IAEA Nuclear Energy Series

No. NG-G-3.1 (Rev. 1)

Milestones in the Development of a National Infrastructure for Nuclear Power

IAEA
International Atomic Energy Agency

IAEA NUCLEAR ENERGY SERIES PUBLICATIONS

STRUCTURE OF THE IAEA NUCLEAR ENERGY SERIES

Under the terms of Articles III.A and VIII.C of its Statute, the IAEA is authorized to foster the exchange of scientific and technical information on the peaceful uses of atomic energy. The publications in the **IAEA Nuclear Energy Series** provide information in the areas of nuclear power, nuclear fuel cycle, radioactive waste management and decommissioning, and on general issues that are relevant to all of the above mentioned areas. The structure of the IAEA Nuclear Energy Series comprises three levels: **1 — Basic Principles and Objectives**; **2 — Guides**; and **3 — Technical Reports**.

The **Nuclear Energy Basic Principles** publication describes the rationale and vision for the peaceful uses of nuclear energy.

Nuclear Energy Series Objectives publications explain the expectations to be met in various areas at different stages of implementation.

Nuclear Energy Series Guides provide high level guidance on how to achieve the objectives related to the various topics and areas involving the peaceful uses of nuclear energy.

Nuclear Energy Series Technical Reports provide additional, more detailed information on activities related to the various areas dealt with in the IAEA Nuclear Energy Series.

The IAEA Nuclear Energy Series publications are coded as follows: **NG** — general; **NP** — nuclear power; **NF** — nuclear fuel; **NW** — radioactive waste management and decommissioning. In addition, the publications are available in English on the IAEA Internet site:

http://www.iaea.org/Publications/index.html

For further information, please contact the IAEA at PO Box 100, Vienna International Centre, 1400 Vienna, Austria.

All users of the IAEA Nuclear Energy Series publications are invited to inform the IAEA of experience in their use for the purpose of ensuring that they continue to meet user needs. Information may be provided via the IAEA Internet site, by post, at the address given above, or by email to Official.Mail@iaea.org.

MILESTONES IN THE DEVELOPMENT OF A NATIONAL INFRASTRUCTURE FOR NUCLEAR POWER

The following States are Members of the International Atomic Energy Agency:

AFGHANISTAN
ALBANIA
ALGERIA
ANGOLA
ARGENTINA
ARMENIA
AUSTRALIA
AUSTRIA
AZERBAIJAN
BAHAMAS
BAHRAIN
BANGLADESH
BELARUS
BELGIUM
BELIZE
BENIN
BOLIVIA, PLURINATIONAL STATE OF
BOSNIA AND HERZEGOVINA
BOTSWANA
BRAZIL
BRUNEI DARUSSALAM
BULGARIA
BURKINA FASO
BURUNDI
CAMBODIA
CAMEROON
CANADA
CENTRAL AFRICAN REPUBLIC
CHAD
CHILE
CHINA
COLOMBIA
CONGO
COSTA RICA
CÔTE D'IVOIRE
CROATIA
CUBA
CYPRUS
CZECH REPUBLIC
DEMOCRATIC REPUBLIC OF THE CONGO
DENMARK
DJIBOUTI
DOMINICA
DOMINICAN REPUBLIC
ECUADOR
EGYPT
EL SALVADOR
ERITREA
ESTONIA
ETHIOPIA
FIJI
FINLAND
FRANCE
GABON
GEORGIA
GERMANY
GHANA
GREECE
GUATEMALA
GUYANA
HAITI
HOLY SEE
HONDURAS
HUNGARY
ICELAND
INDIA
INDONESIA
IRAN, ISLAMIC REPUBLIC OF
IRAQ
IRELAND
ISRAEL
ITALY
JAMAICA
JAPAN
JORDAN
KAZAKHSTAN
KENYA
KOREA, REPUBLIC OF
KUWAIT
KYRGYZSTAN
LAO PEOPLE'S DEMOCRATIC REPUBLIC
LATVIA
LEBANON
LESOTHO
LIBERIA
LIBYA
LIECHTENSTEIN
LITHUANIA
LUXEMBOURG
MADAGASCAR
MALAWI
MALAYSIA
MALI
MALTA
MARSHALL ISLANDS
MAURITANIA
MAURITIUS
MEXICO
MONACO
MONGOLIA
MONTENEGRO
MOROCCO
MOZAMBIQUE
MYANMAR
NAMIBIA
NEPAL
NETHERLANDS
NEW ZEALAND
NICARAGUA
NIGER
NIGERIA
NORWAY
OMAN
PAKISTAN
PALAU
PANAMA
PAPUA NEW GUINEA
PARAGUAY
PERU
PHILIPPINES
POLAND
PORTUGAL
QATAR
REPUBLIC OF MOLDOVA
ROMANIA
RUSSIAN FEDERATION
RWANDA
SAN MARINO
SAUDI ARABIA
SENEGAL
SERBIA
SEYCHELLES
SIERRA LEONE
SINGAPORE
SLOVAKIA
SLOVENIA
SOUTH AFRICA
SPAIN
SRI LANKA
SUDAN
SWAZILAND
SWEDEN
SWITZERLAND
SYRIAN ARAB REPUBLIC
TAJIKISTAN
THAILAND
THE FORMER YUGOSLAV REPUBLIC OF MACEDONIA
TOGO
TRINIDAD AND TOBAGO
TUNISIA
TURKEY
UGANDA
UKRAINE
UNITED ARAB EMIRATES
UNITED KINGDOM OF GREAT BRITAIN AND NORTHERN IRELAND
UNITED REPUBLIC OF TANZANIA
UNITED STATES OF AMERICA
URUGUAY
UZBEKISTAN
VENEZUELA, BOLIVARIAN REPUBLIC OF
VIET NAM
YEMEN
ZAMBIA
ZIMBABWE

