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Basic infrastructure for a nuclear power project

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FOREWORD

There are several stages in the process of introducing nuclear power in a country. These include development of nuclear policies and regulations, feasibility studies, public consultations, technology evaluation, requests for proposals and evaluations, contracts and financing, supply, construction, commissioning, operation and finally decommissioning. This publication addresses the "basic" infrastructure needs, which are adequate until the issue of the construction license. It is obvious that a fully developed nuclear infrastructure will be required for the further implementation stages of a nuclear power reactor. The officials and experts in each country will undertake the transition from a basic infrastructure to a fully developed infrastructure that covers the stages of construction, commissioning, operation and decommissioning.

The publication is directed to provide guidance for assessing the basic infrastructure necessary for:

- A host country to consider when engaging in the implementation of nuclear power, and
- A supplier country to consider when assessing whether the recipient country is in an acceptable condition to begin the implementation of a nuclear power project.

The target users are decision makers, advisers and senior managers in the governmental organizations, utilities, industrial organizations and regulatory bodies in the countries adopting nuclear power programmes or exporting supplies for these programmes. The governmental organizations that may find this publication useful include: Ministries of Economy, Energy, Foreign Affairs, Finance, Mining, Internal Affairs, Academic Institutions, Nuclear Energy Agencies and Environmental Agencies.

This publication was produced within the IAEA programme directed to increase the capability of Member States to plan and implement nuclear power programmes and to establish and enhance national nuclear infrastructure. This publication should be used in conjunction with the IAEA Safety Standards Series and other appropriate safety related and safeguards publications.

The IAEA wishes to acknowledge the assistance provided by the contributors listed at the end of the report. In particular, appreciation is due to A. Rastas (Finland) and J. Costa Mattos (Brazil), who chaired the review meetings, and to the drafter A. Alizadeh (Canada).

The IAEA officers responsible for this publication were N. Pieroni and R.I. Facer of the Division of Nuclear Power.

CONTENTS

1. INTRODUCTION

1.1. Background

The consideration of the nuclear power option and implementation of the first nuclear power project requires a basic infrastructure which addresses the minimum issues to deal with all aspects of a nuclear power project. Once established, the basic infrastructure can be expanded in time to support a comprehensive, long term and localized nuclear industry in the country. The stages of the development of the basic infrastructure include:

- Development of nuclear power policy and its formal adoption by the government.
- Confirmation of the feasibility of implementing a nuclear power project.
- Establishment of institutional components of the infrastructure including a nuclear regulatory body (NRB).
- Establishment of physical component of the infrastructure
- Development, contracting and financing of the first nuclear power project.
- Construction of the first nuclear power plant to the established safety, quality and economic requirements.
- Safe, secure and efficient operation of the first nuclear power plant.

Government and utility funding is required to establish major components of the basic nuclear infrastructure. These may include:

- National legal framework and international agreements
- Nuclear safety regulatory body and environmental regulatory authority
- Physical facilities
- Finance/ Economics
- Human resources, education and training
- Operational practices and processes to assure safety and performance throughout the life of the facility
- Public information and acceptance.

This publication is intended to provide government and industry leaders with an overview of the basic infrastructure for the implementation of the first nuclear power project. The stages and extent of the infrastructure institutions and facilities depend on the long term plans for nuclear power and the role envisaged for the government and the private sector in its development. This includes sources of funding for the construction of the plants, timing and capacity of nuclear generation, technology alignments and agreements, commercial conditions and contract type for the planned projects. This publication should be considered as a living document that will be further revised to reflect feedback experience from its use and future developments.

1.2. Objective

The objective of this publication is to provide guidance on the issues that need to be addressed within a basic nuclear power infrastructure framework. The guidance is not meant to prescribe an all-inclusive list and will have to be utilized with due consideration given to the existing legal, institutional and industrial infrastructure and financial conditions of the country.

1.3. Scope

This publication covers the basic infrastructure needs that should be considered until the issue of the construction license for the first nuclear power project.

1.4. Users

This publication is intended for decision makers, advisers and senior managers in the governmental organizations, utilities, industrial organizations and regulatory bodies in the countries adopting a nuclear power programme.

The information is also useful for a supplier country to consider when assessing whether the recipient country is in an acceptable condition to begin the implementation of a nuclear power project

1.5. Structure

This publication consists of four main sections along with this introduction. In section 2 the process of establishing a nuclear policy is described. In section 3 the main issues related to the infrastructure are outlined briefly. In section 4 the process of implementing the nuclear power is described. Section 5 outlines the basic infrastructure necessary for various aspects of the programme implementation. IAEA publications with additional information related to the infrastructure issues covered in this publication are listed in the references.

1.6. How to use

This publication should be used as a reference on how to assess the basic infrastructure needed for the implementation of the first nuclear power plant. The publication is not prescriptive and should be considered as a guide. The quantitative measures given for resources in this publication should be adjusted by the user to fit the needs and capabilities of the country. This publication should be used in conjunction with the IAEA Safety Standards Series and other appropriate safety related and safeguards publications.

2. DEVELOPMENT OF POLICY FOR IMPLEMENTATION OF NUCLEAR POWER

2.1. General

The decision to implement nuclear power requires expert and public input in the early stages of the development of the policy. The government, through a national advisory and consultative process should seek expert views and consult the general population as well as those of the individuals, agencies and organizations, which represent various interest groups. Prominent and experienced technical, financing and policy experts with balanced views should be drawn into this process as advisors to the government and moderators and coordinators of public discussion forums. The task of advising the government to arrive at a decision should be assigned to the ministry responsible for the development of energy policy.

Establishment of a basic nuclear power infrastructure follows the formalization of a positive decision on nuclear power. The basic nuclear power infrastructure is that which enables the sponsoring utility or the designated implementer to undertake the development and construction of the first nuclear power plant. Major concerns of the investing utility are the selection of reactor site, reactor technology, and project financing and execution models. Confidence of the investing utility in the political, regulatory and public consultation processes is essential to the realization of the nuclear power projects.

Public consultation is complementary to the decision by the government and the nationally elected bodies of the country. It can be a lengthy process, as the various interest groups need time to prepare and present their position to the authorities conducting it.

The purpose of public consultation is not to develop support for nuclear power among a majority of population but rather to provide adequate and satisfactory response to legitimate safety, economic and environmental concerns of the public. The issues of nuclear project safety, cost, and environmental management of nuclear waste are well known to the public and the proponents of nuclear power will need to demonstrate that they are properly addressed and their impacts on the development programme are considered. It is very likely, for example, to face significant difficulties in the public acceptability of the nuclear option if no thought is given to the concept of waste management since the impact of this issue on future generations is of great concern to the public.

It is clear that not all aspects of the nuclear power programme could be examined at this stage to the extent needed in the implementation stage. However, a rational outline of the manner of dealing with all issues is necessary for the plan to be presentable to the public and defendable by the authorities.

The environmental assessment process for the specific site and project should also engage the public, in particular, the public in the area surrounding the potential site. They should be consulted in the early stages of the process so that their views are fully considered by the project sponsors prior to the start of the project. However, once the legitimate public concerns are addressed to the satisfaction of the government and regulatory approvals for the project are granted, the legal framework should be in place to protect the project against unnecessary interruption due to frivolous use of the public input process.

Nuclear power projects have a long duration of development and implementation and it is necessary for the government to provide assurances through policy and legislation that the long term interests of the investors are not adversely affected by political changes

Major changes to the licensing rules imposed by the nuclear and environmental regulatory bodies after the start of the project are of major concern to the investing utility. It is therefore important that the legal framework be established such that meeting the requirements set and commitments made in the safety and environmental approvals at the start of the project remains, as much as possible, the sole criteria for monitoring the project to its completion.

2.2. Nuclear power implementation agency

The formulation of the policy and the initial development of the basic elements of nuclear infrastructure organizations, prior to the involvement of the electric utilities and investors, may be facilitated through the establishment of a dedicated agency by the government and referred to in this publication as nuclear power implementation agency (NPIA). The NPIA is set up by the government to study the nuclear power option for the purpose of drafting the nuclear policy, identifying the basic infrastructure elements and planning their implementation.

The extent of basic infrastructure necessary for nuclear power plant implementation depends on the national strategy with regard to the size of the planned nuclear capacity and the desired extent of the localization of various aspects of nuclear technology.

The step beyond the basic infrastructure involves the localization of the various aspects of nuclear technology and requires a much stronger political and financial support by the government and longer term planning for large nuclear output. Electricity markets regulated by the government and utilities owned by the government are capable of implementing such programmes in both plant construction and fuel cycle. The deregulated markets are driven by the project business case and often do not have the mechanisms necessary for the implementation of such long term planning and funding for the localization of nuclear technology.

This NPIA should be established at a high level within the government hierarchy reporting to a ministry such as energy, industry or economy. It should be adequately funded by the government and be headed at the level of deputy minister with sufficient staff covering all areas of expertise required. The NPIA should have a clear mandate from the government to develop nuclear power policy for consideration by the government and identify and establish the required enablers prior to the start of the implementation of the nuclear power plants by government owned or private sector utilities. A typical structure of the NPIA organization is shown in Fig. 1.

In formulating the recommendations to the government, the NPIA should undertake the following basic assessment activities:

- Position of nuclear power in the electricity market and generation mix.
- Economics of nuclear power.
- Legal, regulatory and legislative aspects of nuclear power.
- Environmental and siting aspects of nuclear power.
- Nuclear power technology.
- Nuclear fuel cycle including waste management and decommissioning.
- Expected role of the government and the private sector in the development of the nuclear programme.
- Extent of availability of the industrial base and of the human resources needed for the nuclear programme in the country.
- Extent of the uranium resources in the country and its impact on the fuel supply policy.
- Public acceptance.

The recommendation should include a plan and schedule for the implementation of nuclear power. A period of 18 to 24 months is needed for the NPIA to conclude its studies and make a recommendation to the government.

Upon the completion of this task, the role of the NPIA will change to the implementation of the recommended and approved policy and monitoring the development and progress of the nuclear power programme.

The NPIA is a transitory government organization that, after accomplishment of its tasks should be dissolved and the established organizations (regulatory and industrial) take over the further conduct of the nuclear power programme.

The NPIA may have to address the development of nuclear power in two stages. The first is the development of the basic infrastructure for the first nuclear power plant, which includes the legislative and statutory framework and the establishment of the independent NRB, and the second is the plan for the longer term and larger nuclear output.

The first stage is to guide the government in arriving at the decision regarding the approval of the nuclear power programme and the outline of the basic infrastructure for the implementation of the first nuclear power plant. This stage is required regardless of the structure of the electricity market and the ownership of generating utilities. In this stage, although not an essential requirement, it is desirable to localize a portion of the scope of work if the local suppliers and contractors can meet the technology and delivery requirements while remaining commercially competitive. At the completion of this stage the country/utility should be able to purchase one or a series of reactors of a type, which has received certification in the country of origin and is licensed for operation at a site with certain acceptable characteristics.

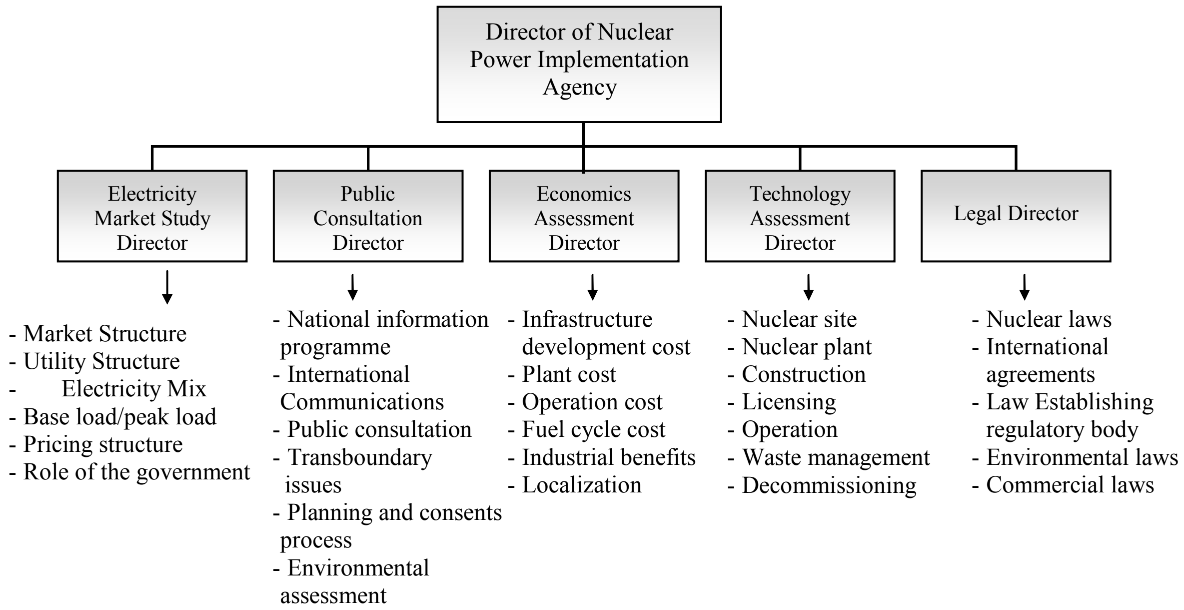


Fig. 1 Typical structure of the nuclear power implementation agency

The second stage, if the government so decides, is to outline a plan for the establishment of the legal, regulatory, social and industrial infrastructure for the long term localization of the nuclear industry in the country. This stage is more applicable to the countries with more advanced industrial base and where the electricity generation planning is centralized and the government substantially owns the generation facilities. In this stage, the localization may also include the fuel fabrication technology. The planning of the localized fuel cycle will have to address the phases of mining (if uranium resources are available in the country), refining, conversion and enrichment (other than for natural uranium fuel), and fuel element and fuel assembly (bundle) fabrication. In case of enriched uranium fuel cycle it should be assumed that the localization would not include the enrichment even if the uranium were supplied from local mines. The second stage requires a much more significant level of planning and government support and is beyond the scope of this publication.

2.3. Nuclear power development cycle

Implementation of nuclear power has a longer initial timeline than most other commonly used electricity generation options. The reason for this is the need for:

- National energy planning.
- Public consultation on nuclear power option.
- Comparative economic assessment of nuclear power.
- Policy development for nuclear power by the government.
- Establishment and enactment of legislation on nuclear law.
- Establishment of nuclear regulatory body, licensing regulations and applicable codes and standards.
- Development and streamlining of planning and permits process.
- Human resources development.
- Site selection, environmental assessment and public consultation including cross boundary.
- Nuclear technology selection.
- Development of a management system which integrates safety, health, the environment, security, quality and economics elements.
- Development of waste management and decommissioning strategy.
- Conclusion of commercial and financing contracts.
- Plant construction and commissioning.

The timeline for realization of the first nuclear power plant should be considered in such a manner as to address all of the above milestones. An overview of the nuclear power development cycle is shown in Fig. 2.

2.4. Nuclear power technologies

Design and development of nuclear reactors is a major undertaking, which requires significant technical and financial resources. Recent developments in the nuclear power market have led to the consolidation of the nuclear power supplier companies. This means that the countries considering the implementation of nuclear power should be familiar with the range of options offered by these suppliers. The supply of a reactor to specific requirements of the importing country may not be economically feasible. Therefore, the characteristics of the reactors currently available and reactors under development and their output size should be considered in the country's implementation programme.

