Annex IV
BANGLADESH

Annex IV

SOME ISSUES AND STRATEGIES OF PLANNING FOR NUCLEAR POWER IN A DEVELOPING COUNTRY - EXPERIENCE OF BANGLADESH[1]

1. INTRODUCTION

According to various estimates, a significant part of the future incremental demand for electricity on a global basis will come from the developing countries. The projected rapid growth rate in these countries will be caused by an increase of the present low base of per capita electricity consumption and the demand driven by the overall economic development. Such a shift in global distribution of electricity generation could put additional pressure on fossil fuels, which in turn, could lead to an energy crisis. The environmental dimension of energy and the resulting universal concern for emissions of green house gases are now overwhelming. Any future global consensus on remedial measures could compel nations to introduce clean energy generation technologies. Other forms of interventions, such as the carbon tax, could also escalate the price of fossil fuels. This situation will make it difficult for many developing countries to sustain their overall economic growth. The question of energy security is also expected to assume more importance. These are some of the factors that are likely to influence the future energy scene of the world in general, and energy starved developing countries in particular.

On the other hand, the development of new energy technologies has not been as intensive as it deserved after the global energy crises of the last century. Renewable energy technologies like solar photovoltaic cells and wind turbines may be useful for meeting energy needs of small, fragmented and isolated demand centres. Their roles as components of a global fuel-mix, therefore, remain insignificant. The present status of development of comparatively more promising alternate technologies, namely fusion and hydrogen energy, indicates that intensive research and development efforts are required before they are commercially available and technically and economically feasible. Therefore, these alternatives cannot be considered as components of an energy mix of a country even when the planning horizon is extended to 30-40 years.

Most of the developing countries cannot respond quickly to abrupt changes in technology of power generation or the international fuel market due to the inadequacy in infrastructure and other enabling capabilities. They tend to rely more on matured technologies. Thus, in the ultimate analysis, the role of a matured technology like nuclear power has to be objectively assessed as one of the options for meeting future energy demands. On the other hand, no developing country could succeed in accessing nuclear power even after the energy crises of the 70's and 80's in the last century. Planning for nuclear power is quite complicated and encompasses a whole range of activities, strategies and policy issues. The long gestation period also compounds the task to a great extent.

2. RATIONALE FOR NUCLEAR POWER IN BANGLADESH

Nuclear power was identified as a viable proposition for Bangladesh way back in the 1960's. A site for the first project was selected based on relevant criteria and land for it was acquired. Several feasibility studies and site studies were conducted since then. All of these confirmed the technical, economic and financial viability of nuclear power.

2.1. Energy Demand

The present per capita electricity generation is only about 100 kWh. For obvious reasons, this is impeding economic growth of the country. According to the low scenario of demand projection of the National Energy Policy, the average annual growth rate of demand should be in the range from 7 to

[1] Annex IV contains information from Bangladesh, which has submitted relevant information in the framework of the IAEA activity on integrated approach of nuclear power programme planning. In addition, the Secretariat has added the EEDB data and the international agreements.

8% over the next fifteen years, resulting in an increase of the per capita electricity consumption to roughly 350 kWh by 2015.

2.2. Fuel Options

Natural gas now accounts for roughly 85% of the total electricity generation. The estimated reserves of gas and its demand for other sectors suggest that its supply cannot meet the entire incremental demand of the future. This entire reserve is located in the Eastern Zone, which is separated from the Western Zone by the system of major rivers (see Fig. 1). This compels the Western Zone to depend on an electrical inter-connector for import of electricity for meeting even a part of its base load. In fact, nuclear power was initially envisaged for the Western Zone to reduce the dependence on imported electricity as well as imported fuel.

The other indigenous fuels, namely newly found coal deposits and the lone exploitable site for hydro-generation, are inadequate for meeting the rest of the incremental demand for electricity. Therefore, the country will have to import fossil fuels even for meeting the needs for sustaining even a modest growth in demand for electricity.

FIG. 1. Map of Bangladesh

2.3. Shortcoming of Imported Fuels

Bulk import of fossil fuels for power generations will be difficult due to the uncertainties in price and their availability in the international fuel market. Moreover, the existing infrastructure will be inadequate for catering to the demands of handling, internal transportation and other logistics associated with such bulk imports. The environmental effects of fossil fuel in general and coal in particular are also additional factors of concern.