The Agency's Statute was approved on 23 October 1956 by the Conference on the Statute of the IAEA held at United Nations Headquarters, New York; it entered into force on 29 July 1957. The Headquarters of the Agency are situated in Vienna. Its principal objective is "to accelerate and enlarge the contribution of atomic energy to peace, health and prosperity throughout the world''.

IAEA NUCLEAR ENERGY SERIES No. NG-G-3.1 (Rev. 1)

MILESTONES IN THE DEVELOPMENT OF A NATIONAL INFRASTRUCTURE FOR NUCLEAR POWER

INTERNATIONAL ATOMIC ENERGY AGENCY
VIENNA, 2015

COPYRIGHT NOTICE

Marketing and Sales Unit, Publishing Section
International Atomic Energy Agency
Vienna International Centre
PO Box 100
1400 Vienna, Austria
fax: +43 1 2600 29302
tel.: +43 1 2600 22417
email: sales.publications@iaea.org
http://www.iaea.org/books

Printed by the IAEA in Austria
July 2015
STI/PUB/1704

IAEA Library Cataloguing in Publication Data

Milestones in the development of a national infrastructure for nuclear power. — Vienna : International Atomic Energy Agency, 2015.
p. ; 24 cm. — (IAEA nuclear energy series, ISSN 1995–7807 ; no. NG-G-3.1, rev. 1)
STI/PUB/1704
ISBN 978–92–0–104715–1
Includes bibliographical references.

1. Nuclear power plants — Management. 2. Nuclear power plants — Safety measures. 3. Infrastructure (Economics) — Management. I. International Atomic Energy Agency. II. Series.

IAEAL 15–00978

FOREWORD

One of the IAEA's statutory objectives is to "seek to accelerate and enlarge the contribution of atomic energy to peace, health and prosperity throughout the world." One way this objective is achieved is through the publication of a range of technical series. Two of these are the IAEA Nuclear Energy Series and the IAEA Safety Standards Series.

According to Article III.A.6 of the IAEA Statute, the safety standards establish "standards of safety for protection of health and minimization of danger to life and property". The safety standards include the Safety Fundamentals, Safety Requirements and Safety Guides. These standards are written primarily in a regulatory style, and are binding on the IAEA for its own programmes. The principal users are the regulatory bodies in Member States and other national authorities.