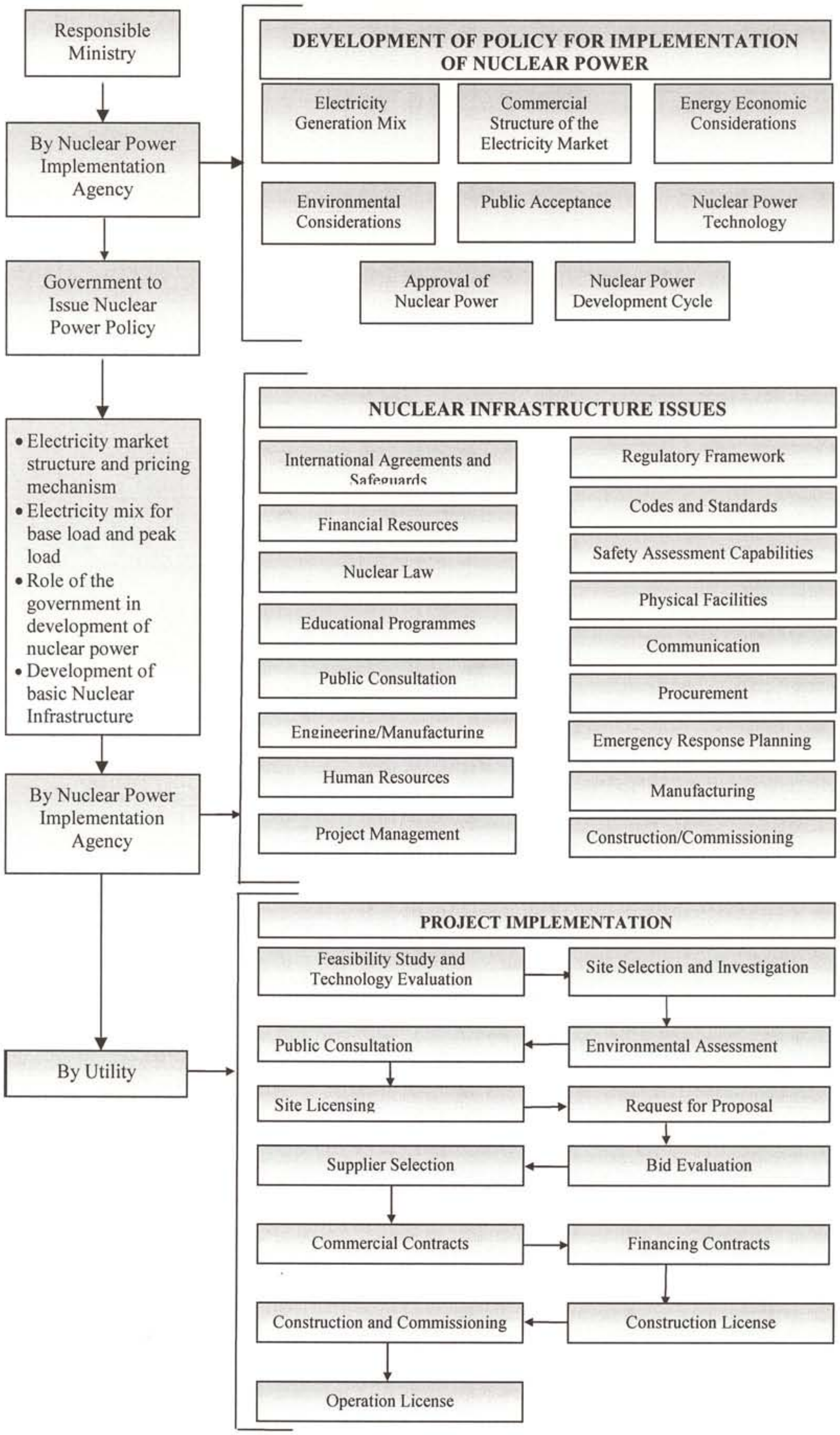


Fig. 2 Nuclear power development cycle

3. NUCLEAR INFRASTRUCTURE ISSUES

Once the government has completed its policy review and consultation and formally decided on the implementation of the nuclear power, a basic infrastructure is needed to plan, construct and operate nuclear power plants. The major subjects in establishment of basic infrastructure include the following.

3.1. National laws of nuclear power

Nuclear laws and regulations are the means of providing legal and structural framework to the nuclear related activities. Nuclear laws and regulations should address the following:

- The safety principle (prevention and protection);
- The security principle (peaceful use of nuclear power);
- The responsibility principle (operator or licensee);
- The permission principle (review and authorization by regulatory body);
- The continuous control principle (right of inspection and access by the regulatory body);
- The compensation principle (extent of nuclear liability);
- The sustainable development principle (protection of future);
- The compliance principle (international and transboundary agreements, treaties and conventions);
- The independence principle (separation of regulatory body from nuclear implementation organizations);
- The predictability and transparency principle (clarity of the process and availability of information on all aspects of nuclear power to the applicants and to the public).

a. Law establishing powers of regulatory bodies

Implementation of nuclear power requires that the Country establishes and maintains nuclear regulatory legislation (international conventions) and regulatory body for the primary purpose of limiting, in a manner consistent with the country's international obligations, the risks to national security, the health and safety of persons and the environment that are associated with the development, production and use of nuclear energy and the production, possession and use of nuclear substances, prescribed equipment and prescribed information.

b. National law on nuclear security

Special legal measures are required (international convention on physical protection) to protect and account for the types and quantities of nuclear material that may pose security risks. These measures must protect against both accidental and intentional diversion from the legitimate uses of these materials and technologies.

c. Law on radioactive materials and radiation

Radiation sources must be kept secure to prevent theft or damage and to prevent any unauthorized person from carrying out illegal activities with such sources. The Code of Conduct on the Safety and Security of Radioactive Sources [1] and Guidance on Import and Export of Radioactive Source [2] outlines a number of measures that should be taken to address this issue.

d. Law on nuclear liability

A convention on Third Party Liability in the Field of Nuclear Energy was signed in Paris on 29th July 1960 and was amended by the Additional Protocol of 28th January 1964 and by the Protocol of 16th November 1982. It is necessary that the convention and its amendments are ratified by the country and its intent be reflected in the country's nuclear liability law.

e. Radioactive waste, spent fuel and decommissioning law

The purpose of this law is to enable the provision of sufficient funds and development of technical and commercial enablers needed for the safe storage and disposal of nuclear waste and decommissioning of the plant.

f. Non proliferation treaty and additional protocol obligations

The objective of this treaty is to ensure that nuclear material is not diverted for use in the production of nuclear weapons or other nuclear explosive devices. Through a number of international, regional and bilateral agreements, countries have undertaken to accept the application of safeguards to nuclear material and activities under their jurisdiction or control.

g. Legislation to implement international conventions and agreements

As a matter of international law, States must take the necessary steps under their national laws to ratify and enter into force the necessary conventions and treaties and be bound by the obligations arising out of their international relations.

h. Environmental protection law

An environmental assessment (EA) should be carried out for all major projects with the potential to significantly affect the environment. Environmental protection law establishes the regulation and the agency for the implementation and enforcement of sound environmental practices by the proponents of major projects. Environmental frameworks and standards must also be established to guide and regulate the preparation and approval process for the EA.

i. Law on emergency notification of nuclear incidents

The Convention on early notification of a nuclear accident [3] establishes a notification system for nuclear accidents that have the potential for international transboundary release that could be of radiological safety significance for another State. It requires States to report the accident's time, location, radiation releases, and other data essential for assessing the situation.

j. Law on foreign investment

The trend towards private sector owned electricity generation requires the participation of foreign investments in the power generation sector in the country. Major issues affecting foreign investment, which needs to be addressed, include protection against expropriation, guarantee of transfers, access to real estate, international arbitration and employment of expatriates.

k. Law on safety of nuclear installations

The purpose of this law is to ensure that the nuclear safety objectives are achieved in order to protect the workers, public and the environment from harm by establishing and maintaining in the nuclear installation effective measures against radiological hazards.

3.2. Nuclear regulatory body

3.2.1. Defined nuclear regulatory body

The function of the NRB includes regulatory functions, establishment of safety requirements and regulations, establishment of codes and standards, independent safety assessments and reviews of safety analysis reports, authorizations, inspection, enforcement, co-ordination with other national and international bodies, and public information. A possible structure of the NRB is shown in Fig. 3.

In some countries the NRB may consist of more than one authority, and in such case, effective arrangements should be made to ensure that regulatory functions and responsibilities are properly discharged and co-coordinated.

The NRB capabilities may also be augmented with assistance and advice from independent consultants, support organizations, other States or from international organizations whose expertise is well established and recognized. The NRB should create and maintain a basic capability of performing regulatory review and assessments, or evaluating assessments performed for it by consultants or other organizations.

It is expected that a developing regulatory body will be licensing a reactor, which is either built in another country or is already licensed for construction by a credible regulatory body such as that of the country of origin. In such cases, for the licensing activities, the developing NRB, while complying with its own regulations, will rely heavily on the work done by the experts in the country of origin of the selected reactor.

A number of departments may be set up in the line of functions described above to carry out the activities required for the licensing of the nuclear power facilities.

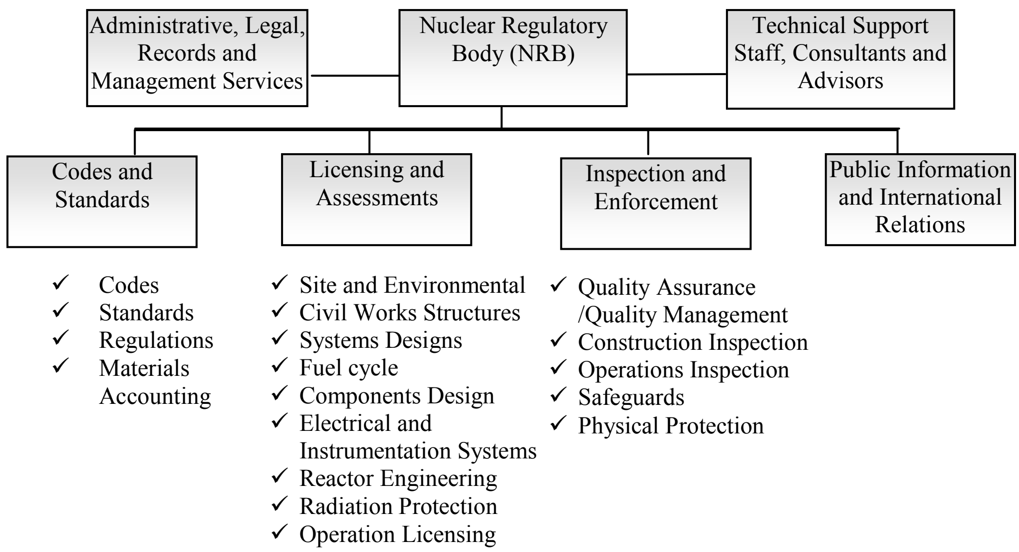


Fig. 3 Possible structure of a nuclear regulatory body

3.2.2. Transparency

The NRB should determine clearly the extent of information and documentation on its assessments and determination, which should be in public domain and set up mechanisms to provide access to such information by the public.

3.2.3. Predictability in the process

Predictability in the nuclear regulatory process is essential in order to provide commercial confidence to the energy investment community. The nuclear regulatory rules and processes should be established such as to provide assurance of licensability in principle to the utility at the time of the issue of the start of construction. As an example, the combined construction and operation license process initiated by the US Nuclear Regulatory Commission provides the required confidence in and predictability of the licensing process.

3.2.4. Codes and standards for design and regulation

Codes and standards governing the design of nuclear power plants require provisions beyond those of other industrial facilities. The regulation framework could be as comprehensive as the development of local requirements for licensing or reactors and development of local fuel and components manufacturing. However, as a basic, it should adopt an internationally accepted set of requirements for licensing of the reactor such as those developed by the IAEA or by the country of origin of the reactor supplier; or those of the countries that already have a fully developed nuclear regulatory regime. There are three categories of codes and standards governing the design of nuclear power plants:

a. Codes and standards for regulating nuclear safety

The first issue to be decided is whether the country wants to develop its own nuclear regulatory codes or to adopt from other NRB regulations or the IAEA safety standards. In the early stages of the nuclear power programme, development of the country specific regulations may not be necessary as most of the commercially available reactors are already licensed in one or more of the major regulatory regimes. As a result, the nuclear regulatory codes at the start of the nuclear programme may be adopted and harmonized with those of the country of origin of the technology or those of the countries that already have a fully developed nuclear regulatory regime, while at the same time ensuring compliance with IAEA safety standards.

b. Codes and standards for the design of the buildings, systems and components

These codes and standards govern the behavior of materials and performance of equipment under all operating conditions. Nuclear class components require codes and standards which are more stringent than the ones used in other industrial designs. Countries with reactor design and development programmes have developed civil, mechanical and electrical design codes specifically for the nuclear application. As a result, the nuclear design codes and standards could once again be adopted and harmonized with those of the country of origin of the reactor technology selected or those of the countries that already have a fully developed nuclear regulatory regime.

c. Environmental assessment requirements

National regulations and requirements would have to be in place for the environmental assessment of nuclear projects. World Bank, OECD, ISO and export development agencies have environmental frameworks, which are used by proponents of various projects to carry out environmental assessments and can be adopted by the country. The purpose of environmental codes, standards and frameworks is to enable the project sponsor to achieve:

- Compliance with environmental regulations equivalent to those accepted internationally,
- Mitigation of adverse impacts of the project on the environment,
- Setting of environmental objectives and targets and their review mechanism, and
- Documenting, implementing and maintaining an environmental management and communication plan.

3.3. Physical facilities

Physical facilities needed for effective implementation of the nuclear power plant are to be established in compliance with the codes, standards and regulations or by using the best engineering and organizational practices. Prior to the awarding of the construction permit and during the construction and commissioning, the authorities must review and approve the plans set up by the project sponsor to establish these facilities.

3.3.1. Site

The most important element of infrastructure is the existence of a site with acceptable characteristics such as appropriate geological and seismic conditions, access to adequate cooling water, proper location on the grid, etc. The selected site will have to have its own infrastructure features and facilities as described below:

a. Water supply

Sources of water for construction phase and for cooling and other services during operation of the plant should be acceptable from quantity and quality points of view. Site locations could be costal, on major rivers, or inland and away from major bodies of water. For non-coastal locations cooling towers may be required.

b. Power supply

Power supply during construction and operation is often provided through the regional grid and supplemented by standby and emergency power supply systems. Substations are needed to provide the required voltages during the construction and operation phases of the plant.

c. Transport/Access

It is necessary to survey the access roads and railways to the site in order to determine if the width of the roads, radius of the bends and the clearance under bridges and in tunnels are adequate for the heaviest, widest, longest and tallest pieces of equipment which have to be delivered by road. For sites located on large rivers and seashores, construction of a harbor capable of receiving and handling very heavy loads is needed to utilize delivery of large equipment by water.

d. Micro earthquake monitoring station

The seismic hazard study determines the maximum ground motion parameters under the largest potential earthquake with sufficiently low probability of occurrence for the site. In order to verify the methodology and conclusions of the seismic hazard study, a number of micro earthquake monitoring stations have to be set up the region of the site for several years in advance of construction to provide data on rock characteristics and attenuation laws.

e. Meteorological and hydrological station

Site investigation studies require significant meteorological and hydrological data including maximum, basic and mean values for air and seawater temperatures, wind speed and direction, atmospheric pressure, dispersion patterns rainfall, ground water and surface flooding, wave action and tsunamis. Stations for collection and monitoring of this data are required to be put in place for a number of years prior to the approval of the site.

f. Town site and administration facilities

Pre project and project management activities require working space and in remote sites, town site for living accommodations of the workers. This could be set up by the authorities in advance, or could be contracted as part of the project supply contracts.

3.3.2. Grid

The interaction between the grid and the nuclear power plant is impacted by several factors including:

- Size of the plant output compared to the grid size,
- Location of the plant on the grid,
- Reliability of the grid interconnects.

The commercially available reactors are mostly of large size, and may have economic impact as a result of the need for additional spinning reserve, transmission lines, and interconnect equipment which may be required to strengthen the grid for accepting the large output of a single nuclear unit.

The grid should also have the capability of providing the plant with external power supply which is independent of the plant output.

3.3.3. Physical protection facilities

The security of the nuclear facilities is an important criterion for site selection and for establishing plant configuration and plant operational procedures. Plant security is ensured primarily through features that are built into the strength of the structures, configuration of the systems and layout of the buildings, and barriers and security systems which are set up to restrict access and entry into the plant. The final security measure is through the regional and national security agencies that monitor the potential sources of threat against the critical facilities such as nuclear power plants and devise and implement plans and procedures to counter them.