2.4. Energy Security

Bangladesh is still struggling hard to attain the threshold of development. Reliability of energy supply is thus critical. Sustainability of the future energy development programme is also equally important. The future energy-mix should, therefore, include an array of supply options and technologies that can facilitate attaining energy security.

3. LESSONS FROM THE PLANNING EXERCISES OF THE PAST

Bangladesh, and in particular the Bangladesh Atomic Energy Commission (BAEC) has been involved in planning for nuclear power for about four decades. The general continuity in government decision and firm commitment necessitated continued planning exercises by the executing agency (BAEC) over this extended period. The Government decision coupled with the country's impeccable commitment to nuclear non-proliferation may be considered as some of the strong enabling measures already taken for accessing nuclear power technology. The excess and unutilised manufacturing capacities of the nuclear industry world-wide and a shrinking global demand for the technology, which has resulted in a typical buyer's market scenario, can be an ideal condition for the developing countries to implement nuclear projects. In spite of such favourable conditions, it has not been possible to initiate the project. It is, therefore, worthwhile to identify and analyse the specific issues and inadequacies of the planning phase for nuclear power as experienced by Bangladesh.

Nuclear power as compared to most of the conventional technologies is essentially complicated and the decision on its implementation directly or indirectly involves multiple parties, both internal and external to the nation as well as some international organizations. The key issues influencing the decision include safety, liability and the requirements related to the international non-proliferation regime. In the case of Bangladesh, decisions regarding the nuclear power project were always taken at the highest level of the government and in consultation with the relevant government agencies. Even then, it was not possible to resolve all the problems confronting the implementation of a nuclear power programme. Some of the limiting factors as encountered are as follows:

(a) Limitations of the grid and size of the plant

In the past, the Bangladesh grid was fragmented and its total demand required that the size of the nuclear unit was to be less than 300 MW. Options available for this size were limited. However, the subsequent integration of the fragmented demand centres and installation of an East-West electrical inter-connector have resulted in a moderately developed integrated grid. The projected growth of this grid vis-à-vis the gestation time for implementation of a nuclear power project indicates that a 600 MW unit may be planned for integration into it. The supply market for such plants, though not ideal, is expected to have a number of options.

(b) Financing and its international connotations

Bangladesh is traditionally dependent on bilateral and to some extent multi-lateral funds for the growth of its power sector. Perception and apprehension of these sources are that the developing countries cannot adopt nuclear power technology or operate nuclear power plants safely, reliably and efficiently. Additional factors that usually influence the decision of the potential financiers may include risk, higher interest rate, export credit facilities, longer repayment schedules, cost of money resulting from cost and schedule over-runs, project management capabilities, etc. If it is decided to keep the options of innovative financing, such as joint ventures, build, operate and own (BOO), etc., then it will be essential to formulate the matching policy and other legal framework. All the above factors have to be adequately addressed at the planning stage of a nuclear power programme. It will also require concerted persuasive actions in resolving the complex problem of financing.

(c) International non-proliferation regime

Concern for nuclear non-proliferation is one of the main factors that can influence the decision on the export of nuclear technology. Over the years, Bangladesh's firm commitment in this context has been well established. However, the non-proliferation regime is a dynamic process and is being evolved and updated continually. It is, therefore, important to identify the whole range of requirements that a country has to meet.

4. FACTORS NEEDING CONSIDERATION IN PLANNING FOR NUCLEAR POWER

Several factors may be identified that deserve attention in planning for nuclear power. They include the following:

- Establishing the need for nuclear power as a component of the overall energy mix of the country and linkage with macro level planning;
- Convincing the decision makers, both internal and external;
- Adoption of an action plan;
- Establishing a human resource development programme;
- Developing legal instruments;
- Establishing an institutional framework;
- Providing public information and obtaining public acceptance;
- Meeting the conditions of the international non-proliferation regime.

With respect to the need for nuclear power as a component of the overall energy mix, it should be born in mind that building one single unit of a nuclear power plant is often not profitable in view of the large fore-cost involved in it. Therefore, the intending developing country should aim at a nuclear power programme and not a mere nuclear power project. A programme would fetch many tangible, intangible and spin-off benefits from a nuclear power programme, thereby making contributions to not only the energy sector but also the overall economic activity.

The relative importance and priority of the above broad issues are, of course, dependent on the socio-economic and political system of the particular country. The salient features of experience of Bangladesh in planning for nuclear power over an extended period are enumerated in the following paragraphs.