The IAEA Nuclear Energy Series comprises reports designed to encourage and assist R&D on, and application of, nuclear energy for peaceful uses. This includes practical examples to be used by owners and operators of utilities in Member States, implementing organizations, academia, and government officials, among others. This information is presented in guides, reports on technology status and advances, and best practices for peaceful uses of nuclear energy based on inputs from international experts. The IAEA Nuclear Energy Series complements the IAEA Safety Standards Series.

Energy is essential for development. Nearly every aspect of development — from reducing poverty and raising living standards to improving health care and industrial and agricultural productivity — requires access to modern energy sources. Current forecasts suggest that global electricity use will increase 65–100% by 2030, with most of the growth in developing countries. Many IAEA Member States without nuclear power have expressed interest in introducing it in order to meet their energy needs without increasing reliance on fossil fuels.

To introduce nuclear power, a wide range of infrastructure issues needs to be considered. The IAEA described these issues in the 2007 brochure Considerations to Launch a Nuclear Power Programme, targeted mainly at policy makers. Later that year, the IAEA followed up with the original version of this publication, Milestones in the Development of a National Infrastructure for Nuclear Power, which expanded the three phases of development outlined in the brochure and laid out a sequential process to develop a nuclear power programme. It provided a more detailed description for a broader audience of the full range of infrastructure issues to be addressed and the expected level of achievement for each issue by the end of each phase.

Milestones in the Development of a National Infrastructure for Nuclear Power was well received. It is widely used, and its framework and terminology have been broadly adopted.

It has now been revised to incorporate several developments since 2007. First, in 2009 the IAEA began offering Integrated Nuclear Infrastructure Review missions, based on the 'milestones framework', to countries introducing or expanding nuclear power, and these have generated practical lessons that are incorporated in this revision. Second, since 2007 the IAEA has published more detailed advice on many of the 19 infrastructure issues summarized in this publication. Those publications incorporate developments after 2007, and the content of this revision harmonizes those more detailed publications. Third, this revision takes into account lessons learned from the 2011 Fukushima Daiichi accident and the implementation of the IAEA Action Plan on Nuclear Safety. Fourth, the original publication was framed in the context of a competitive bidding process, assuming this would apply in most cases. However, other approaches are also being used, involving, for example, strategic partners, sole suppliers and direct negotiations through intergovernmental agreements.

The aim of this publication is to help Member States to understand the commitments and obligations associated with a nuclear power programme — most importantly that, even if extensive foreign assistance is acquired, the responsibility for implementing a nuclear power programme rests with the country and cannot be subcontracted.

This publication can also be used by countries that already have nuclear power to help to assess their preparedness for expanded use. Suppliers, nuclear energy agencies and utilities may also find assessments based upon this publication useful. Such assessments could build confidence that the relevant countries are able to regulate, construct and operate nuclear power plants safely and securely.

The guidance in this new edition of Milestones in the Development of a National Infrastructure for Nuclear Power is provided within the context of the IAEA's other guidance and materials relevant to nuclear power development. These include the IAEA safety standards, with IAEA Safety Standards Series No. SSG-16, Establishing the Safety Infrastructure for a Nuclear Power Programme, providing guidance on the establishment of a national nuclear safety infrastructure as a key component of the overall preparations required for new nuclear power programmes. SSG-16 is intended to be used in conjunction with this new edition of Milestones in the Development of a National Infrastructure for Nuclear Power.

The IAEA officers responsible for this revision were M. Aoki, M. Ferrari and A. Starz of the Division of Nuclear Power.

EDITORIAL NOTE

This publication has been edited by the editorial staff of the IAEA to the extent considered necessary for the reader's assistance. It does not address questions of responsibility, legal or otherwise, for acts or omissions on the part of any person.

Guidance provided here, describing good practices, represents expert opinion and is reflective of the publication's review process, which included consultations with Member States, but does not constitute recommendations made on the basis of a consensus of Member States.

Although great care has been taken to maintain the accuracy of information contained in this publication, neither the IAEA nor its Member States assume any responsibility for consequences which may arise from its use.

The use of particular designations of countries or territories does not imply any judgement by the publisher, the IAEA, as to the legal status of such countries or territories, of their authorities and institutions or of the delimitation of their boundaries.

The mention of names of specific companies or products (whether or not indicated as registered) does not imply any intention to infringe proprietary rights, nor should it be construed as an endorsement or recommendation on the part of the IAEA.