3.3.4. Component manufacture and material supply

The nuclear power plant project consists of several stages as shown in Figure 4. The manufacturing of equipment starts in the early stages of the project shortly after the contract effective date when the purchase orders are ready. Therefore, it is essential that facilities for the localized manufacture of equipment and supply of material be operational early in the project schedule. Any support by the government to maximize the local scope of supply should be in place well in advance of the start of construction. In general, the local facilities may start with the supply of civil materials and non-nuclear mechanical and electrical equipment and material.

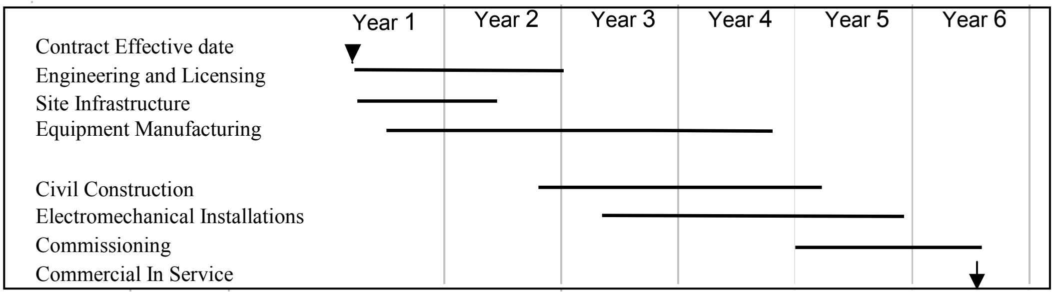


Fig. 4 Stages of project activities following contract effective date

3.3.5. Standard calibration laboratory facilities

The safe construction and operation of the nuclear power plants requires devices for the reliable measurement of various nuclear, thermal, hydraulic and mechanical parameters needed to determine the operating status of the plant at any time. These devices are calibrated during the commissioning process and are tested and recalibrated periodically thereafter

3.3.6. Storage/Disposal of low and medium radioactive waste

Low and intermediate radioactive waste are to be stored by minimizing the space required and in a manner that will allow an easy transfer to disposal sites in the future. The safe storage of this material will provide sufficient time for the utility and the government to select and apply the most appropriate disposal approach and technology. National laws and specific agreements with the government, which are independent of changes to the owners and operator of the plant, should ensure operational stability and safety of the waste management facilities.

3.3.7. Spent fuel storage and disposal facilities

In many nuclear plants, the management of spent fuel is carried out in three stages. In the first stage the fuel is stored in pools of water, which are part of the power plant, in order to be cooled off before reprocessing or for transfer to interim storage facilities. In the second stage the spent fuel is either shipped and reprocessed in central facilities (to extract its fissile material for reuse as fuel) or is stored in interim storage facilities within the plant exclusion zone and which are often designed for over 100 years of operational life. The final stage is the permanent disposal of the spent fuel in deep geological formations, which is currently being developed by several countries. The reliability of the interim storage concept provides sufficient time and confidence in the timely commercial deployment of disposal facilities.

3.3.8. Safeguards plan and equipment

The purpose of safeguards is to ensure that special fissionable and other nuclear materials, services, equipment, facilities, and information are not utilized for purposes other than for the peaceful application of nuclear energy. To implement the safeguard, a state system of accounting for and control of nuclear materials must be established in the country in order to coordinate the agencies in possession of nuclear material and for interface with IAEA safeguard inspectors. Adequate physical protection of the plant and of any nuclear material is a combined utility and national responsibility.

3.3.9. Emergency response facilities/ Emergency response organization

Concern for potential accidents underlines the importance of the establishment, by the regulatory authority, of requirements for the plans and procedures for coping with their impacts on the plant operators and the general population. In preparation for an unlikely event of a nuclear incident, the plant operator's emergency plans and procedures should ensure that all issues of concern are planned for and are covered.

3.3.10. Emergency notification of nuclear incidents

The preparation of plans and procedures to cover emergency situations transcending the power plant's limits is also essential and involves local and national organizations and authorities in addition to the utility and the regulatory body. According to the international convention on early notification, all relevant information should be made available to all countries with potential impact from the emergency.

3.3.11. Communication

Implementation of an advanced computer based information management system capable of exchanging, controlling, and archiving all correspondences and publications of the project is needed at the start of the project. Through the use of high speed internet connections, the various sites with project related activities should be in contact at all times. In remote site locations where there may not be access to the national network of high speed data links a special satellite communication station should be set up for the project to link the project management team at the site to the suppliers' home offices, nuclear regulatory headquarters and other regulatory and licensing authorities.

3.4. Knowledge base and human resources

Development of adequate local knowledge and expertise for the development of the nuclear power plant is part of the basic infrastructure and in the long run is the most economical option for the country. The principle involved is to identify the knowledge base in the areas affecting the implementation of nuclear project and to develop human resources and educational institutions for their training as well as institutions for the discharge of their function.

3.4.1. Knowledge for government policy and support

In the first stage of the development of nuclear policy and conducting of conceptual studies, dedicated expertise in a number of areas should be employed by the NPIA in order to carry out the task of determining the need and establishing the national nuclear policy and priorities.

The depth of expertise of the resources available to the NPIA is of great significance to the success in the discharge of its mandate. The government should fund the NPIA, as its task is to determine if the nuclear power programme is beneficial to the country and if so develop the policy on the basis of which the private sector and/or the government utilities could embark on realization of the nuclear power projects. The size of the nuclear power agency can be kept to a basic through the use of expert advisors in each area of activity.

3.4.2. Functions and knowledge for nuclear regulatory body

A knowledgeable NRB is key to effective licensing of the nuclear plant and the timely issuing of the various permits and conducting of inspections. The laws and regulations governing the NRB must empower it with broad statutory authority and functional autonomy to carry out its functions independent of owners, operators, manufacturers and suppliers of nuclear power plants and other interested parties in both the public and private sectors. Qualified professionals to perform the major functions outlined in Fig. 5, of regulation, assessment, enforcement, and public information dissemination and exchange should staff the regulatory body.

All four functions of the regulatory body are required for its proper functioning. However the scope of activities and the level of staffing of each function vary with the size of nuclear power programme.

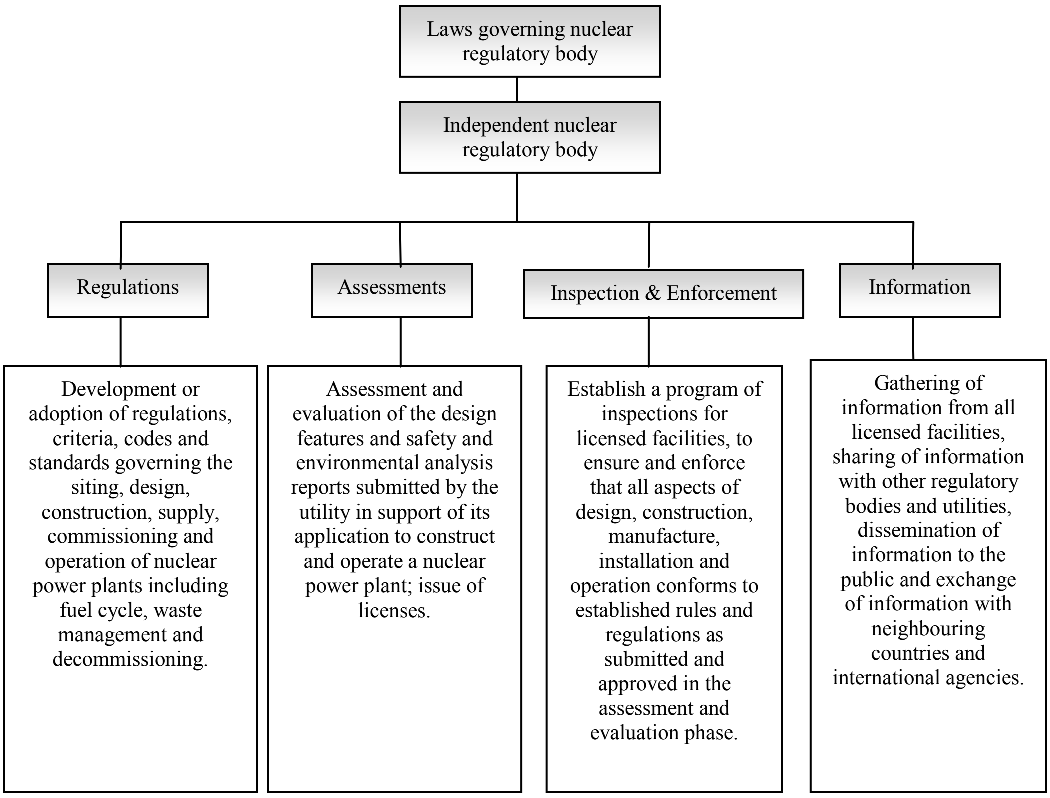


Fig. 5 Functions of nuclear regulatory body

The regulation function could be as comprehensive as the development of local requirements for licensing of reactors and development of local fuel and components manufacturing however, as a basic it will be the adoption of an internationally accepted set of requirements for licensing of the reactor such as those developed by the IAEA or by the country of origin of the reactor supplier or those of the countries that already have a fully developed nuclear regulatory regime.

Whether by developing its own or adopting international regulations, the NRB should address the following issues:

- Establishment of national nuclear safety regulations, design codes, and standards.
- Capability for technical assessment, design review and licensing of reactor, fuel and waste management facilities in all phases of siting, design, fabrication, manufacturing, construction, commissioning, and operation.
- Issuance of permits and licenses in various stages of the execution of the nuclear power project.
- Licensing of operators.
- Inspection of design and manufacturing facilities to ensure compliance with the requirements of the approved codes, standards, criteria, and specifications.
- Capability to address emergency and abnormal events regarding the security and safety of the nuclear power plants.

The human resource and physical facilities for the training and deployment of the required expertise will have to be sized to match the scope of the activities of the regulatory body.

3.4.3 Radiation knowledge and awareness among the workforce

As part of the development of construction and commissioning work force, training in radiation awareness is needed since the site will receive nuclear fuel in the commissioning phase. Such training should cover a range of topics such as:

- Radioactivity and its sources
- Radiation health (biological) effects
- Radiation protection methods and regulations
- Measuring of radiation
- Exposure and contamination control
- Handling of radioactive wastes
- Establishment of radiation protection programmes

The training should also cover the applied safety topics such as:
- Radiation detection instruments
- Troubleshooting instruments
- ·Radiation instruments laboratory
- Radiation safety surveys
- Releases and emergency response

It should be noted that when applying scientific and technical knowledge to plans and procedures that are to ensure radiation health and safety of the workers and the public, it is accuracy, integrity and honesty that are essential to successful outcome. Some of these traits can not be taught in a programme of technical courses and require special programme involving psychologists and behavioral scientists.

3.4.4. Economic and financing expertise and resources

The first step is to demonstrate that the economics of nuclear power is within the acceptable range for inclusion in the generation mix. Once the positive economics of nuclear power are demonstrated, the next step is to develop a financing model for the implementation of the project.

3.4.4.1. Economic assessment of nuclear power

The economic assessment of nuclear generation should be carried out for the lifetime of the facility and should consider all components of cost. Economic analysis should include the combined impact of cost and benefit factors including:

- Internal costs including siting and land acquisition, capital, financing, operation and maintenance, fuel cycle,
- Decommissioning and spent fuel disposal,
- External costs including infrastructure needs and impact on grid,
- Industrial benefits and job creation through localization of work,
- Environmental benefits through avoidance of carbon emissions, and
- Reduced foreign exchange for the import of fossil fuels.

The most common practice of carrying out economic analysis is to determine the present values of all costs and benefits and calculate the unit energy cost on a given base date.

Capital cost is the largest component of the unit energy cost and can be estimated fairly accurately for a given project implementation model. Operation and maintenance cost includes among other items, operation and maintenance staff, support and head office staff, spare parts and consumables, hardware, software and tools, capital improvements and upgrades, security, insurance and taxes, fees, contracts for special works, and outage management. Operation and maintenance cost can be assessed through exchanges with experienced operators of similar power plants. Fuel costs for short term and long term contracts can be obtained from international fuel suppliers. Medium term storage cost for the fuel can be obtained from the suppliers of this technology. Spent fuel disposal and decommissioning estimates are often less accurate and should be based on conservative assumptions. External costs for infrastructure and grid expansion are more complex to assess and should be spread over a number of reactors not to adversely affect the economics of the first project.

A simplified version of the unit energy cost calculation uses the real or nominal discount factor, which is defined by the utility or by the government for the energy sector projects or for nuclear power projects specifically. Alternatively the unit energy cost for a specific model of financing can be based on the actual terms and conditions of investment and loans used to fund the project.

In the early stages of economic analysis a simulation model (e.g. WASP [4]) is needed to determine the timing and size of the nuclear power option within the generation mix by considering the additional strategic and fuel availability constraints.

3.4.4.2. Funding of the nuclear power programme

For a country embarking on nuclear power programme, financing and economic resources should be assessed in two separate stages:

Stage 1 – Financing of the pre-project development programme

The activities of this stage include the establishment of policy and start up of nuclear infrastructure elements needed for the project implementation phase to begin. The funding for this stage should be provided through the government budgets. This activity will span a number of years and the programme set up by the NPIA will have to include a long term plan with defined schedule and milestones as well as budget allocations. In addition to the ministry responsible for nuclear energy, the involvement of the ministry of finance officials in the development of the pre-project development plan is essential. Compared to the investment needed for the implementation of nuclear project, the funds required for the pre-project activities are relatively small. Therefore, sufficient funds should be made available to allow the engagement of skilled personnel and expert consultants and contractors.

Stage 2 – Financing of project implementation

Financing of a nuclear power plant is the most challenging element of the realization of the project. The reasons for the difficulty in financing include high capital cost of nuclear plant in particular with reactor units with larger outputs, long schedule for environmental approval and construction, relatively higher project completion risk associated with the design, licensing and construction and finally the assumption of nuclear legacy obligations in waste and decommissioning. As a result there has been no nuclear project financed in recent years without the direct or indirect involvement of the government of either the country offering the technology or the country receiving it. The means of financial involvement of the government may include:

- Direct supply of funds to the project
- Guarantee of loans from export credit agencies and commercial banks
- Guarantee of long term power purchase agreements
- Agreement to assume all liabilities in case of the failure due to force majeur, political risk, etc
- Guarantee of project completion through backstopping of the vendor's fixed price and schedule commitment
- Assumption of waste and decommissioning liabilities beyond the provisions made by the utility throughout the operation of the plant

3.4.4.3. Methods of financing nuclear power plants

The financing approach to nuclear power plant is mostly affected by the ownership structure of the project and the strength and maturity of the electricity market. The financing of the nuclear projects could be fully supported by the government, it could be financed solely by private commercial companies and utilities, or it could be a financed by a public (government) private partnership. The difference is primarily in the assignment of financing and project risk and how the financing agencies are assured of the repayment of their loans.

a. Projects fully financed by government owned utility

In this case the utility is fully owned by the government and is mandated to implement the first nuclear power project and the project is financed through borrowing secured through final recourse to the government as the shareholder of the utility. This model, shown in Fig. 6, is used for initial implementation of most of the existing nuclear power plants around the world. The government support and ownership of the nuclear programme enhances also the development of localized nuclear infrastructure and support facilities and organizations.