4.1. Linkage of Nuclear Power Planning with the Macro level Planning

In Bangladesh, the medium to long-term and short-term (annual) macro planning are conducted under term plans (Five Year Plan) and Annual Development Programmes, respectively. The Term Plan is divided into various sectoral plans. Development targets of electricity generation, transmission and distribution over a plan period are set under the energy sector. Thus, any decision on nuclear power programme is taken by considering the overall programme for the sector. Various studies are conducted to assess energy demand during the plan period and on the supply side the technologies for generation are identified by considering the relevant factors such as economics, fuel option, environmental dimension, project gestation period, availability of finance, etc. The National Energy Policy, with a perspective period of 25 years is also consulted for the purpose. In the case of Bangladesh, the need for introducing nuclear power is identified in all these macro-level plans and policy documents. The existing executive framework for the project, which is discussed in a later paragraph, has been proved useful in establishing the linkage with the macro level planning.

It is also equally important to assess the economic aspects of nuclear power as a component of a least cost generation plan. The environmental impact of various options should also be assessed properly as one of the tools for decision-making.

In many developing countries, the new trend is to deregulate the electricity sector. Private entrepreneurs are attracted to invest in the entire range of activities, including generation. Of late, entrepreneurs have established generating plants in Bangladesh under Power Purchase Agreements. In the transitional phase, extreme care has to be taken in choosing the technology and fuel options for evolving the optimum generation plan. In particular, the conditions of power purchase agreement for the private sector generation may upset overall optimisation of the system. Other factors deserving attention include the administered price of indigenous fuels and energy tariff. Centralized planning for generation may thus need some structural changes and review of strategies by considering the above changes.

4.2. The Need for an Integrated Approach to Planning

The macro-micro linkage is an important pre-requisite for the integrated approach to nuclear power project planning. However, the other important facet is the need for integration among various elements of micro planning of nuclear power programme. The two broad strings of activities that have to be addressed with equal earnestness and seriousness right from the inception of a nuclear power programme are:

(a) Technical, economic and financial management of the nuclear power programme; and
(b) Safety and regulatory aspects.

Since the above two categories of functions are to be ultimately conducted independent of each other, the planning for nuclear power, including capacity building and human resource development activities as well as the necessary legal frameworks for each of these, need to be addressed properly. Issues like management of radioactive waste including a policy on ultimate disposal of high level wastes also require attention at the early stage. Other issues, like capacity building in quality management, identification of codes, guides and standards, project management, etc., also deserve due consideration. In particular, the human resource development programme should be developed in such a way that the core manpower acquires at least working knowledge in the above mentioned key areas of the nuclear power programme.

4.3. Decision Making Process

Nuclear power projects are very complicated and any decision on it, unless taken at an appropriate level of the government, might be rendered ineffective. Continuity of decision over a long time is also an important requirement. In the case of Bangladesh, a Cabinet Committee, chaired by the Head of the Government, has the responsibility to take decision on the project. This Committee includes Ministers and Permanent Secretaries of all relevant Ministries as well as the government agencies related to the project, the Planning Commission of the government and the energy sector in general. It takes all policy decisions based on the information and analyses made available to it. This has also facilitated establishing proper linkages between the macro and micro level planning. The Bangladesh Atomic Energy Commission has been given the responsibility for implementation of the policy decisions.

It is equally important for a developing country to convince relevant foreign governments on the priority of the project, because these are the sources for technology and finance. This may be accomplished through the contacts made at appropriate levels of the foreign government.

4.4. Human Resource Development Programme

The human resource development (HRD) programme focused on nuclear power in Bangladesh was initiated in the early 60's. However, the number of trained personnel is declining through retirement and migration. The inordinate delay in project implementation also had telling effects on the manpower. Training of manpower for nuclear power is both costly and time consuming and opportunities for such training have also become limited. It may be mentioned that due to the uncertainty, as perceived by the external agencies, the training opportunities for Bangladesh personnel

in nuclear technology almost halted after 1980. It is felt that a group of 10-15 trained professionals could form the core group at the planning stage of the nuclear power project. However, there should be a strong and continuing programme on training, including some on-the-job training opportunities. A separate batch of professionals should be trained on nuclear safety and radiation control so that the country can attain sufficient capability to address various issues of nuclear safety and radiation control, including licensing of facilities and operators. In this context, it is important to take the advantage of the IAEA support to the planning process. This may take the form of using various documents, training opportunities as well as technical advisory services.