The IAEA has no responsibility for the persistence or accuracy of URLs for external or third party Internet web sites referred to in this publication and does not guarantee that any content on such web sites is, or will remain, accurate or appropriate.

CONTENTS

1. INTRODUCTION

1.1. BACKGROUND

A nuclear power programme is a major undertaking requiring careful planning, preparation and investment in time, institutions and human resources. While nuclear power is not alone in this respect, it is different because of the safety, security and safeguards requirements associated with using nuclear material.

A decision to start a nuclear power programme should be based on a commitment to use nuclear power safely, securely and peacefully. This commitment requires establishing a sustainable national infrastructure that provides governmental, legal, regulatory, managerial, technological, human resource, industrial and stakeholder support for the nuclear power programme throughout its life cycle. The demonstration of compliance with international legal instruments, internationally accepted nuclear safety standards, nuclear security guidelines and safeguards requirements is essential in establishing a responsible nuclear power programme.

The required infrastructure includes not only facilities and equipment, but also the human and financial resources and the legal and regulatory framework within which the programme will be carried out. Essentially, the same infrastructure is needed whether the programme is planned for the production of electricity, for seawater desalination or for any other peaceful purpose.

It is the responsibility of the country introducing nuclear power to establish the necessary infrastructure. Those supplying equipment to a new nuclear power programme will expect progress on a schedule that will ensure that their products are used safely, securely and sustainably.

This publication is intended to provide guidance for the benefit of those starting such programmes, based on relevant international legal instruments, IAEA safety standards and guidance publications and documents, as well as the experience and good practices of countries that have nuclear power plants in operation. Experience has shown that early attention to the 19 infrastructure issues presented here will facilitate a successful nuclear power programme. Insufficient attention to any of them may compromise safety or lead to costly delays or even project failure. This publication assumes that a country contemplating the introduction of nuclear power has a stable political, economic and social environment.

Timescales for nuclear power are long. Each nuclear power plant involves a commitment in the order of 100 years, through construction, operation,

decommissioning and waste disposal. Experience suggests that the time from the initial consideration of the nuclear power option by a country to the operation of its first nuclear power plant is about 10–15 years. This may vary depending on the resources devoted to the programme. Depending on the circumstances in the country and the resources available, implementation could take longer.

The use of nuclear material requires constant strict attention to *nuclear safety*, *nuclear security* and *safeguards*. This is a responsibility not only to a country's own citizens but also to the international community. It is embodied in both national and international legal instruments.

Regarding *nuclear safety*, the fundamental safety objective is to protect people and the environment from the harmful effects of ionizing radiation. A comprehensive safety framework needs to be developed that permeates all 19 infrastructure issues described in this publication. The IAEA safety standards provide a system of Safety Fundamentals, Safety Requirements and Safety Guides for ensuring safety, reflecting an international consensus on what constitutes a high level of safety. Safety Standards Series publications also include a roadmap for safety infrastructure development for their use by countries contemplating the introduction of nuclear power. It will be incumbent on the government, the owner/operator[1] and the regulatory body to develop awareness of safety issues and maintain a safety culture throughout the entire programme.

Regarding *nuclear security*, the fundamental security objective is to protect persons, property, society and the environment from the harmful effects of a nuclear security event. As with safety, a comprehensive nuclear security regime needs to be developed and sustained to prevent, detect and respond to nuclear security events.

Regarding *safeguards*, a country must ensure that there is no risk of proliferation of nuclear weapons and that all nuclear material is adequately accounted for and protected. This also requires the development of the appropriate culture, systems and practices to ensure that all staff are aware of their responsibilities and the importance of their actions.

1.2. OBJECTIVE

This publication defines milestones in the development of the infrastructure necessary for introducing nuclear power, and provides guidance on the activities

[1] The owner and the operator may be two separate entities. This is discussed further in Section 3.3, on management. This publication will distinguish between the owner and operator when it is important to do so and will use the combined term 'owner/operator' when the distinction is less important.

that need to be carried out before each milestone. A country can use it to ensure that:

(1) It has recognized the commitments and obligations associated with the introduction of nuclear power.
(2) It has adequately prepared the entire national infrastructure for building a nuclear power plant.
(3) It has developed all the capabilities needed to regulate and operate a nuclear power plant safely, securely and cost sustainably and to manage the resulting radioactive waste.