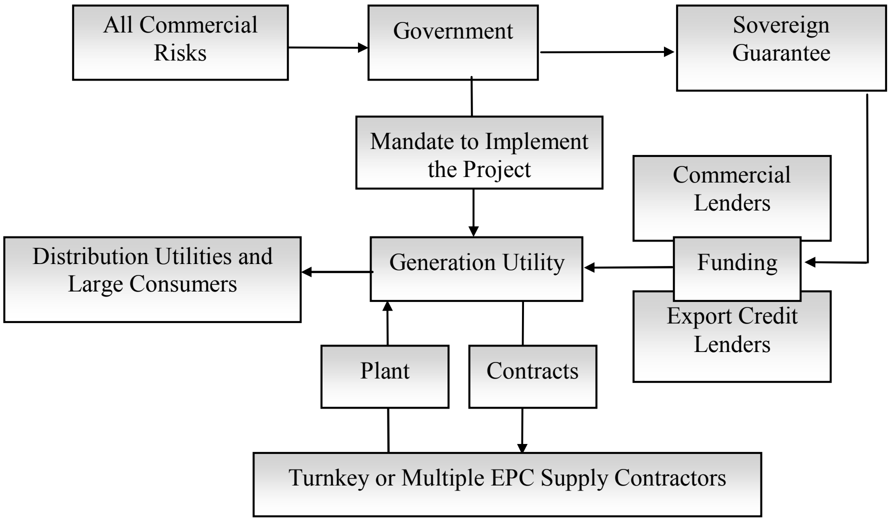


Fig. 6 Project fully financed through government guarantee

b. Projects fully financed by private sector utility

In this case, the utility is privately owned and has the financial strength and credibility to finance the project on its balance sheet and in a combination of equity and debt. The lenders in this case have recourse to the assets of the utility.

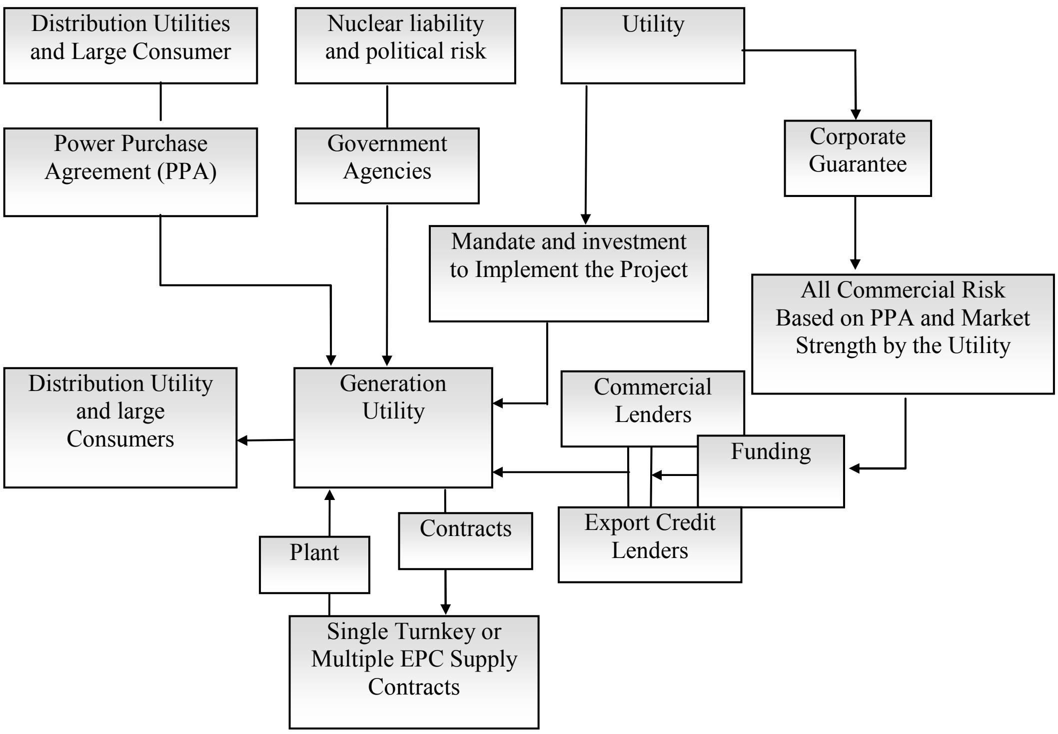


Fig. 7 Projects fully financed by private sector utility

This model, shown in Fig. 7, is used for fossil fuel generation facilities and is currently under consideration by utilities in North America and Europe for new reactor projects. Due to perception of nuclear project risk and its impact on the share values of the utilities, there is expectation of the government to participate in mitigation of project risks such as political, nuclear liability, force major and potential cost overruns of the first project.

c. Project financed by project financing model

To spread the nuclear project risk, a number of utilities and investors, which may include government, will pool together to form a commercial project company (PCO) to carry out the project. In this case, the project is financed on a combination of equity by the investors and debt through borrowing. The PCO in this case will have to demonstrate to the satisfaction of the lenders and investors that the electricity market is strong and electricity demand and prices are sufficient to guarantee the financing of the project.

A variation to the above model, shown in Fig. 8, is a public private partnership model in which the private sector investors bring the equity and loans and the government participates through assets and risk mitigation mechanisms such as a long term power purchase agreement.

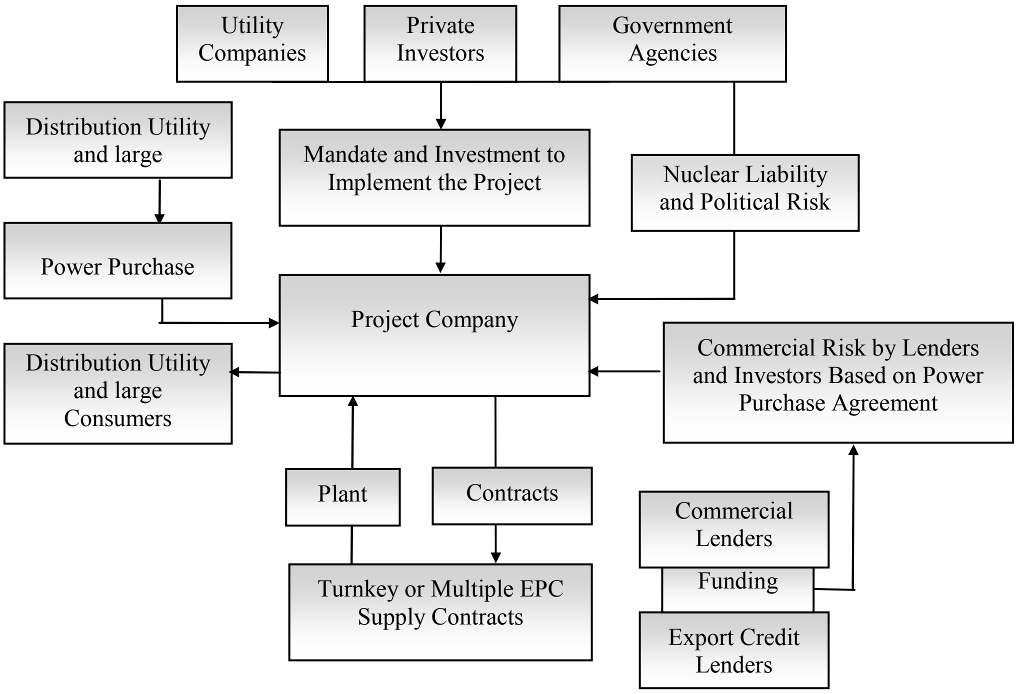


Fig. 8 Projects financed by project financing model

3.4.4.4 Financial and economic assessment

Financing of the project involves a combination debt and equity based on a defined security structure. The cost of financing depends of the strength of the security structure. In general, projects that are backed by the government guarantees or financially strong corporations are able to attract loans with better terms and conditions leading to lower financing cost.

Export credit agencies (ECA) of the supplier countries provide loans to cover the cost of the scope of work from the exporting country. In reality, most ECAs cover only 85% of the total value of the exports and there are restrictions attached to how much of the funds can be spent outside of the exporting country. Equity investment or commercial loans and bonds cover the local scope of work and those not funded by ECAs. The Table 3.1 shows the main financing data, which is required in order to assess the financing cost for the project.

Table 3.1: Main finance data

Loans by Commercial Banks:	**Equity from Investors:**
Management fee for commercial loan	Internal rate of return
Commitment fee for commercial loan	Period of return
Interest for commercial loan	Investment guarantee measures required if any
Repayment period for commercial loan	
Loan guarantee measures required by the banks	**Bonds:**
	Bonds rate
Loans from Export Credit Agencies (ECA):	Financing cost for bonds
Exposure fee (insurance premium) for export credit loans	Bonds retirement
Management fee for export credit loan	
Commitment fee for export credit loan	**Annual Operation Costs:**
Interest for export credit loan	Annual depreciation allowance
Repayment period for export credit loan	Annual decommissioning and waste management fund
Loan guarantee measures required by the ECA	Annual operation & maintenance and fuel cost

3.4.5 Human resources and educational programmes

Except nuclear safety and radiation protection, the majority of the technical expertise needed for the design, construction and operation of nuclear power plants is the same as for other large industrial or conventional power project. Nuclear safety and radiation protection require the establishment of a management system [5] with a much higher level of quality and safety requirements as well as the use of more advanced software and hardware tools in the analysis, design and installation of plant components and structures.

It is important that as part of the basic nuclear power infrastructure, human resources in the areas of design, construction, installation, commissioning and project management be developed in the country during the implementation of the first nuclear power projects. These services constitute a considerable portion of the project cost and their localization will reduce the cost of the subsequent nuclear power projects. The major specialties to be developed for the nuclear programme are as follows:

a. Nuclear plant design review capability

- Nuclear and reactor physics
- Thermal hydraulics methodologies for nuclear and process systems design
- Piping analysis and design including thermal, seismic and water hammer
- Electrical, control and instrumentation
- Structural analysis and design
- Nuclear fuel performance
- Containment systems design including reactor building structure
- Environmental qualification of equipment and systems
- Probabilistic safety analysis
- Radiation and shielding calculations and design
- Human factors engineering principles

The government or the utility should sponsor courses and training programmes for the development of this expertise. The programmes offered by IAEA through long term secondments to countries with nuclear power programme and through short term training programmes should also be considered. It is reasonable to assume that the local involvement in the engineering of the first project will be limited, however the contract with the technology supplier should include class room and on the job training for the transfer of design knowledge to local engineers and scientists.

In an effective localization of design engineering, a team of up to 200 experts with knowledge of design and licensing of nuclear power plant buildings, structures, system and components should be developed either in the government owned agencies or within the private sector engineering firms. With such a capability, and assuming significant standardization of the reactor design, the role of the supplier of technology in the subsequent projects can be reduced to supervising and reviewing.

A smaller team of nuclear design and engineering experts should be developed during the construction and commissioning of the nuclear plant to become part of the operation team of the in service unit. The number of experts needed for this team depends on the operating policy of the plant. Some utilities maintain a very small in house technical team and allow the private sector companies to develop the capability and provide the required services on contract.

The educational institutions and programmes required to develop the engineering expertise are:

- Nuclear design and engineering courses in a specialized nuclear power department or as part of the engineering and science departments for the training of plant design engineers and scientists.
- Specialized programmes in community colleges in specific technical areas such as quality assurance, radiation monitoring and protection, instrument calibrations, etc. for the training of technical experts.

b. Quality Assurance/Quality Management capability

QA/QM activities are part of the organization’s management system and require a formal process which includes preparation of procedures and training of personnel. The purpose of QA/QM is to support the assurance of quality complying with the applicable requirements in all phases of a nuclear power project such as design, procurement, construction, manufacturing, fabrication, commissioning, pre-operational and startup testing and finally operations. The activities of the QA/QM are in general uniform across the project, however the trained personnel will be specialized and assigned to specific disciplines in mechanical, electronics, electrical, and structural or other tasks for the duration of the project.

The QA/QM manual for the project should include the QA/QM organization and its required resources. In the first project the suppliers of nuclear technology could provide their QA/QM plan and procedures for all aspects of project execution as part of the contractual commitments. The role of the utility is to provide the required personnel with the appropriate “quality culture” to be trained to execute the QA/QM plan for the project. The main objective in training of the QA/QM personnel is to instill a responsible attitude towards quality, and radiation safety in the work force of the project. Training in QA/QM should lead to the development of three categories of QA/QM personnel for:

— planning and supervision of inspection and testing programmes,
— performing and documenting the inspections and tests in accordance with procedures
— evaluating the results and determining the adequacy of procedures

c. Project management capability

A successful nuclear project would have to put the plant into commercial operation in accordance with safety and licensing principles but also within the contract schedule and cost. It is reasonable to assume that the overwhelming majority of the work force deployed at the site should be local and should have the basic skills to carry out their assigned tasks. In addition to the general labor with limited or specialized skills, there is also the need for trained personnel to fill the positions within the project management team. The expertise required includes planning and scheduling, QA/QM, equipment and materials supply, field engineering, construction and installation, and commissioning. A typical project management structure is shown in Fig. 9.

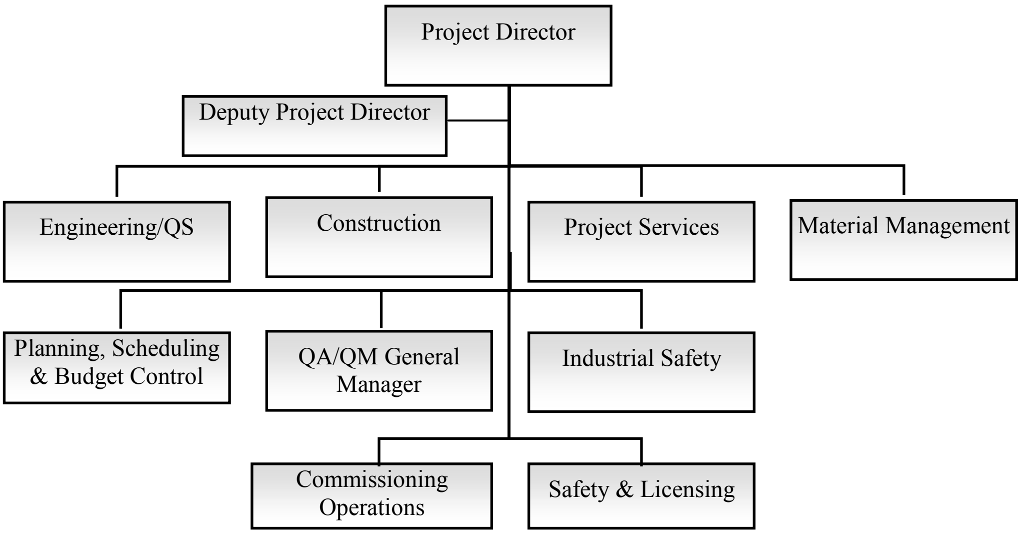


Fig. 9 Typical nuclear project management structure

d. Operational and maintenance capability

Development and training of operation and maintenance staff is through a planned programme, which starts with classroom training at the start of the project and is followed by on the job training during commissioning and testing activities of the project. Provision of a simulator is often part of the scope of supply of the plant. The simulator is used to train the operators before the start of the plant operation. Prior to the reactor criticality, sufficient number of operators should have received their operating license from the NRB.

3.4.6 Public consultation and environmental assessment process

Public consultation process may be carried out in two stages. In first stage, the public is consulted while assessing the appropriateness of nuclear power for implementation into the electricity generation mix. In the second stage, the public is consulted regarding the environmental impact of the siting and construction of each nuclear power plant. A pre-requisite to conducting public consultation in the second stage is the performance of an environmental assessment (EA), which addresses all aspects of the project. Local guidelines with due consideration given to international guidelines issued by the World Bank, OECD and ISO could be used for this purpose. The following issues are of significance and should be addressed in the EA reports.

a. Public consultation

The country's requirements for public consultation should be reviewed and the criteria and methodology for conducting of public consultation should be determined. In most cases public consultation requires the issuing of the EA report for public review and hence the process may be sequential to the preparation of EA report.

Participation in the public consultation should be made available to a wide range of stakeholders and sufficient time should be allocated in order to receive submissions, hold public hearings and respond to the views of the participants. Special attention should be paid to the views of the leaders of thought in the communities in the region around the selected site.

Disclosure of environmental assessment reports is a requirement in most countries and is demanded by regulatory and financing agencies. It requires the establishment of the local and planning inquiries and posting of the EA report on the Internet.