4.5. Legal Instruments

Various legal instruments are some of the pre-requisites for success in implementing a nuclear power programme in a developing country. They are to be formulated in conformity with the existing laws of the country. These instruments may include, among others, provisions for enforcing nuclear safety and radiation control, nuclear liability, establishing independent organizations for safety and promotional activities, deregulation and involvement of the private sector in activities related to nuclear power, etc. Additional legal provisions may be required if the country wishes to attract private entrepreneurs to invest in the nuclear power programme. This is necessitated by the fact that in most countries, at least in the initial phase of a nuclear power programme, all activities are vested in the public sector.

4.6. Institutional Framework

In many countries having an active nuclear power programme, the activities were initiated within the framework of the national agency responsible for nuclear research and development programmes. This strategy may be effective because of the multi-disciplinary nature of such an institution and also cost-effectiveness. As the programme grows, such an institutional arrangement may ultimately become less effective, especially in the areas related to commercial operation and safety. Thus, it becomes essential to establish separate institutions for Safety and Regulatory matters and for construction and operation of nuclear power plants. In Bangladesh, a separate Division of the Bangladesh Atomic Energy Commission (BAEC) with 15 professionals (3 senior level, 2 mid-level and 10 fresh graduates with training on nuclear technology) and other supporting staff conduct all the activities of the pre-implementation phase. A separate Division of BAEC is responsible for enforcement of the provisions of the law and regulations on Nuclear Safety and Radiation Control. The Government plans to establish a separate institution for future nuclear power plants in order to ensure better economic, financial and technological management. This new institution is envisaged to have adequate provisions for maintaining vertical linkage between the plant management and the decision makers of the government.

4.7. Technology Transfer and National Participation

It is important to decide at a very early stage the mode and extent of technology transfer that the country aims at. It is no doubt that the whole planning exercise will depend on this decision, especially as this would influence the size and nature of the HRD programme. The same is also true for the desired extent of national participation in project implementation. A very careful and intensive appraisal of national infrastructure and industrial experience is required in determining the nature and extent of national participation.

4.8. Public Information and Acceptance

Public information and public acceptance may be considered as one of the key determinants for success of a nuclear power programme. Dialogues with the public, the people's representatives at various levels and the decision makers are considered to be important determinants in ensuring transparency and public acceptance. In the case of Bangladesh, the acceptance of nuclear power is in general favourable, especially in and around the site. This is evident from the fact that, in spite of the inordinate delay and land being a precious commodity for the villagers, it has been possible to retain

the land for the project for about four decades. The general perception is that construction of a nuclear power plant would create job opportunities and have other spin-off benefits for the residents. Moreover, way back in the 1960's the families affected by eviction were offered attractive compensation packages. Nevertheless, it is apprehended that opposition groups may be encountered as soon as construction work starts. An effective public acceptance programme has to be designed and implemented in order to enhance public acceptance.

4.9. International Non-Proliferation Regime

Meeting the requirements of the international nuclear non-proliferation regime as well as nuclear liability, safety, etc. are some of the stringent pre-requisites for accessing nuclear power technology. The requirements need to be identified at the early stage and met through signing the related agreements, protocols, etc. In addition to this, it is also useful to enter into bilateral agreements with identified countries.

5. THE FINAL STAGE OF PLANNING

The planning cycle for nuclear power can be divided into multiple stages. The main activities of each of these have some features in common to many countries. However, the strategies adopted by the government concerned, and in particular the firmness of the decision on introducing nuclear power, can influence both the length of the planning horizon and the sequence and intensiveness of the activities.

The activities, following the final decision by the government are intensive, focused and linked with a defined time frame. It may be mentioned that for convenience and to ensure uniformity, the planning horizon for the purpose of the TECDOC on the Integrated Approach to Nuclear Power Project Planning is defined as the period covering up to the issuance of a Request for Proposal. The final stage of planning may, thus, include the period from decision making to the issuance of the Request For Proposal. Generic issues that need to be addressed during this stage may vary from country to country. In the case of Bangladesh, the actions identified for planning are as follows:

a. Upgrading of studies, in particular the confirmation of site. This activity would be necessary to incorporate changes, if any, since the completion of the earlier studies;

b. Review of existing legal instruments and identification of their adequacy for implementation of the nuclear power programme;