1.3. SCOPE

This publication covers both the 'hard' infrastructure (i.e. electrical grid and sites, etc.) and 'soft' infrastructure (i.e. nuclear law, regulations, training, etc.) needed for a nuclear power programme.

Infrastructure needs are discussed from the time a country first considers the nuclear power option, through decision making, planning, procurement, construction and preparations for commissioning. Subsequent steps — operation, decommissioning, spent fuel and radioactive waste management — are addressed only to the degree necessary for planning purposes prior to commissioning. They are included because all stages, including operation and decommissioning, as well as spent fuel and radioactive waste management, should be considered when the decision is made to proceed with nuclear power and because planning for these stages should be in progress by the time specifications for the plant are set. By the time the country is ready to commission a nuclear power plant, it should be ready to manage the longer term commitments associated with operation, spent fuel and radioactive waste management, and decommissioning.

1.4. USERS

This publication is principally for decision makers, advisers and senior managers in government, industry and regulatory bodies in a country interested in introducing nuclear power.

It may also help international organizations to assess a country's progress in developing the infrastructure necessary for nuclear power and to provide timely and meaningful assistance.

Other organizations, such as suppliers, nuclear energy agencies and operator organizations, may use this publication to increase confidence that

a country has the infrastructure necessary for nuclear power or to identify areas for potential assistance.

Countries interested in expanding existing nuclear power programmes may also find the publication helpful, particularly if it has been a long time since they last built a nuclear power plant.

1.5. STRUCTURE

This publication has two sections in addition to this introduction. Section 2 presents the three major infrastructure milestones in the development of a nuclear power programme. Section 3 presents 19 infrastructure issues and, for each issue, the main activities to be carried out in order to reach each milestone.

1.6. USING THIS PUBLICATION

This publication is intended to help a country to plan the steps necessary to develop a national infrastructure for nuclear power and to assess its progress towards that goal. It is not a comprehensive guide on how to create the entire infrastructure needed for a nuclear power programme, but rather presents the elements of infrastructure that should exist at significant points in the development process. More detailed information and guidance on each of the 19 infrastructure issues is available in the IAEA publications listed in the regularly updated bibliography at:

http://www.iaea.org/NuclearPower/Infrastructure/Bibliography/index.html

2. THE PROGRAMME TO DEVELOP INFRASTRUCTURE

2.1. INFRASTRUCTURE MILESTONES

The activities needed to prepare the infrastructure for nuclear power can be split into three phases, with the duration of each dependent on the degree of commitment and resources applied in the country. The term ‘infrastructure milestone’ is used to identify the point at which the activities required in that phase of development have been successfully completed. Each ‘infrastructure

milestone' therefore corresponds to the completion of a set of activities, with no implications about the speed with which it is reached.

The three phases in developing the infrastructure necessary to support a nuclear power programme are:

— Phase 1: Considerations before a decision to launch a nuclear power programme is taken;
— Phase 2: Preparatory work for the contracting and construction of a nuclear power plant after a policy decision has been taken;
— Phase 3: Activities to implement the first nuclear power plant.

The completion of each phase is marked by a specific milestone at which the progress of the development effort can be assessed and a decision can be made to move on to the next phase. These milestones are:

— Milestone 1: Ready to make a knowledgeable commitment to a nuclear power programme;
— Milestone 2: Ready to invite bids/negotiate a contract for the first nuclear power plant;
— Milestone 3: Ready to commission and operate the first nuclear power plant.

Figure 1 is a schematic representation of the phases and milestones.