Public consultation should be addressed at national regional and local levels. It is the public acceptance, as much as possible, at the local level that has to be achieved for the start of the project. The main driver in obtaining this acceptance is the social and economic benefits of the project to the local area. Other drivers are improvement of health, education, safety and security for the people around the site locality. The proponent of the project should outline and promote such benefits to the local residents. Local leaders and persons of influence should also be engaged in the planning and be informed of the measures taken to maximize the local benefits and mitigate the adverse impacts of the project. Examples of such individuals are the elected municipal officials, academic teachers and administrators, health and safety officials, key business and industry leaders, religious leaders.

b. Cross boundary public consultation

This involves consideration of consultation with neighboring countries to fulfill the international requirements.

c. Role of non-governmental organizations

This poses a risk of potential challenges and delays to the project and should be managed with a proactive public relations programme and close adherence to the established basis and terms of reference.

d. Study of alternatives to the project and no project

Regulations in some countries require that the project proponents establish the advantages of the selected project over the alternative projects and to the case of having no project at all. Socio-economic, strategic, technical, and environmental aspects should be considered for this comparison. This study should demonstrate that the project is needed and is the preferred alternative from a combination of socio-economic, strategic, technical and environmental aspects.

e. Environmental effects of other projects in the area

The combined impact with other major industries in the affected area should be assessed in this study. This should include the construction as well as operation phase.

f. Environmental management plan (EMP) and system (EMS)

Upon the completion of EA process the EMP and EMS for the station should be established to ensure and demonstrate compliance with the requirements of the EA results. This includes adoption of a response plan in case of environmental emergency.

g. Establishment of legal and administrative framework

Based on a combination of national and international laws and regulations a formal regulatory document should be prepared to define the basis for the undertaking, preparation and approval of the EA report. The frameworks used by OECD, World Bank and export credit agencies can be used for this purpose.

3.5. Guidance and standards related with infrastructures issues

Several IAEA publications deal extensively with basic issues of infrastructure and provide detailed information on many aspects of adoption of a nuclear power programmeme. See references [6] to [15].

The IAEA Safety Standards Series provide recommendations for establishing the nuclear safety requirements. For standards that are in particular relevant regarding infrastructure subjects see references [16] to [20].

4. NUCLEAR POWER PROGRAMME IMPLEMENTATION

Establishment of government policy regarding implementation of nuclear power makes it possible for the country/utility to embark on the implementation of the first nuclear power plant. A number of activities would have to be undertaken following the formal approval of nuclear power by the government or the utility. These activities can, to a great extent, be undertaken in parallel and will lead to the preparation and issuing of bid specifications to potential reactor suppliers.

4.1. Site selection, environmental assessment and site permit

Nuclear power site selection is a lengthy and extensive activity requiring the engagement of a number of disciplines. In general a number of sites are considered first for a high level screening resulting in ranking of the sites and finally selection of the preferred site for full site investigation and environmental assessment. The major areas considered in the final investigation of the preferred site include:

- Integration into the electric grid system Geology, tectonics and volcanic
- Geology , tectonics and volcanic studies
- Seismology and seismic engineering
- Hydrology (including ground water, floods and tsunamis)

- Cooling water availability, intake and discharge
- Demography and land use
- Meteorology and atmospheric dispersion (including wind patterns, tornados and hurricanes)
- Study of flora and fauna
- Nuclear safety and radiation protection aspects
- General environmental effects
- Risks from man-made events
- Local infrastructure
- Cultural and historic sites
- Access and emergency response roads
- Air, land and sea transportation patterns
- Legal aspects
- Public consultation

Environmental assessment (EA) is a process that receives input from specialized technical studies, public and non-governmental organizations, neighboring countries, and governmental agencies. Following the best professional practices, the EA must demonstrate that all risks to the environment and to the public are mitigated to as low as reasonably achievable. In making this demonstration, the proponent of the project satisfies the requirements of the national and international environmental frameworks and regulations.

Following site selection and EA, the NRB will review the documentation and issue a site permit to the utility. The current trend is to issue a site permit for the envelop of the parameters of a number of nuclear power plant types prior to awarding a construction permit for the selected technology. This provides the utility the commercial flexibility for the competitive selection of the nuclear power plant.

4.2. Bid invitation specifications, bid evaluation and selection

Once the site is selected and the site parameters affecting the design of the plant are known, the technical specification for the plant should be prepared and the request for proposal should be issued. This activity requires a combination of technical, commercial and financing expertise and can benefit from engagement of an international consultant to coordinate the technical part of the specifications.

The utility undertaking the task of implementing the nuclear project should acquire adequate knowledge of the bidding process and technology assessment as well as sufficient funds and human resources to carry out the task. The utility for this purpose should develop in house resources and engage expert consultants in all areas of customer/supplier interface. The consultant selected should have experience in all technologies for which proposals are requested.

Once the expertise is made available a decision will have to be made on the project commercial model. The types of contract model can vary from a single turnkey model in which the utility role is minimized to a multiple package model with a significant role played by the utility.

4.2.1. Types of contractual approach

Basically there are three different types of contractual approach that have been applied for nuclear power plant projects.

- *Turnkey contract*: a single contractor or a consortium of contractors takes the technical responsibility for the whole nuclear power plant project

In this type of contract the contractor has total responsibility from site preparation to commissioning of the nuclear power plant and hand over to the utility after satisfactory demonstration of its operation at rated capacity. A turnkey model is often used for the first project and also on subsequent projects when the country and utility have no long term plans for a comprehensive localization of the nuclear technology.

The turnkey supplier is contracted to initiate, manage and complete all activities from site preparation and site infrastructure all the way to commissioning and putting the plant in commercial service. The role of the utility in this model includes approval of invoices and supply of funds, contract administration and supervision, periodic technical and financial audits, obtaining of permits and licenses from the local and national authorities, and assumption of risks not accepted by the contractors. The utility also assumes the nuclear liability and the responsibility for decommissioning and final spent fuel disposal. A variation to the turnkey model is when the owner's scope, which often does not require high technology capability, is carried out by the utility. The utility's scope may include:

- Site preparation and clearing
- Bulk excavation
- Water and power supply
- Roads and harbors
- Construction and operation of the townsite,
- Civil structures for cooling water system
- Supply of commissioning and operation staff for training

- *Split-package*: the overall responsibility is divided between a relatively small number of contractors, each building a large section of the work.

The scope of the nuclear power plant consists of distinct parts, which can be supplied through separate contracts. The breakdown can be done into two main contracts: for a nuclear island and a turbine generator island (two-package approach) or into more packages (i.e. three to five-split-package approach).

- *Multi-contract*: the utility or its architect-engineer assumes overall responsibility for engineering the station, issuing a large number of contracts

Based on the nuclear steam supply system and turbine generator contracted for supply, the architect-engineer designs the balance of plant around this equipment. For this model to be successful, the utility should have extensive experience in contracting and management of large projects. The utility can adopt this model and progressively increase the national scope of supply and services in the successive projects. In this model the packages and island each have their own contracts with clear interface definition. The nuclear island supplier will warrant the steam quality and fuel burn up and the turbine generator supplier will warrant the electrical output based on the interface parameter specified in the respective contracts.

4.2.2. Content of bid specifications

Regardless of the contract model the bid specifications should address issues such as:

- General Terms and Conditions
- Definitions
- Required contract documents and correspondences
- Languages of the contract
- Conditions precedent and effective date of the contract
- Scope of the total supply and services
- Technical specifications of the supplies and services
- Scope of supply and services by the utility
- Scope of supply and services by the supplier
- Relations between the owner, supplier and third parties
- Price, price adjustments and terms of payment
- Invoicing
- Project schedule
- Applicable laws, decrees, codes and regulations
- Permits, licenses and authorizations from country authorities
- Quality assurance/Quality Management programme
- Inspection and testing
- Review of project documents and drawings
- Shipment and transportation
- Survey and inspection of civil and electromechanical installations, materials and equipment
- Progress reports
- Procedure for changes to the contract
- Provisional acceptance and transfer of possession
- Final acceptance
- Warranties, liabilities, penalties and liquidated damages
- Ejection and suspension of work and termination and/or liquidation of the contract
- Assignment of the contract, substitution and transfer
- Patents and royalties
- Taxes, custom duties, insurance and other fees
- Disputes
- Nuclear liability

The bid specification should outline the evaluation criteria, which informs the bidders of the various basic, required, desirable and optional aspects of the bid request. The bidders will utilize these criteria to structure their bids from a competitive point of view. The bid specifications should also identify the weight given by the utility to technical excellence, commercial compliance, price and financing terms of the bids.

4.2.3. Evaluation of the proposals and ranking of the bids

Proposal evaluation is carried out on the basis of the criteria outlined in the bid specification. The evaluation criterion is often carried out in four stages, which address basic, technical, commercial, and financing requirements of the utility. The completion of these stages of evaluation should lead to the ranking of the proposals and identification of the preferred bids.

During the bid evaluation, the utility could choose the option of inviting the bidders to clarification meetings in which the utility describes the deficiencies of the bids and the bidders are given the opportunity to remedy the deficiency. In general, most owners do not accept any deviation from the specified commercial terms and conditions since it will not be easy to convert such deficiencies to an equivalent increase in the price of the proposal.

4.2.4. Negotiations and contracts

Contract negotiations cover technical, commercial and financing aspects of the project. In general, the technical and commercial contracts should clearly identify the scope of the work of the supplier and the owner, schedule, price, performance parameters, warranties, rights and obligations of the utility and the supplier, and mechanisms of reviews, adjustments, approvals and dispute resolution. Financing contracts are concluded among project equity holders, lending agencies and electricity off-takers. The contract effective date (CED) being the first day of the project schedule is the day that all technical, commercial, and financing contracts for the project are signed.

4.3. Project Quality Assurance/Quality Management manual

Shortly following the CED, the utility should submit the project QA/QM manual to the regulatory body. The project QA/QM manual defines the procedures for quality execution of the work, project management structure, lines of authority, decision making and accountability, interface control between various disciplines of work and stages of construction.

4.4. Construction license

The project work starts at the contract effective date. Site infrastructure work can begin immediately following CED. However, placement of the first concrete and ordering of major nuclear equipment may not be allowed until the approval of the preliminary safety analysis report (PSAR) and other regulatory requirements by the NRB.

4.5. Operation License

Once the contract has progressed to the point when the commissioning tests are completed and the reactor is to achieve criticality, various operational licenses are to be issued by the NRB allowing the reactor power to be raised to 100% for the completion of the full power test. Once the NRB is satisfied with the reactor performance at various power levels, as well as with the fulfillment of any other regulatory requirement, the full operating license will be issued prior to the start of the commercial operation of the reactor.

4.6. Emergency response preparedness plan

As part of the operating procedures of the nuclear power plant an emergency response preparedness plan should be prepared and approved by the NRB and the national and local authorities prior to the start of operation. The role of the plant operation team, the NRB, the government and local authorities should be clearly defined. The plan should also comply with early notification requirements of the relevant international conventions. Emergency response plans requires multiple paths of access to and evacuation from the plant and its immediate area, and should be considered as part of the basic infrastructure.

4.7. Fuel supply policy and contracts

Long term supply of fuel should be secured through long term contracts with internationally recognized fuel manufacturers. In general, local fuel fabrication for a small number of reactors may not be economically justifiable. However, many countries have localized fuel fabrication for strategic reasons such as industrial benefits and security of supply. In general there are two types of nuclear fuel:

- Enriched uranium fuel used in light water cooled and gas cooled reactors
- Natural uranium fuel used in heavy water cooled reactors

Enrichment technology is most likely not feasible for the countries starting nuclear programme.

4.8. Radioactive waste and spent fuel management

The waste management issue requires a combination of technical, political and public relations effort. The strategy for waste management can be determined through a review of the current commercially available interim spent fuel storage technologies and the disposal strategy can be developed over a longer period based on technologies under development in several countries around the world. The political and public relations implication of the nuclear waste issue in the country can be addressed jointly by the utility and the special organization set up by the government for nuclear waste management and decommissioning planning.

4.9. Decommissioning

National legislation should assign roles, responsibilities and legal procedures for the permanent shutdown, operation-to-decommissioning transition and decommissioning process. This should include inter alias provisions to allocate decommissioning funds over the facility’s lifetime including contingencies.

5. RESOURCES NEEDED FOR BASIC NUCLEAR POWER INFRASTRUCTURE

The basic infrastructure for the activities, institutions and facilities described in previous sections is a function of the size of the intended nuclear programme and the extent of the desired localization of technology and supply chain. In this section the resources for the basic infrastructure needed for the implementation of the nuclear power project are outlined.

The role of different organizations in the development of basic infrastructure should be determined at the onset with allocation of adequate funds and other resources. Table 5.1 provides an example for the division of responsibilities.

Table 5.1: Example for the division of responsibilities

Division of Responsibility for the Establishment of Basic Nuclear Power Infrastructure			
Infrastructure Issue	**Responsible**	**Funding and Implementing Organizations**	
		Primary	Supporting
Nuclear Power Implementation Agency (NPIA)	Government	Ministry of Energy	Other Ministries and Existing Nuclear R&D Institutes
Nuclear Power Policy	Government	NPIA	Ministry of Energy
Nuclear Related Laws	Government	NPIA	Ministry of Justice
Nuclear Regulatory Body	Government	Government	NPIA
Educational Institutions	Government	NPIA	Ministry of Education
Economic Assessment	Utility	Utility Finance and Commercial Department	NPIA
Financing Assessment	Utility	Utility Finance and Commercial Department	NPIA, Ministry of Finance, Consultants
Public consultation	Utility	Utility Public Relations Department	Consultants, Ministry of Environment
Siting and Site Infrastructure	Utility	Utility Technical Department	Consultant, Ministries of Energy and Industry
Grid Strengthening	Utility	Transmission Utility	Department of Energy
Transportation Means	Utility	Utility Technical Department	Ministry of Transport
Environmental Assessment	Utility	Utility Technical Department	Consultants, NRB, Ministry of Environment
Bid Request, Evaluation and Vendor Selection	Utility	Utility Technical and Commercial Departments	Consultant, Ministry of Energy
Licensing	Utility	Utility Technical Department	NRB, Consultant
Emergency Planning	Utility	Utility Technical Department	NRB, Consultant
National Laboratories	Government	NPIA	Ministries of Industry, Science and Technology
Engineering	Utility	Private Sector Companies	Utility, Ministries of Industry and Energy
Project Management and Commissioning	Utility	Private Sector Companies	Utility, Ministries of Industry and Energy
Fuel Supply	Utility	Utility Through International Suppliers	NRB, Ministries of Energy and Foreign Affairs
Waste Management	Utility	Utility	NPIA, NRB, Waste Management and Decommissioning Authority

In the following sub-sections the resource aspects of basic infrastructure are outlined for:

- Development of nuclear policy
- Nuclear regulations and regulatory body
- Economics and financing
- Nuclear technology selection and project implementation
- Fuel supply, radioactive waste and spent fuel management

— Physical facilities to implement the project
— National and international nuclear laws, treaties and conventions
— Additional educational programmes and human resources development
— Potential government incentives to be included in basic infrastructure

It should be noted that there is overlap of resources and actions among the charts in these subsections. The total resources and facilities should therefore be optimized in order to avoid redundancies and gaps

The basic human resources specified in the following subsections are considered to be the nucleus of the teams assigned to carry out the specific project tasks and should, as part of their mandate, specify the additional resources required to complete the task.

When the project development tasks are sequential, human resources can be shared among tasks in order to speed up the activities and further simplify the infrastructure needs. Therefore, as the initial activities of the NPIA are completed, the experienced resources can be redeployed in the various project implementation phases.