c. Review of the existing institutional framework to determine the needs for establishing new independent institution(s) for implementation of the nuclear power programme and especially to separate promotional from regulatory activities;

d. Identification of the adequacy of agreements, treaties, protocols as related to the international non-proliferation regime and additional bilateral/multilateral arrangements for facilitating transfer of technology as well as others related to liability and safety;

e. Formulation of a strategy on financing. In this context, it may be important to examine the conditions to be fulfilled for a transition from the public sector to the private sector initiative for nuclear power. If the situation demands, the relevant legal provisions may require review and modifications;

f. Identification of codes, guides and standards to be used in the nuclear power plants as well as the licensing procedure. In this context, an early dialogue with the regulatory authorities may be useful.

In the case of Bangladesh, it was observed that the manpower available and their expertise were not adequate to perform all the activities efficiently and in time. In a similar situation, actions need to

be initiated to solve the problem. The HRD programme should also envisage the needs for conducting other activities like bid evaluation, contract negotiation as well as those related to the early stage of project implementation.

It is equally important that the HRD programme of the regulatory body should have adequate provision enabling it to cater to the needs of licensing and other regulatory matters of nuclear power plants.

6. NEED FOR A NUCLEAR POWER ACTION PLAN

A blanket administrative provision is essential to ensure efficient implementation of a government decision on the national nuclear power programme. Its overwhelming role is evident from the wide range of national as well as international agencies, whose concerted participation is essential for the success in realizing the decision effectively. Such a provision is best served through a National Nuclear Action Plan, adopted at the appropriate level of the government. The main purpose of this document is to identify:

a. Various activities needed for implementation of the nuclear power programme;
b. The agencies responsible for each of these activities;
c. Enabling measures like funding, for conducting the activities.

The structure and timing for adoption of such a policy document would depend on the progress of the planning cycle. The contents of Bangladesh Nuclear Power Action Plan is as follows:

Preamble	Scope and objectives of the Action Plan
The General Action Plan	International obligations Legal aspects and provisions of Bangladesh on nuclear safety and radiation control and their enforcement Safety culture Institutional framework Management of radioactive waste and decommissioning Nuclear fuel cycle Development of human resources Public acceptance, public information and education National participation Financing
Specific Action Plan for the Short-term	Objective of the short term plan Site evaluation The feasibility study report Bid invitation document Bid invitation Bid evaluation Financing Supplementary project Technical Co-operation of the IAEA

The Bangladesh Nuclear Power Action Plan was drafted based on the contents of the IAEA document “Choosing Nuclear Option: Factors to be considered”. Since this Action Plan is binding on the local agencies in particular, it is expected to facilitate conducting all activities efficiently and effectively.

7. POSSIBLE AREAS OF IAEA SUPPORT

It cannot be expected that a developing country at the early stage of planning for nuclear power can have all the professionals and expertise needed for all the activities. IAEA can be considered as a vital source for the development of the enabling capacity or the enhancement of the existing infrastructure. Some of the conditions that are to be met for obtaining such support are:

(i) Government commitment to the nuclear power programme;
(ii) Fulfilment of the requirements of the international non-proliferation regime;
(iii) Development of a Nuclear Action Plan.

It is to be borne in mind that a request from the Government to the IAEA can lead to a Technical Co-operation Project, in which the required areas of IAEA co-operation can be identified. A Fact Finding Mission from the Agency at an early stage can also be considered important in this context.

The possible areas of IAEA support concern areas such as human resource development and provision of available documents and tools.

7.1. Human Resource Development

The availability of trained professionals is a key parameter to the planning activities. Regional as well as inter-regional training courses on different aspects of nuclear power, including those related to the planning cycle, are organized by the IAEA as well as under the RCA. Since the positions available for these short-term training courses are limited, preference is usually given to the countries that have a known commitment to nuclear power.

If a technical Co-operation Projects exists, then additional manpower may be trained under it. Such training courses may take the form of classroom as well as on the job training.

It is also useful to organize national training courses/workshops focused on the pre-implementation phase. IAEA can provide valuable support like:

(a) Determining the format of the course;
(b) Determining the course contents; and
(c) Providing international experts for various topics.