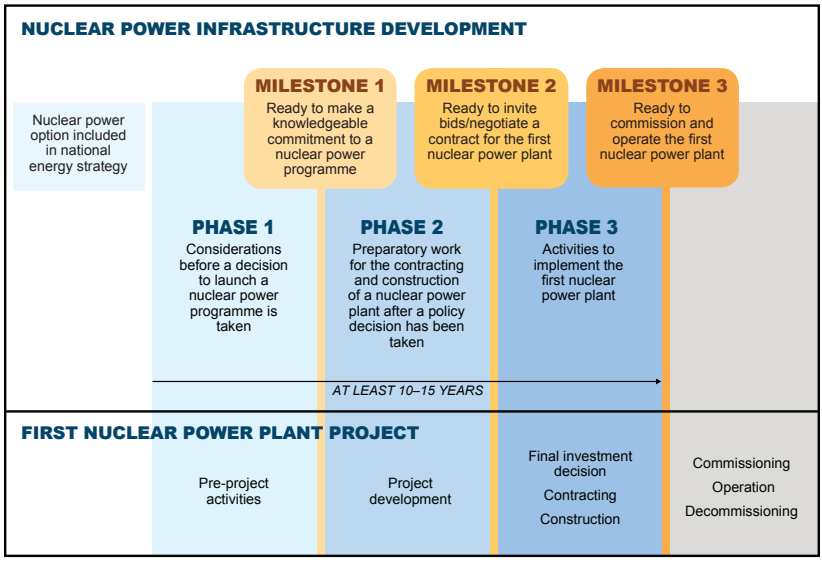


FIG. 1. Development of the infrastructure for a national nuclear power programme.

The three phases and three milestones refer to developing the national infrastructure to support a nuclear power *programme*. The programme includes one or more nuclear power plants, possible related projects, such as uranium exploration and fuel fabrication, and the supporting infrastructure. As the programme develops, many specific activities will be undertaken to implement the first nuclear power plant *project*, and it is important that the distinction be clear. Projects are temporary undertakings to develop and construct nuclear power plants. The infrastructure provides the processes and capabilities to enable the project activities and the subsequent operation of the nuclear power plant to be implemented safely, securely and sustainably.

In the development of the nuclear infrastructure, three key organizations are involved: the government, the owner/operator of the nuclear power plant and the regulatory body[2]. Each has a specific role to play, with responsibilities changing as the programme advances. The owner/operator may be State owned or private, be part of a domestic or international utility or be another commercial entity. The development of the regulatory body should ensure growing independence so that in Phase 2 it is effectively independent in its regulatory decision making. It will not be entirely separate from other governmental bodies, but must have sufficient authority, staffing and financial resources to be able to make independent regulatory decisions, free from any undue influences, such as pressures associated with changing political circumstances or economic conditions, or pressures from government departments or other organizations.

In this publication, it is assumed that the government will create a mechanism (which may involve high level and working level committees) to coordinate the work of these and other organizations involved in infrastructure development. In this publication, this mechanism is called the nuclear energy programme implementing organization (NEPIO). It should be noted that this designation is used here for illustrative purposes only. The country may organize the activity in a manner most appropriate to its own customs and needs.

Table 1 shows the 19 infrastructure issues that need to be considered for each milestone. The order does not indicate relative importance. Each issue is important and requires careful consideration. Different organizations will need to consider which issues relate most to them and to plan their work and resources accordingly. The three key organizations — that is, the government, the owner/operator and the regulatory body — need to ensure awareness of all issues.

---

[2] There may be more than one regulatory body. For example, there may be one for nuclear safety and another for nuclear security. Thus, statements in this publication about ‘the regulatory body’ should generally be read as ‘the regulatory body or bodies’.

TABLE 1. INFRASTRUCTURE ISSUES

The 19 infrastructure issues	
National position	Stakeholder involvement
Nuclear safety	Site and supporting facilities
Management	Environmental protection
Funding and financing	Emergency planning
Legal framework	Nuclear security
Safeguards	Nuclear fuel cycle
Regulatory framework	Radioactive waste management
Radiation protection	Industrial involvement
Electrical grid	Procurement
Human resource development	

2.2. MILESTONE 1: READY TO MAKE A KNOWLEDGEABLE COMMITMENT TO A NUCLEAR POWER PROGRAMME

At the beginning of Phase 1, it is assumed that a country has determined that it needs additional energy and has considered nuclear power as a possible option to meet some of these needs. During Phase 1, the country will analyse all issues that would be involved in introducing nuclear power, so at the end of Phase 1, it is in a position to make a knowledgeable decision on whether or not to introduce nuclear power.