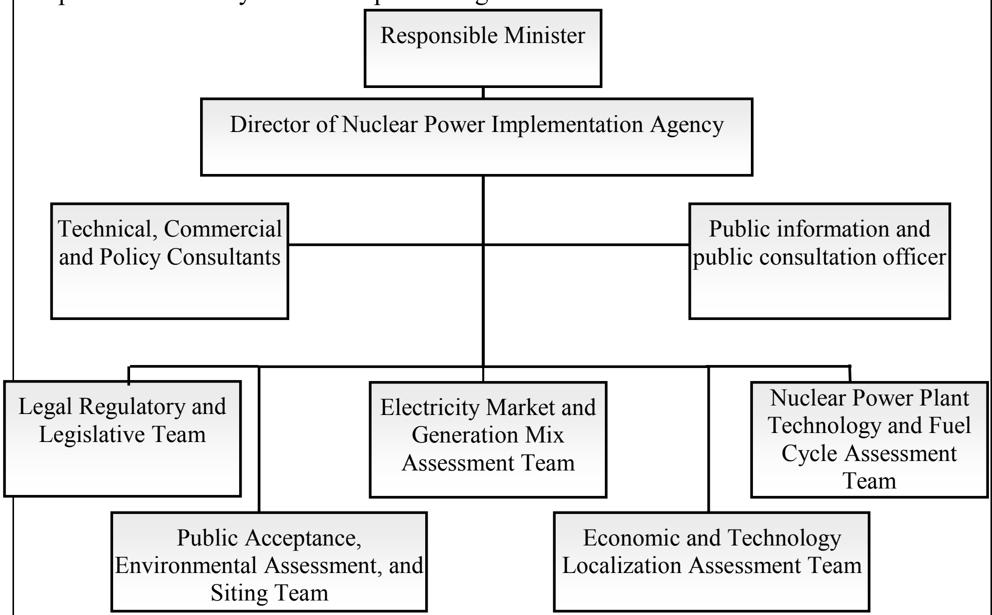
In many countries, an agency dedicated to the study, application and regulation of nuclear science and technology exists even if there are no nuclear power plants in operation. It is advisable to assess and utilize the expertise within such agencies in the development of the basic nuclear power infrastructure.

It is essential that the NRB be established or expanded with its own human resources, which is independent of the NPIA and the project implementation.

5.1. Development of nuclear policy

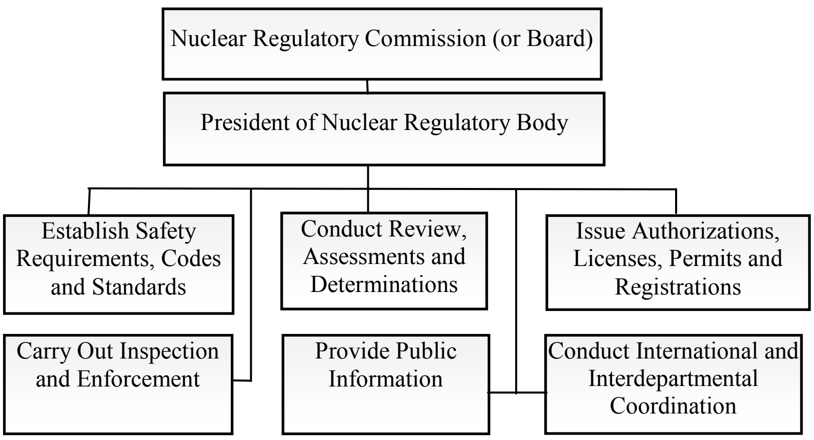
Table 5.2: Basic infrastructure for development of nuclear policy

Infrastructure Item	Description
1. Establishment of a "Nuclear Power Implementation Agency" (by the government)	Once there are indications that nuclear power option may be needed to meet the electricity demand of the country, the government should establish a high level "Nuclear Power Implementation Agency" (NPIA).
2. Objective of the NPIA	The objective of the NPIA is to carry out an overall assessment of all aspects of the nuclear power option and make a recommendation to the government. The NPIA would also lead the definition and implementation of infrastructure issues and their basic needs. The objective and scope of activities of NPIA are further described in sub-section 2.2.

3. Structure of the NPIA (by the government)	The government determines the structure of the NPIA and provides the required funds for the engagement of the necessary resources to carry out its activities. Director of the NPIA should have a high rank at the level of reporting to a minister or deputy minister. Technical staff for each activity should be supported by the work contracted to expert consultants. A period of 1.5 to 2 years is needed for the NPIA to conclude its studies and make a recommendation to the government. Parallel with the development of policy and if advisable, the NPIA can also draft the required nuclear legislation, determine the structure of the regulatory bodies and the responsible authority for each aspect of regulation. 
4. Basic Resources and Enablers for the NPIA (by the government)	The government should provide the funds needed for the NPIA to acquire the required expert staff and other enablers. These include: • Clear mandate and authority from government vested in NPIA and its director • Adequate funding by the government for the duration of the NPIA activities • Schedule of activities with defined milestones • Office space, office equipment, and reference publications • Liaison with IAEA technical services departments and training programmes • Access to IAEA technical publications, guidelines and design guides • Access to preliminary technical and economic data from reactor technology suppliers • Access to facilities and resources to hold public information, consultations and hearings events **Basic human resources may include**: • One policy, legislative, regulatory and legal expert • One environmental assessment and siting expert • Two nuclear power plant experts including fuel cycle and waste management • One public information and public relations expert • One energy economics, financing and commercial expert • One electricity generation and demand supply expert • One industrial benefits and localization expert • Required consultants and staff to support the work of the NPIA These positions could be combined or be part time if extensive use is made of the services of expert consultants

5.2. Nuclear regulations and regulatory body

Table 5.3: Basic infrastructures in establishment of regulations and regulatory body

Infrastructure item	Description
1. Draft legislation for the establishment of nuclear regulatory body (by NPIA)	The NPIA will assist the responsible ministry, to prepare and ratify the necessary legislation for the establishment of the nuclear regulatory body (NRB) and determination of its mandate and functions. In achieving this objective, the NPIA should: • Use IAEA Handbook on Nuclear Law [6] and engage expert legal consultant to draft the required legislation. • Determine the basic structure of NRB that meets the requirements of the legislation and the nuclear programme • Determine and provide funding for the NRB as part of the national budget **Basic human resources may include**: • One policy, administrative and legislative expert • One legal expert in nuclear affairs • One expert in nuclear regulatory, review, licensing and enforcement process • One expert on radiation protection, transport and physical protection. • Additional consultants and advisors as required to complete the legislative process for the establishment of nuclear industry
2. Defined nuclear regulatory body (by the NPIA)	NPIA will establish the NRB, or expand the existing NRB to address the regulatory, assessment, licensing, enforcement and public information tasks related to the first nuclear power plant. To achieve this the NPIA should: • Establish the NRB or expand the existing NRB, which is independent of the nuclear industry and of the operating utilities and is accountable to the parliament • Establish the concept of a Nuclear Regulatory Board or Commission to be the final decision maker for the regulatory, licensing and enforcement issues • Establish the position of the operational head or President of the NRB and competent organization to carry out the activities • Establish the organizational structure and human resource needs of a basic NRB. A possible structure may be:  **Basic human resources may include**: In addition to the resources in item 1 above: • Additional experts or consultants as required for developing the mandate of the NRB and its organizational structure

3. Nuclear regulatory safety requirements, codes and standards (by NRB)	The NRB should assume and exercise its responsibility through the establishment of a set of regulatory requirements, and guides. • Consideration of IAEA safety standards to set the general requirements for the assessment of potential technologies • The requirements should permit the consideration of all credible reactor designs by the sponsoring utilities • Once the utility has selected the reactor to be implemented, arrange and obtain comprehensive training from IAEA and the NRB of the country of the origin of the selected reactor • Adopt the basic nuclear safety and licensing regulations, design and manufacturing codes and standards, and QA/QM standards based on a combination of the IAEA safety standards and of the regulatory regime of the country of origin of the reactor • As time progresses, the NRB may expand and adjust its regulatory codes and standards to address the country's specific public safety and security concerns **Basic human resources may include**: In addition to the resources in items 1 and 2 above: • Two to four experts in nuclear safety and probabilistic safety assessment • Two experts in power plant technologies • One expert in nuclear fuel cycle, including the back end • One expert in process and mechanical systems and equipment • One expert in electrical, control and instrumentation technologies • One human factors expert • One expert in software development and qualification • One expert in layout and design of buildings and structures • One expert in seismic hazard assessment for the site and seismic analysis and qualification for structures and components • One expert in QA/QM including surveillance, audits and inspections • One expert in nuclear law and international conventions and treaties • Additional staff and expert consultants as required In addition to human resources above: • Complete set of IAEA safety standards and related guidance publications • Complete set of regulatory documents from the country of origin of the selected reactor The initial task of the NRB staff is to establish the basis for nuclear plant design requirements, codes and standards on the basis of which the utility can request bids from the vendors and select the reactor to be constructed at its approved site. Once the regulations, codes and standards are established, the above team will become the core staff of the NRB and will recruit additional staff as required by the workload during the licensing of the first nuclear power plant project.
4. Nuclear regulatory review, assessment and determination and licensing process (by NRB)	The NRB should establish the framework, organization and procedures to undertake the assessment, determination and licensing of the selected reactor. This assessment and determination process starts once the utility has selected the reactor and has applied for the licensing of the reactor for a specific site. In this phase, the NRBs are pursuing two different approaches at this time: • A traditional approach is to first review the site investigation and environment assessment documentation, which may cover the parameters for the selected reactor or the envelope of parameters for a number of reactor types and issue site license to the utility. This is followed by construction license based on preliminary safety analysis report of the selected reactor and finally operation

	license based on the final safety analysis report prepared during the commissioning and testing of the plant. • A second approach followed currently by the US Nuclear Regulatory Commission, is to first consider an early site permit (ESP) based on the site investigation and environment assessment documentation which may cover the envelope of the parameters of a number of reactor types (this is similar to the previous approach). This is followed by a combined construction and operation license (COL) for the selected reactor based on the review of sufficient documentation on the design, construction and operation of the reactor at the start of construction. Successful licensing of the first nuclear power plant can be achieved by: • Clear identification of deliverables and milestones for the applicant to prepare and submit in a timely manner • Adopting as closely as possible the review process followed by the country of origin of the reactor supplier or those of the countries that already have a fully developed nuclear regulatory regime • The services of expert consultants to assist in the activities related to review of safety and licensing documents and of the reactor design • A predictable process that gains the confidence of the applicant utilities and investors • A transparent process that gains the confidence of the general public as well as the various interest groups **Basic resources**: By utilizing the core human resources in 1, 2, and 3 above: • Create and staff an organization for the NRB along the lines of function and activities
5. Environmental regulations (by the utility and by the NRB)	The responsible ministry or the agency in charge of the environmental protection may undertake the overall aspects of the environmental impact assessment (EIA) process. The role of the NRB in the EIA process is related to the radiological aspects of nuclear power. The organization responsible for the EIA should: • Establish framework, criteria and process for the EIA of the nuclear project • Define a process for technical assessments, public consultation and formal review • Develop relations between the nuclear and the environmental regulatory agencies for division of responsibility and elimination of duplication (in general the aspects of radiation safety and plant security by the NRB and other environmental aspects by the environmental regulatory body) • Review and adopt its environmental assessment framework from among those of the World Bank, EBRD, OECD, ISO and export credit agencies. • Engage, if necessary, the services of an environmental consultant with nuclear knowledge to advise on the establishment of the process and regulations **Basic human resources may include**: • One expert in environmental assessment of large infrastructure projects • One expert in nuclear safety, waste management and physical security • One expert in public consultation and public hearings • Additional experts or expert consultants as required to carry out the required tasks in the environmental review and approval process
6. Transparency, accountability and predictability (by NRB)	The NRB should adhere to the principle of transparency and accountability in the process: • Transparency in the nuclear regulatory process is essential for the development

	of public support and confidence in the nuclear industry • The NRB will determine clearly the extent of information and documentation, which will be in public domain • The NRB will recognize the extent of the information which will be in controlled domain due to commercial or security considerations • Expert consultants will be engaged to assist in demarcation of public and controlled information The NRB will be accountable to a high authority and will be independent of the hierarchy of nuclear industry and of the electrical utilities. This authority could be a combination of the parliament and the office of the auditor general. The NRB should adhere to the principle of predictability in the process: • Predictability in the nuclear regulatory process is essential for the development of commercial confidence in the energy investment community • The legal basis of the regulatory process is established such as to provide closure to the public consultation process, once the public questions, objections and comments are obtained and response to them from the project sponsor, satisfactory to the competent authorities, is received • The nuclear regulatory rules and process are established such as to provide assurance of licensability to the utility at the time of the issue of the construction license conditional that commitments made at the time are fully met before the start of the operation of the plant • Expert consultants are engaged to assist in determining the extent of design, construction and operating information and documentation needed at the time of the issue of construction license

5.3. Economics and financing

Table 5.4: Basic infrastructure for financing of nuclear power plants

Infrastructure Item	**Description**
1. Assessment of nuclear power economics in comparison with other fuel cycles (by NPIA)	In the policy development phase and as part of assessing the nuclear option, NPIA allocates funds to: • Establish the overall economic viability of the nuclear option by assessing capital, operation, fuel, waste management and decommissioning costs • Assess project commercial risks and their associated costs • Determine unit energy cost and demonstrate the competitiveness of nuclear option • Assess potential financing resources and options • Receive approval from government to proceed to the next stages of project development **Basic human resources may include**: • One expert in energy and nuclear power costing and economics • One expert in financing arrangements and structures • Expert consultant advice as required

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<tr><td>2. Establishment of the specific project cost and business model (by the utility)</td><td>In the implementation phase, the utility (or the implementer of the first nuclear power plant) allocates the funds to carry out a detailed economic analysis of the selected nuclear power project and the business model for its implementation. The business model can fall into one of the following types:
• Investment by the government or government owned utility for base load security
• Investment by the utility with government incentives such as risk coverage, power purchase agreements or capacity contracts
• Investment by utility on its balance sheet in a liberalized market
• Public private participation model between government and private sector through formation of a project company

Basic human resources may include:
• One expert in nuclear project costing and economics,
• One expert in financing and financial operations of nuclear utilities
• One expert in electricity market regulations, demand supply and pricing
• Additional expert consultants as required</td></tr>
<tr><td>3. Project execution model and risk assessment (by the utility)</td><td>In the implementation phase, the utility (or the implementer of the first nuclear power plant) allocates the funds to:
• Identify the utility (or the government agency) responsible for development, funding and financing of the nuclear power project

• Establish the project execution model by considering the project management and procurement capabilities of the utility:
o Turnkey model
o Split package model
o Multi- package model

• Identify the license holder
• Identify the entity for project management
• Identify the owner’s representative
• Identify all national and local agencies involved in the issuing of licenses and permits such as:
o Nuclear regulatory body (NRB)
o Environmental approval authority
o Nuclear liability and waste management agency
o Customs
o Pressure vessel and nuclear component registration
o Fire protection
o Emergency response
o Transportation authorities
o Industrial safety and labor relations

• Identify the entities responsible for:
o Financing guarantees
o Project management and completion
o Project cost and schedule
o Risks associated with planning, consents, licenses, permits and authorizations
o Operational performance
o Electricity selling
o Transmission and distribution
o Nuclear liability</td></tr>
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	Basic resources may include: • One project management and procurement expert • One expert in financing and project structure • One expert in nuclear project licensing and implementation activities • One expert in commercial risk assessment and insurance • Input from reactor, turbine generator and auxiliary systems suppliers • Expert consultant advice as required

4. Financing of the Project (by the utility)	In this phase of implementation the utility will carry out a detailed financial feasibility study to demonstrate the positive economics of the nuclear power in general. No specific technology is needed to be selected in this stage however, preliminary technical and commercial input from the nuclear technology suppliers is needed to arrive at credible conclusions. In this study, the utility will also determine a financing plan and business model for the project.
	
	For this purpose, the utility (or the implementer of the first nuclear power plant) allocates the funds to carry out the following activities.
	