Bangladesh organized such a National Training workshop in 1999 with a duration of 10 weeks, which was attended by 32 local fresh to mid-level professionals. The IAEA had provided 22 international experts for the Workshop which consisted of 220 hours of lectures, group discussions, presentations by the participants and appraisal tests. The success of the Training Workshop was manifested by the fact that even the fresh professionals attending it have acquired knowledge and confidence that are enabling them to make significant contributions towards various activities in the pre-implementation phase, including updating of the Site Report and preparation of the Request For Proposal document.

7.2. IAEA Documents

IAEA has published a significant number of documents, guides, technical reports, etc. addressing a wide range of topics of nuclear power. These may be considered as a valuable source of information and guidelines needed for the planning, implementation as well as the operation & maintenance phases of the programme. The TC project may envisage the identification of the related documents as well as making them available to the country concerned.

7.3. IAEA Analytical Tools

Various analytical tools, such as ENPEP, WASP, DECADES, etc., are available for use by its Member States. These can be profitably used in assessing the role of nuclear power as a component of the long-term least cost generation plan based on economic considerations, fuel options and environmental effects of each alternative of fuel and technology. IAEA also provides training opportunities on the application of these analytical tools.

7.4. Other Forms of IAEA Support

IAEA support may also be requested and obtained for drawing up various documents related to the nuclear power programme. These may include amongst others, the National Nuclear Action Plan, review of the Site Report and Review of the Request For Proposal.

8. OTHER REQUIREMENTS

The above issues are some of the basic requirements at the planning stage of a nuclear power programme in a developing country. However, these alone cannot solve all the problems for accessing technology and finance. Success in implementing the nuclear power programme will require support of external sources as well as the international organizations such as the IAEA.

9. PRESENT STATUS OF THE NUCLEAR POWER PROGRAMME

Since the adoption of the National Nuclear Power Action Plan, Bangladesh is now taking various steps of the pre-implementation phase of its nuclear power programme. The milestone events that are underway include the following:

(a) Training of manpower for the pre-implementation phase;
(b) Updating of the Site Investigation Report;
(c) Preparation of a "Request For Proposal" document, which will be basis for inviting comprehensive bids for technology and finance for the first project.

It is expected that the IAEA would provide technical support to all these activities. The end result of the planning exercise will be evident after obtaining responses from potential suppliers and financiers.

10. ENERGY AND ECONOMIC DATA

TABLE 1. POPULATION INFORMATION

							Growth rate (%)
	1960	1970	1980	1990	2000	2001	1980 To 2001
Population (millions)	51.6	66.5	85.4	110.0	137.4	140.4	2.4
Population density (inhabitants/km²)	358.3	461.7	593.3	764.1	954.5	974.8	

Predicted population growth rate (%) 2001 to 2010	19.6
Area (1000 km²)	144.0
Urban population in 2001 as percent of total	

Source: IAEA Energy and Economic Database.

TABLE 2. GROSS DOMESTIC PRODUCT (GDP)

	1970	1980	1990	2000	2001	Growth rate (%) 1980 To 2001
GDP (millions of current US$)		17,482	28,759	46,033	47,741	4.9
GDP (millions of constant 1990 US$)	11,633	18,246	29,023	46,361	48,840	5
GDP per capita (current US$/capita)		205	261	335	340	2.4

Source: IAEA Energy and Economic Database.

TABLE 3. ESTIMATED ENERGY RESERVES

	Estimated energy reserves in 1999 (Exajoule)					
	Solid	**Liquid**	**Gas**	**Uranium (1)**	**Hydro (2)**	**Total**
Total amount in place		0.25	11.66		0.48	12.39

(1) This total represents essentially recoverable reserves.

(2) For comparison purposes a rough attempt is made to convert hydro capacity to energy by multiplying the gross theoretical annual capability (World Energy Council - 2002) by a factor of 10.

Source: IAEA Energy and Economic Database.

TABLE 4. ENERGY STATISTICS

	1960	1970	1980	1990	2000	2001	Average annual growth rate (%) 1960 To 1980	1980 To 2001
Energy consumption								
- Total (1)			0.17	0.33	0.51	0.54		5.75
- Solids (2)			0.05	0.07	0.03	0.03		-2.68
- Liquids			0.07	0.10	0.12	0.12		2.97
- Gases			0.05	0.15	0.35	0.38		10.69
- Primary electricity (3)			0.01	0.01	0.01	0.01		2.00
Energy production								
- Total			0.10	0.23	0.38	0.42		7.35
- Solids			0.04	0.06	0.02	0.02		-2.69
- Liquids				0.01				9.70
- Gases			0.05	0.15	0.35	0.39		10.79
- Primary electricity (3)			0.01	0.01	0.01	0.01		2.00
Net import (Import - Export)								
- Total			0.07	0.10	0.13	0.14		2.98
- Solids			0.00	0.01	0.00	0.00		-2.61
- Liquids			0.07	0.08	0.13	0.13		3.22
- Gases								

(1) Energy consumption = Primary energy consumption + Net import (Import - Export) of secondary energy.

