry and government professionals who have to deal with questions raised by the public.

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[8] RCA: Regional Co-operative Agreement for Research, Development and Training Related to Nuclear Science and Technology.

[9] ARCAL: Regional Co-operative Arrangements for the Promotion of Nuclear Science and Technology in Latin America.

7.3. PROJECT PREPARATION AND IMPLEMENTATION

The preparedness and capabilities of a country, in terms of its key infrastructures, organizations and manpower, are important for the technical, economic and financial viability of nuclear power programmes and projects. It is recommended that in order to assist developing countries in these matters, the IAEA should:

(6) *Strengthen assistance and involvement in nuclear power project feasibility studies* in developing countries (including financial feasibility), with the co-operation of the World Bank where possible.

(7) *Play a stronger role in assisting developing Member States to assess infrastructures* (manpower, industrial support, ability to absorb transferred technology, etc.) and in drawing up development plans for them, building as far as possible on a country's experience with nuclear techniques and research reactors. The IAEA's manpower development assistance should be systematic and continuous, from the very early stages of nuclear research through the developing nuclear power programme, and should include assistance to strengthen and upgrade local capabilities for project management and implementation.

(8) *Encourage the development of and promote information exchange on methods for reducing costs and construction times* of nuclear power plants without compromising their safety and reliability.

(9) *Continue and strengthen support for nuclear power plant operation* in order to achieve (and to document and publicize) a 'record of excellence' for nuclear power, through the exchange of information, experience and reports on operating performance.

(10) *Continue efforts to find partners in order to implement and finance a feasibility study* for a nuclear power plant of existing design in the SMPR range.

(11) Strengthen and make more systematic its activities to *assist developing Member States in establishing national legislation* as a basis for radiation protection and safety standards. Assistance in establishing a regulatory organization and collaboration in safety studies in the first phases of a project would be very helpful.

7.4. NUCLEAR POWER FINANCING

The financing of nuclear power projects involves complex issues which need to be fully understood by all the parties involved. The IAEA should initiate actions to enhance its capabilities to advise and assist its developing Member States with regard to the financing issues. In particular, it is recommended that the IAEA should:

(12) *Promote information exchange between the buyers, suppliers, financing organizations and export credit insurers* to achieve at an early stage a better understanding by all parties of the special requirements, complexities and possibilities of nuclear power financing, in particular for projects in developing countries.

(13) *Assist, in conjunction with the World Bank, in strengthening and supporting local government and utility capabilities for financial planning* (installation of appropriate tariff structures, project finance and debt management) in the electric power sector, in order to help improve the availability of financing for nuclear power.

(14) *Encourage involved Member States to review the Sector Understanding on Export Credits for Nuclear Power Plants, which is part of the OECD 'Consensus'*, with a view to improving the loan conditions for the supply of nuclear power plants.

(15) *Study and promote the exchange of information on schemes for nuclear power financing* (e.g. the build–operate–transfer model and countertrade arrangements).

(16) *Encourage other international organizations,* in particular the World Bank, *to include nuclear power among the possible options* in long term power sector planning in individual developing countries, when appropriate.

LIST OF PARTICIPANTS

MEETINGS OF SENIOR EXPERT GROUP

Vienna
1–3 July 1986 (1)
8–12 December 1986 (2)
19–22 May 1987 (3)

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Vienna
14–17 October 1986 (1)
17–20 March 1987 (2)

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SUBJECT GROUP: V
Reactors and Nuclear Power/All