	• Examine potential investment and financing issues such as:
	  o Country/utility's credit rating with the international funding and rating agencies
	  o Possibility of government guarantee of financing for the project
	  o Possibility of financing of the project on utility company credit
	  o Feasibility of forming a project company to finance the project on the credit of its shareholders
	  o Establishment of a merchant plant based on the strength of the national and regional electricity markets
	  o Mechanism for providing government guaranteed power purchase agreement to the utility
	  o Establishing a pool of large power purchasers with proportional share of investment in the project
	  o Assess the electricity market and its potential for return on investment for the private investors
	• Engage expertise and input from ministry of finance of the country in support of the financing activities
	
	• Determine optimum debt to equity ratio based on the sources of funding such as:
	  o Extent of government and private investor interest in the project and their expectation of return
	  o Possibility of loans from export credit agencies
	  o Possibility of loans from commercial banks
	  o Potential for bond issue
	
	• Determine a realistic cost for various possible financing models recognizing that as the project model commercial risk increases, the cost of financing and therefore electricity generation increases also
	
	• Determine and recommend the optimum and feasible project implementation and financing plan
	
	Basic resources may include:
	• Two experts in nuclear project economics, financing, commercial risks and insurance
	• Two experts in nuclear power technologies
	• Input and cooperation from nuclear power technology suppliers
	• Input and cooperation from export credit agencies, commercial banks and investment firms
	• Input and cooperation from ministry of finance
	• Expert consultant advice as required
	• A credible financing advisory firm with extensive knowledge of nuclear projects to lead the financial feasibility study

5. Nuclear liability insurance coverage (by the utility and the government)	In the policy development phase, NPIA allocates the funds to develop and ratify nuclear liability legislation to provide: • Liability insurance by the utility, if possible, up to the limit required by the relevant international convention • Liability coverage by the government beyond the capability of the utility **Basic human resources may include:** • One expert in nuclear liability laws and conventions. • Expert consultant advice as required
6. Decommissioning and radioactive waste and spent fuel management fund system (by NPIA)	In the policy development phase, NPIA allocates the funds to develop nuclear waste and decommissioning legislation for ratification by the government. In addition the NPIA should: • Ensure that sufficient funding for storage and disposal of all levels of waste is included in the tariffs and is set aside by the utility from the start of operation. • Ensure that the operating utility, as a license holder, is responsible and has the capability for the waste management and decommissioning planning and implementation • Establish national nuclear waste and decommissioning authority to ensure that plans are in place, from the beginning, for the storage and disposal of spent fuel and irradiated waste from, operation and decommissioning (initially this could be part of the authority of the NPIA or NRB activities). **Basic human resources may include:** • One expert in waste management and decommissioning technologies and their economics. • Expert consultant advise as required
7. Identification of the required government incentives (by NPIA)	In the policy development and project implementation phases, NPIA should allocate the funds to assess and identify possible incentives needed to facilitate the implementation of the initial nuclear power projects. The mechanisms by which such incentives could be made available by the government include: • Project completion risk sharing during implementation with transfer of risk to utility at service date • Tax credits during construction and/or early operation years • Base load capacity payments • Government floor price guarantee to the utility • Accelerated depreciation schemes • Clean air and carbon displacement credits • Funding of nuclear regulatory agencies • Long term power purchase agreements **Basic resources may include:** • One expert in government funding, taxation and accounting • One expert in the structure of the electricity market including emission trading schemes • Input and cooperation from ministry of finance
8. Electricity trading arrangements (by NPIA)	In the policy development phase, the NPIA should allocate funds to assess the long term electricity market structure to demonstrate its strength and stability that is required by large output and high capital cost nuclear power projects. The long term role of the government in control and regulation of the market, ownership of generation facilities and financial support for new base load generation should be made clear as part of this assessment.

	Basic resources may include: • One expert in the structure of the electricity market • Input and cooperation from independent electricity market operator or the agency in charge of security of electricity supply

5.4. Nuclear technology selection and project implementation

Table 5.5: Infrastructure for the assessment of nuclear technologies, bid specifications, bids evaluation and contract negotiation

1. General	This is a summary of actions to be undertaken and resources to be engaged by the utility in the project implementation phase for the assessment and selection of the preferred nuclear power plant. All credible reactor technology types may be considered as potential alternatives in order to obtain the most technically beneficial and economically advantageous option.
2. Decision to proceed with nuclear power (by the government)	The government should review, modify if needed and adopt the policies and regulations developed by the NPIA for the establishment of the nuclear power plant programme. This includes allocation of resources and funding for the completion of of pre-project phases carried out by NPIA as described in Section 5.1.
3. Project model and financing structure (by the utility)	Once given the mandate, the utility (or the implementer of the first nuclear plant), should fund the activities required to determine the project execution model and financing plan. The details of these activities are described in Chart 5.3.
4. Preparation of bid invitation specification (by the utility)	Bid invitation specifications documents should outline the general, technical, commercial and financing requirements of the utility. The technical requirement should be set up such as to allow as many of the reactor suppliers as possible to participate by bidding for the project. The bid invitation should also outline the bid evaluation criteria which in turn may assign rank and weight to various aspects of bid specification in accordance with their importance to the utility. In the implementation of the first nuclear project, risk mitigation and economics of electricity generation are the highest priority requirements. The services of an internationally credible consulting firm are advisable in order to provide direction and expertise in different areas of activity. The architect/engineering firms with experience in nuclear power are suitable candidates for this purpose. The future role of such consulting firm in the project should be defined from the start in order to avoid complexities related to potential conflict of interest. IAEA publication "TECDOC 919 – Management of Procurement Activities in a Nuclear Installation" provides guidance regarding the selection of the consultant for these activities. Responding to request for proposal is a costly undertaking for the reactor suppliers. As a result, bid request and evaluation activities should be conducted with high degree of professional competence in order to provide confidence to the potential bidders. **Basic resources may include:** • One expert familiar with local commercial requirements • One expert familiar with local industrial and project management requirements • One expert familiar with training and technology localization • One expert familiar with assessment of risk and ranking of general, commercial and technical specifications on the basis of their risk impact and significance. • A number of support staff and expert technical consultant with knowledge of reactor plant, balance of plant, fuel cycles and waste management • Two experts familiar with the licensing process in the country and in the countries with established nuclear regulatory regime • An expert consulting firm to provide technical and commercial expertise to the project implementation team

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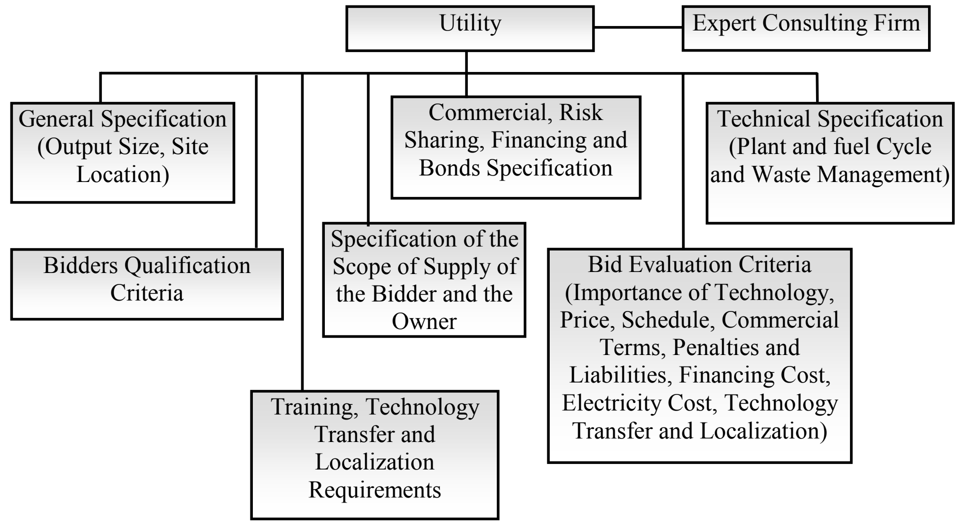

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<td>5. Bid evaluation</td>
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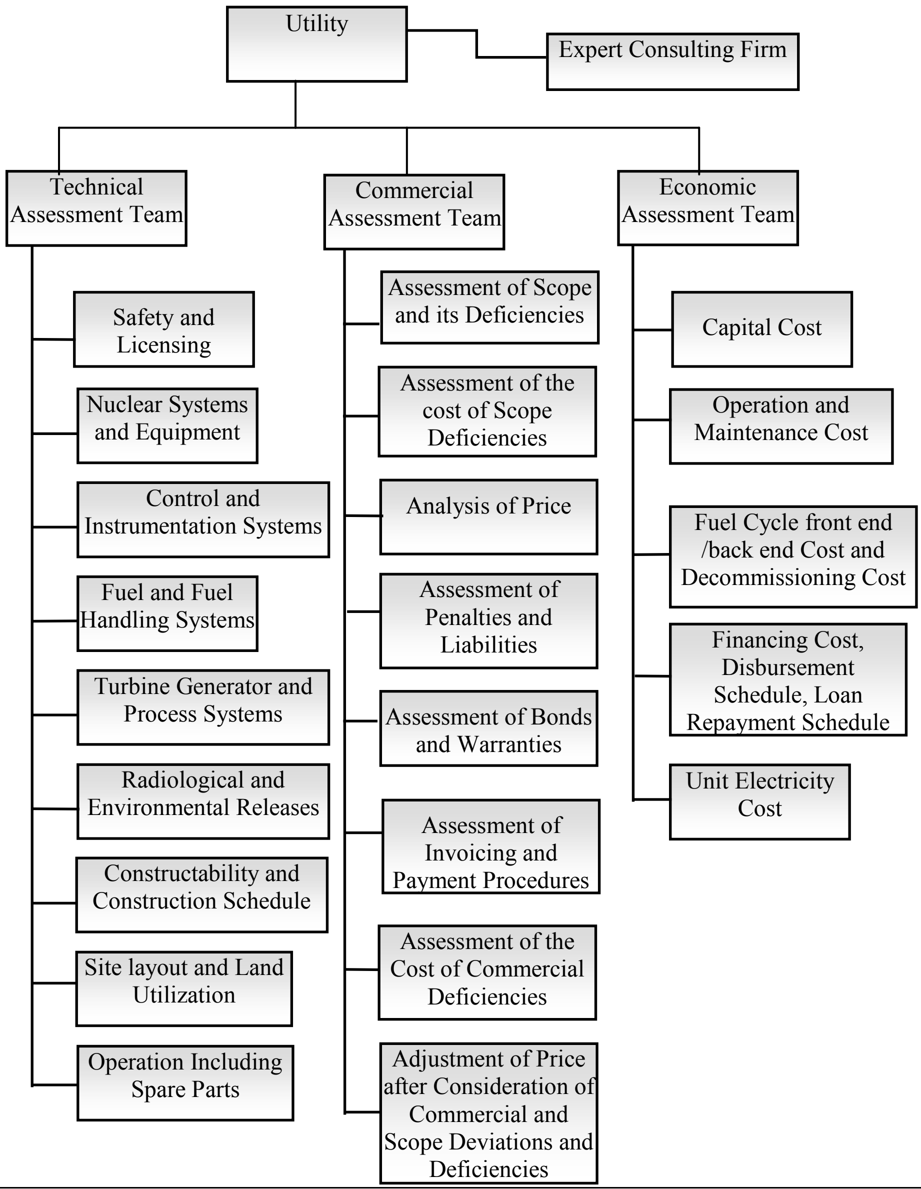
Bid evaluation should be carried out on the basis of the criteria stated in the bid specification. The process should be open and impartial. Expert local and international consultants should be engaged in the evaluation of the bids.


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Prior to the completion of bid evaluation, a process is needed for receiving clarifications from the bidders. The technical evaluation may be carried out prior to the commercial evaluation. Commercial evaluation may then be carried out for the bids passing the basic technical requirements.

Basic human resources may include:

- A team of technical experts for evaluation of reactor safety and reliability, mechanical and electrical systems and equipment, turbine generator, fuel cycle, environmental impact, and operational performance of the proposed reactors;
- A team of commercial experts for evaluation of the proposals for compliance with requirements, commercial exceptions and deviations, risk sharing and risk mitigation;
- A team of economic experts for the assessment of proposals for completeness of scope, total plant price, fuel cycle cost, operation and maintenance cost, financing cost and the resulting unit electricity cost.

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<td>6. Contract negotiations</td>
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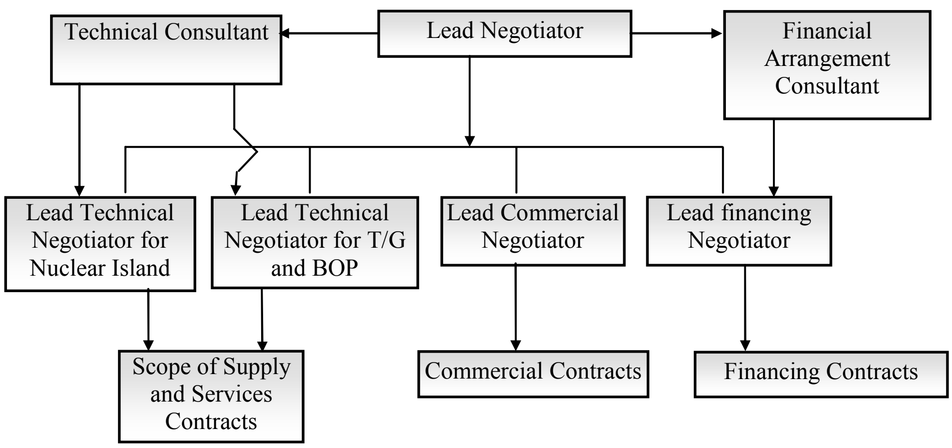
Once the bid evaluation is completed the utility should select the two top ranking bidders for the start of preliminary negotiations and detailed clarifications. The utility should prepare a detailed list of demands, adjustments, extras, and discounts for preliminary negotiations with the two top ranking bidders. All adjustments to the price and scope should be discussed with the two top bidders. This round of discussions and clarifications should lead to the determination of the top-ranking bidder for the start of contract negotiations.

The structure of the negotiation teams is similar to that of the evaluation teams. Technical and commercial negotiations while interrelated can be conducted primarily in parallel.

Basic human resources may include:

- Lead negotiator
- Lead technical negotiator for nuclear island and nuclear licensing
- Lead technical negotiator for nuclear fuel cycle
- Lead technical negotiator for turbine generator (T/G) and balance of plant (BOP)
- Lead commercial negotiator
- Lead financing negotiator
- Support staff as required
- Technical consultant
- Financing arrangement consultant



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5.5. Fuel supply, radioactive waste and spent fuel management

Table 5.6: Basic infrastructures for fuel supply, radioactive waste and spent fuel management

Infrastructure item	Description
1. General	• Develop nuclear fuel market expertise or engage an expert consultant to advise. • Develop regulatory expertise for handling of fuel and spent fuel • Ratify the required international agreements related to fuel cycle • Legislate national laws and regulations to implement the requirements of international agreement and conventions
2. Long term fuel supply guarantees (by the utility and by government)	• Utility to establish long term commercial contracts with internationally credible fuel suppliers • Government to establish and maintain political agreements on nuclear cooperation with fuel supplier countries • In case of enriched uranium fuel cycle, sign contracts for initial reactor refueling and develop expertise to localize refueling activities • Develop commercial ties with multiple sources of fuel • Arrange for a strategic stockpile of fuel for a number of years of operation **Basic human resources may include:** • One technical/commercial expert in international fuel market • One expert in international laws, and conventions related to nuclear fuel • Expert consultant advice as required
3. Uranium enrichment	Not required
4. Fuel fabrication	Fuel fabrication is not required unless: • There is abundance of uranium resources in the country • There is commercial interest in mining and processing of uranium and local fabrication of fuel by the private industry • There is a strategic reason for government support for the localization of the fuel fabrication If local fuel fabrication is deemed necessary, an agency should be established to assess the complete cycle including uranium mining, yellowcake production, fuel pellets production, and fuel assembly (for LWR reactors) or fuel bundle (for PHWR reactors) fabrication. Based on the results of the assessment, should develop plan for the localization of fuel supply in compliance with the commercial and strategic requirements of the nuclear power programmeme.
5. Radioactive waste and spent fuel management (by government and utility)	• Outline the short term and medium term storage policy and strategy as part of the environmental impact report • Place a contract for the fuel supply with spent fuel take-back agreement if applicable • If in country spent fuel storage plan is selected, place a contract for the interim storage technology and the delivery of the first storage module as part of the nuclear plant project • Consider space within the site for medium term storage of spent fuel. • Plan for site security concept including spent fuel storage area • Pass and enact the required laws and regulations for the handling, transportation and storage of various levels of radioactive waste • Start a programme for the long term planning of the local repository for the disposal of spent fuel • Enact regulations to ensure that the utility develops a reliable cost model and sets aside adequate funds (to be included in electricity tariff) for radioactive waste and spent fuel disposal and decommissioning

	• Establish a national “nuclear waste management authority” for planning and monitoring of the implementation of safe and economic nuclear waste management activities

5.6. Physical facilities to implement the project

Table 5.7: Basic infrastructures for physical facilities

Infrastructure item	Description
1. Site (by the utility)	Upon the selection of the preferred site: • Appropriate the required area for the site, with characteristics discussed in sub-section 3.3.1, as close to the load centers as possible and large enough to accommodate additional units in the future **Basic resources may include:** Site operations: • Team of engineers, scientists and technicians at the site or visiting the site to carry out data collection and public information work and assist in the planning of the site infrastructure • Technical expertise, equipment and facilities for collection, analysis and storage of data related to demography, land use, regional industries and agriculture, flora and fauna, meteorology, seismology and micro-earthquakes, geology and geotechnics, hydrology, transportation, and site security • Public information center, staff and programme • Quarries for concrete aggregate • Fresh water source (regional network, stream or aquifer) • Transmission access to load centers
2. Storage and disposal of low/intermediate waste	• Adequate interim storage facilities suitable for the lifetime of the plant should be planned at the site and at the start of the project. The system selected should be modular in order to be expanded in time as the volume of waste increases • The technology for such facilities is not complex and local engineering and construction firms should be identified to receive the technical know how through the contract for the first modules and carry out the work locally for future modules • The NRB should have the expertise to license the long term waste storage facility at the start of the project
3. Storage of spent fuel	• The plan for final disposal of the spent fuel is often not ready at the start of the first nuclear project. The modular long term spent fuel storage facilities should be included at the site and as part of the plant supply contract • The technology for the modular concept should be selected and local engineering and construction firms should be identified to receive the technical know how through the contract for the first modules and carry out the work locally for future modules • The NRB should have the expertise to license the interim spent fuel storage facility at the start of the project • The establishment of the interim spent fuel storage facility should be approved at the political and environmental levels at the start of the project
4. Grid facilities	The site should have adequate transmission link to the national grid and to the load centers. The switchyard and substations are often part of the scope of supply of the plant (either by the utility or by the plant supplier).