(2) Solid fuels include coal, lignite and commercial wood.

(3) Primary electricity = Hydro + Geothermal + Nuclear + Wind.

(*) Energy values are in Exajoule except where indicated.

Source: IAEA Energy and Economic Database.

TABLE 5. ELECTRICITY PRODUCTION AND INSTALLED CAPACITY

	1960	1970	1980	1990	2000	2001	Average annual growth rate (%) 1960 To 1980	Average annual growth rate (%) 1980 To 2001
Electricity production (TW.h)								
- Total (1)			2.65	8.06	16.41	24.18		11.10
- Thermal			2.07	7.17	15.55	23.29		12.22
- Hydro			0.58	0.88	0.85	0.88		2.00
- Nuclear								
- Geothermal								
Capacity of electrical plants (GWe)								
- Total			0.99	2.52	3.65	3.83		6.65
- Thermal			0.91	2.29	3.41	3.59		6.75
- Hydro			0.08	0.23	0.24	0.24		5.40
- Nuclear								
- Geothermal								
- Wind								

(1) Electricity losses are not deducted.

Source: IAEA Energy and Economic Database.

TABLE 6. ENERGY RELATED RATIOS

	1960	1970	1980	1990	2000	2001
Energy consumption per capita (GJ/capita)			2	3	4	4
Electricity per capita (kW.h/capita)			30	69	112	138
Electricity production/Energy production (%)			27	34	41	55
Nuclear/Total electricity (%)						
Ratio of external dependency (%) (1)			44	29	26	25
Load factor of electricity plants						
- Total (%)			31	36	51	72
- Thermal			26	36	52	74
- Hydro			83	44	41	42
- Nuclear						

(1) Net import / Total energy consumption.

Source: IAEA Energy and Economic Database.

11. INTERNATIONAL, MULTILATERAL AND BILATERAL AGREEMENTS

AGREEMENTS WITH THE IAEA

- NPT related safeguard agreement INFCIRC/301. Entry into force: 11 June 1982
- Additional Protocol Entry into force: 30 March2001
- Improved procedures for designation of safeguards inspectors Accepted on: 25 April 1995
- Supplementary agreement on provision of technical assistance by the IAEA Entry into force: 31 December 1979

• RCA	Entry into force:	24 August 1987
• Agreement on privileges and immunities	Non-Party	

OTHER RELEVANT INTERNATIONAL TREATIES etc.

• NPT	Entry into force:	31 August 1979
• Convention on physical protection of nuclear material	Non- Party	
• Convention on early notification of a nuclear accident	Entry into force:	7 February 1988
• Convention on assistance in the case of a nuclear accident or radiological emergency	Entry into force:	7 February 1988
• Convention on civil liability for nuclear damage	Non-Party	
• Joint protocol	Non-Party	
• Protocol to amend the Vienna convention on civil liability for nuclear damage	Non-Party	
• Convention on supplementary compensation for nuclear damage	Non-Party	
• Convention on nuclear safety	Entry into force:	24 October 1996
• Joint convention on the safety of spent fuel management and on the safety of radioactive waste management	Non-Party	
• ZANGGER Committee	Non-Member	
• Acceptance of NUSS Codes	No reply	
•		
• Nuclear Suppliers Group	Non-Member	

REFERENCES

[1] Data & Statistics/The World Bank, www.worldbank.org/data.

[2] IAEA Energy and Economic Data Base (EEDB).

[3] IAEA Power Reactor Information System (PRIS).

Appendix

DIRECTORY OF THE MAIN ORGANIZATIONS, INSTITUTIONS AND COMPANIES INVOLVED IN NUCLEAR POWER RELATED ACTIVITIES

NATIONAL ATOMIC ENERGY AUTHORITY

Bangladesh Atomic Energy Commission
(BAEC)
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P.O.Box 158,Dhaka 1000,
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