In Phase 1, it is essential that the country acquire a comprehensive understanding of the obligations and commitments involved, and what would be required to fulfil them, before any decision on implementation be taken. It is important that the country have a clear understanding of its energy needs and the potential role of nuclear power within its long term energy and economic development plans.

A country considering nuclear power would probably already have infrastructure for nuclear security, radiation safety and emergency preparedness covering its current facilities and activities. Building on the existing infrastructure and associated experience should greatly assist the country in establishing the necessary infrastructure for a nuclear power programme.

In Phase 1, the NEPIO should ensure overall coordination, ensure the engagement of all important parties, compile the information and studies necessary for a knowledgeable policy decision on whether to proceed with nuclear power and, at the end of Phase 1, provide a comprehensive report that, should it recommend a positive national decision, defines and justifies a national strategy for nuclear power. Any pre-feasibility study done during Phase 1 can

be a significant input to the comprehensive report, although it is important that the report fully address all 19 infrastructure issues described in Section 3.

2.3. MILESTONE 2: READY TO INVITE BIDS/NEGOTIATE A CONTRACT FOR THE FIRST NUCLEAR POWER PLANT

Following the policy decision to proceed with the development of a nuclear power programme, substantive work for achieving the necessary level of technical and institutional competence should be undertaken. This phase requires a significant, continuing commitment from the government, and the responsibility should be clearly assigned to an appropriate governmental ministry. It is also important that the work of all organizations continue to be well coordinated and driven through the NEPIO. The key NEPIO functions include:

— Maintaining momentum and providing a continuing forum for communication and cooperation among the organizations described throughout Section 3 (e.g. the owner/operator, the grid operator, the regulatory body, relevant government agencies, legislators and other decision makers);
— Ensuring that the roles of the key organizations (i.e. the government, the regulatory body and the owner/operator) are well defined and understood by all stakeholders;
— Ensuring that the key organizations develop in line with the project schedule;
— Ensuring that the rationale for the national decision to introduce nuclear power is well understood by all stakeholders;
— Ensuring that the contracting approach and technical specifications remain consistent with the country's nuclear power development strategy.

During Phase 2, the country will carry out the work required to prepare for the contracting, financing and construction of a nuclear power plant. It should develop the necessary infrastructure (covering all 19 infrastructure issues) to the point of complete readiness to invite bids/negotiate a commercial contract between the owner[3] and the supplier. An effectively independent regulatory body should be developed to a level at which it can fulfil all of its authorization and inspection duties.

[3] The reference here to just the owner, rather than the owner/operator, reflects the possibility that a country may prefer that a sole supplier or strategic partner offer operating services as part of its proposals. In those cases, the 'operator' would only be established with the conclusion of the contract negotiations at the beginning of Phase 3.

The owner/operator has a key role at this time to ensure that by the end of Phase 2, it has developed the competence to manage a nuclear power project, meet regulatory requirements and be a knowledgeable customer in Phase 3. The owner/operator should also have, by the end of Phase 2, clear plans to develop or acquire during Phase 3 the capability to safely operate the plant.

2.4. MILESTONE 3: READY TO COMMISSION AND OPERATE THE FIRST NUCLEAR POWER PLANT

For countries using competitive bidding, Phase 3 starts with the bidding and subsequent negotiation of the contract for the design, construction and commissioning of the nuclear power plant. For other countries, Phase 3 starts directly with the negotiation of the contract. Much of the work on infrastructure development will be well advanced by the beginning of Phase 3, but the greatest capital expenditure for the nuclear power plant will occur during Phase 3. Depending on the specific agreements between the owner/operator and the contractor(s), the contract may involve different phases of work (e.g. detailed design and construction) with different price agreements (e.g. fixed price or cost plus). After agreement on the contract, the final investment decision by investors may wait for final project cost and schedule agreements and other financial arrangements. Whatever the detailed contract arrangements are, the final investment decision is a pivotal step.

The initial work will be to develop the site specific design, produce the preliminary safety analysis report and achieve all the required licensing and planning approvals. At this stage, the project costs and schedule can be finalized. Subsequent work will then include all procurement and construction activities, under appropriate management arrangements, and will involve regulatory oversight and approvals throughout the phase.