	Basic resources may include: Transmission authorities should be engaged to study and implement the required strengthening of the grid in parallel with the construction of the power plant
5. Calibration laboratory facilities	Calibration laboratories are needed for a number of industries and technologies including nuclear power. For nuclear power, this activity starts with the construction and commissioning and continues throughout the operation. It is essential to obtain the equipment and technological know how (if not already available locally) and establish facilities at site as well as the expansion of the centralized national labs to include nuclear power applications. **Basic resources may include:** Technicians, equipment and facilities for calibration instruments and devices for the measurement and monitoring of parameters related to electric, thermal, pressure, flow, velocity, vibration, radiation, water borne and air borne particulates, stresses and strains, ductility and brittleness, and corrosion phenomena.
6. Safeguards plan and equipment	Safeguard plan and equipment is often included in the scope of supply and services of the plant. The safeguard systems should be operational prior to the arrival of nuclear fuel in the site. IAEA publications on safeguard requirement and systems should be used during the design phase of the facility.
7. Emergency response facilities and organization	Emergency response preparedness is part of the environmental permits and nuclear license commitments of the utility. It addresses all aspects of response needed for the management of the accident and post-accident emergencies in the plant, in the site region and in the neighbouring regions. **Basic resources may include:** • Emergency response center in the plant and in the region outside of the plant • Regular training programme for the plant workers and public • Arrangements for speedy access to specialized technical resources from outside of the plant • Plan for distribution of first aid to the affected area and availability of adequate fire fighting stations, security forces and medical centres • Plan for the evacuation of the affected area including multiple access and egress routes from the area • Plans for the halting of distribution of contaminated food and water and relocation of livestock • Plans for national and transboundary early notification in accordance with the relevant international conventions • Integrated plans with the civil and military defense authorities
8. Communication	• Establish a wide network of public and inter-organizational information exchange • Establish strong communication link between the plant, head office, NRB, security forces and government public information services • Establish strong communication link with neighboring countries and with IAEA **Basic resources may include:** • Telephone, e-mail and direct satellite links between various locations of information exchange • A comprehensive plan for dissemination of information to all relevant parties • Experienced staff for information management and exchange
9. Transport/Access	• Reliable and open access to and from site is needed in all phases of the project • During construction large and heavy equipment must reach the site from sea or land

	• Sea route requires adequate harbour and local site roads for delivery of equipment to construction lay down areas and stores **Basic resources may include:** • Land and railway routes with sufficient bridge and tunnel clearance for large loads • Deep harbours and ship unloading cranes and platforms • Special transport equipment for delivery of extra heavy and extra large loads • Special craned and lifting devices for handling of large and heavy loads at harbours and at site
10. Fuel Fabrication Facilities	In this publication the fuel supply is assumed on the basis of a long term supply contract.

The following issues are not part of the basic infrastructure needs. However, their consideration in the first nuclear project enhances the industrial benefits to the country and facilitates localization programme in the subsequent units.	
1. Engineering, construction and project management	The local input to the engineering and construction of the plant is not a necessary condition of the basic infrastructure. However, since the resources for these activities often exist in the country, their inclusion in the implementation of the first nuclear power plant will improve the industrial benefits and increase the localization in future projects. As the nuclear power project starts, engineering and project management are the areas that need a large number of personnel, which can be developed locally. The contracts with the plant supplier may include the transfer of technology for the portion of engineering and construction and project management which is to be carried out by local suppliers. **Basic engineering resources may include:** • Civil designers for design of site, buildings and structures • Mechanical designers for design of piping and pipe support systems • Electrical designers for design of equipment wiring and lightings • Computer aided design and drafting (CADD) technicians • Technical reference material • Computational software and hardware equipment Engineering for site adaptation and local design requirements is needed even for standard reactor designs with generic license **Basic construction and project management resources may include** • Planners and schedulers • QA/QM and quality surveillance technicians • Material management systems software technicians • Documentation control and approval software technicians • Construction foremen, welders, pipe fitters, instrument calibrators, crane operators, non destructive examination technicians
2. Civil material supply and non-nuclear component manufacture	The local input to the civil material supply (except for basic construction material such as concrete) and non-nuclear components of the plant is not a necessary condition of the basic infrastructure. However, since the resources for these material and equipment may exist in the country, their inclusion in the implementation of the first nuclear power plant will improve the industrial benefits and increase the localization in future plants. **Basic resources may include:** Civil material and equipment supply firms for: • Aggregate, cement and rebar • Pre-stressing cables, ducts and tensioning equipment • Formwork and scaffolding • Concrete batch plant • Concrete admixture, curing agents and paints Fabrication and fabrication equipment supply firms for: • Steel profiles, built up sections, bolts and anchors • Steel structures, steel embedded parts and piping and equipment supports

	• Heavy lift crane and hoisting devices • Welding machines and welding supplies • Non nuclear low and medium pressure pipes, tanks and vessels • Non nuclear small pumps and motors • Non nuclear electrical equipment and cables

5.7. National and international nuclear laws, treaties and conventions

The requirements for the peaceful use of nuclear power is harmonized and coordinated through recognized national and international laws, treaties and conventions.

The laws, conventions and treaties are developed to address the following basic issues:

i. Radiological safety and protection of the plant workers and the public
ii. Safe construction, commissioning and operation of the nuclear plant and its associated facilities such as fuel fabrication and waste management and disposal
iii. Secure and safe handling, transportation and storage of nuclear material
iv. Protection of the environment and mitigation of the impact of the establishment of nuclear power plant and its associated facilities
v. Responsible and transparent export and import of nuclear material and equipment
vi. Responsible, open and effective communication of nuclear emergencies and accidents resulting in potential threat to environment and to public
vii. Safeguards
viii. Nuclear liability and coverage

For non-weapon states, the required laws, conventions and treaties are also designed not to violate the countries laws on commercial, technical and security related issues.

It is therefore advisable, that the country in consultation with IAEA and with the assistance of a team of legal experts in nuclear laws, conventions and treaties, drafts and enacts legislations and ratifications to comply with as many of such laws, conventions and treaties as is deemed necessary by IAEA advisors and by the legal experts.

More details on the subject of nuclear laws are given in section 3.1 of this publication with complete description available in the Handbook of Nuclear Law by IAEA [21].

5.8. Additional educational programme and human resources development

Table 5.8: Basic infrastructures for educational programme and human resources

Infrastructure Item	Description
1. Development of educational facilities for nuclear related subjects	Facilities to be considered: • Universities, community colleges and vocational schools in particular those in the region where potential site is located. Sources of educational staff • Departments of civil, mechanical, electrical, metallurgical, chemical, computer and environmental engineering and department of physics

2. Courses to be added to strengthen the human resources development for the first nuclear power reactor	• Nuclear physics and reactor design • Nuclear safety • Radiology, radiography and radiological protection • Thermal, hydraulics and thermo hydraulics analyses • Advanced structural analysis and structural mechanics • Advanced computer hardware and software design and maintenance (control computers hardware and real time control software) • Materials sciences for civil, mechanical and process related applications (steel, concrete, zirconium, ceramics, resins, cabling, etc.) • Application, calibration and maintenance of electrical, mechanical and digital instrumentation devices • Human factors engineering principles • QA/QM processes and methodology • Planning, scheduling, material management and cost control • Environmental analysis
3. IAEA supported training programmes	Arrange through technical cooperation with IAEA for a combination of: • IAEA technical missions with workshops on implementation of nuclear power plant and its required infrastructure • IAEA short term (weeks) and long term (months) training programmes in countries with nuclear power programme
4. Training programmes from countries with nuclear power programme	• Training programmes arranged directly with reactor vendors and constructors • Training programmes arranged directly with NRBs of countries with nuclear power technology

5.9. Potential government incentives to be included in basic infrastructure

Table 5.9: Potential government incentives and risk sharing to be included in basic infrastructure

Infrastructure Item	**Description**
1. Funding of initial elements of nuclear power infrastructure	Agencies and initial activities to be funded by the government may include: • Formation and staffing of the NPIA • Activities and studies carried out by the NPIA • Initial activities related to the selection of the first preferred site for the reactor • Enactment of nuclear laws and regulations • Formation and staffing of the NRB • Establishment of nuclear related courses in universities and community colleges • Establishment of the required national laboratories for aspects such as material testing, instrument calibration and radiological issues
2. Logistics of selecting the first preferred site	The risk associated with the uncertainties in the selection of the first reactor site is too high for the private sector to undertake and requires the financial and logistical support from the government. NPIA or a government owned utility are the possible agencies to undertake this activity.
3. Licensing, permits and authorizations risk	The risk to the schedule resulting from licensing by a newly established NRB and other licensing authorities of the country may have to be assumed by the government. It should be noted that the regulatory bodies in the country of origin of the reactor do not have the authority or mandate to issue license in other jurisdictions and the final license has to be issued by the local NRB.

4. Local construction risk	Lack of nuclear construction experience in the country for the first nuclear power project is a risk that the government may have to share with the project sponsor
5. Force Majeure	Due to longer period of time required for the construction and recovery of investment, the government may consider assuming the force majeure risks such as labour unrest, political change and natural events
6. Market risk	In deregulated and liberalized markets, the project sponsor may require instruments such as power purchase agreement and electricity floor price guarantees
7. Physical security risks	The government will have to support the physical security of nuclear power facility through the country's national and regional security forces and agencies

REFERENCES

[1] INTERNATIONAL ATOMIC ENERGY AGENCY, Code of Conduct on the Safety and Security of Radioactive Sources, IAEA CODEOC 2004, Vienna (2004).

[2] INTERNATIONAL ATOMIC ENERGY AGENCY, Guidance on the Import and Export of Radioactive Sources, IAEA CODEOC/IMP-EXP 2005, Vienna (2005).

[3] INTERNATIONAL ATOMIC ENERGY AGENCY, Convention on Early Notification of a Nuclear Accident and Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency, IAEA Legal Series No. 14, Vienna (1987).

[4] INTERNATIONAL ATOMIC ENERGY AGENCY, Wien Automatic System Planning (WASP) Package, Computer Manual Series No. 16, Vienna, (2001).

[5] INTERNATIONAL ATOMIC ENERGY AGENCY, The Management System for Facilities and Activities, IAEA Safety Standards Series GS-R-3, IAEA, Vienna, (2006).

[6] INTERNATIONAL ATOMIC ENERGY AGENCY, Choosing the Nuclear Power Option: Factors to be Considered, IAEA, Vienna (1998).

[7] INTERNATIONAL ATOMIC ENERGY AGENCY, Policy Planning for Nuclear Power: An Overview of the Main Issues and Requirements, IAEA, Vienna (1993).

[8] INTERNATIONAL ATOMIC ENERGY AGENCY, Manpower Development for Nuclear Power: A Guidebook, Technical Reports Series No. 200, IAEA, Vienna (1980).

[9] INTERNATIONAL ATOMIC ENERGY AGENCY, Introduction of Nuclear Power: A Guidebook, Technical Reports Series No. 217, IAEA, Vienna (1982).

[10] INTERNATIONAL ATOMIC ENERGY AGENCY, Interaction of Grid Characteristics with Design and Performance of Nuclear Power Plants: A Guidebook, Technical Reports Series No. 224, IAEA, Vienna (1983).

[11] INTERNATIONAL ATOMIC ENERGY AGENCY, Developing Industrial Infrastructures to Support a Programme of Nuclear Power: Guidebook, Technical Reports Series No. 281, IAEA, Vienna (1988).

[12] INTERNATIONAL ATOMIC ENERGY AGENCY, Quality Assurance within Regulatory Bodies, IAEA-TECDOC-1090, IAEA, Vienna (1999).

[13] INTERNATIONAL ATOMIC ENERGY AGENCY, Nuclear Power Programme Planning: An Integrated Approach, IAEA-TECDOC-1259, IAEA, Vienna (2001).

[14] INTERNATIONAL ATOMIC ENERGY AGENCY, Developing Multinational Radioactive Waste Repositories: Infrastructure Framework and Scenarios of Cooperation, IAEA-TECDOC-1413, IAEA, Vienna (2004).

[15] INTERNATIONAL ATOMIC ENERGY AGENCY, Potential for Sharing Nuclear Power Infrastructure between Countries (in preparation).

[16] INTERNATIONAL ATOMIC ENERGY AGENCY, Legal and Governmental Infrastructure for Nuclear, Radiation, Radioactive Waste and Transport Safety, IAEA Safety Standards Series No. GS-R-1, IAEA, Vienna (2000).

[17] INTERNATIONAL ATOMIC ENERGY AGENCY, Organization and Staffing of the Regulatory Body for Nuclear Facilities, IAEA Safety Standards Series No. GS-G1.1, IAEA, Vienna (2002).

[18] INTERNATIONAL ATOMIC ENERGY AGENCY, Review and Assessment of Nuclear Facilities by the Regulatory Body, IAEA Safety Standards Series No. GS-G1.2, IAEA, Vienna (2002).

[19] INTERNATIONAL ATOMIC ENERGY AGENCY, Regulatory Inspection of Nuclear Facilities and Enforcement by the Regulatory Body, IAEA Safety Standards Series No. GS-G1.3, IAEA, Vienna (2002).

[20] INTERNATIONAL ATOMIC ENERGY AGENCY, Documentation for Use in Regulating Nuclear Facilities, IAEA Safety Standards Series No. GS-G1.4, IAEA, Vienna (2002).

[21] INTERNATIONAL ATOMIC ENERGY AGENCY, Handbook on Nuclear Law, IAEA, Vienna (2003).

ABBREVIATIONS

CED	Contract effective date
EA	Environmental assessment
EBRD	European Bank for Reconstruction and Development
ECA	Export credit agency
EMP	Environmental management plan
EMS	Environmental management system
ESP	Early site permit
NPIA	Nuclear power implementation agency
NRB	Nuclear regulatory body
PCO	Project company
PPA	Power purchase agreement
PSAR	Preliminary safety analysis report
QA	Quality assurance
QM	Quality management

TERMS USED

For general glossary of nuclear terms refer to IAEA safety glossary in the www.iaea.org