Milestone 3 is reached when the entire infrastructure is in place to start the stages of nuclear power plant commissioning that involve nuclear testing. Some verification and non-nuclear testing of equipment and systems will start during Phase 3.

By successfully completing Phase 3, the country will have established a nuclear power programme to realize the benefits of energy security and economic development envisioned in the initial policy decision. At the end of Phase 3, the owner/operator must be fully capable of, and licensed for, commissioning and operating the nuclear power plant. If the owner/operator has been newly created, or is new to nuclear power, this will have required significant development and training for all staff and a demonstration that the owner/operator can manage the project throughout the lifetime of the nuclear power plant.

The regulatory body will have been in operation for some time, having developed safety regulations, reviewed contract specifications, licensed construction of the plant and carried out inspections during construction. It should now be clearly seen as a competent, effectively independent regulatory body to provide continuing oversight of all facilities and activities, and to enforce continuing compliance with all regulatory requirements.

The competence of both the owner/operator and the regulatory body may well be ensured through expertise and support from experienced foreign organizations, including the nuclear power plant supplier. Consideration should be given to the need to ensure competence throughout the lifetime of the nuclear power plant.

While achieving Milestone 3 is a major accomplishment, it should be remembered that it is only the beginning of a lasting commitment to the safe, secure, peaceful and sustainable application of nuclear power.

3. DESCRIPTION OF INFRASTRUCTURE ISSUES

Each of the 19 infrastructure issues presented in this section requires specific actions during each of the three phases. Completion of the actions for a phase represents attainment of the associated milestone. Those actions are described here at a relatively high level. More details are available in the IAEA publications listed in the bibliography at:

http://www.iaea.org/NuclearPower/Infrastructure/Bibliography/index.html

Again, the order in which the 19 infrastructure issues are presented does not imply relative importance. All are important and require appropriate attention.

3.1. NATIONAL POSITION

The government should adopt a clear statement, which reflects broad political support, of its intent to develop a nuclear power programme, and it should communicate that intent locally, nationally, regionally and internationally. The rationale and strategy for pursuing such a programme should be based on a national energy policy supporting the desired economic development goals of the country and should identify the contribution that nuclear power will make to that policy. While nuclear energy is most often used to generate electricity,

if there is an intention to develop nuclear powered desalination or process heat production, this should also be addressed in the statement.

Strong government support at every stage is vital to the success of a nuclear power programme, and the intention to develop such a programme should be announced at the most senior level of government. Government leadership and funding is necessary for initial programme development, and continued government support will be required throughout the lifetime of the nuclear power programme. The government will also have to consider underwriting certain financial risks associated with the programme through, for example, loan guarantees or a power purchase agreement. Careful consideration should be given to the means of maintaining the long term political, economic and social stability that will be required for a successful programme.

3.1.1. National position: Milestone 1 — Ready to make a knowledgeable commitment to a nuclear power programme

The introduction of nuclear power requires long term commitments, both nationally and internationally. A time frame in the order of 100 years should be considered for a nuclear power plant, with waste disposal obligations extending significantly longer. The initial implementation period will be at least 10–15 years. It is of the utmost importance to fully understand these long term programmatic commitments before even considering a specific nuclear power plant project.

A full understanding of the commitments can best be achieved by forming a NEPIO. Its principal purpose in Phase 1 is to compile the information and to complete the studies necessary for a knowledgeable policy decision on whether or not to proceed at this time with the development of a nuclear power programme. It should have clear terms of reference to that effect. Its role should be recognized by all relevant government ministries and organizations. It should report to a senior minister or directly to the head of government, and be given the necessary resources and staff to perform its functions and tasks. It may make considerable use of consulting expertise, but it is critical for the leadership to remain with the NEPIO. The NEPIO should ensure engagement, communication and cooperation of all important parties, including the country's major utilities, the regulatory body for security and radiation safety, other relevant government agencies, legislative representatives and other decision makers. Key staff from a number of these organizations should be part of the NEPIO itself. It should establish a policy and guidance to inform interested parties of nuclear power benefits, costs and risks in order to facilitate their involvement in the decision making.

At the end of Phase 1, the NEPIO should produce a comprehensive report that, should it recommend a positive national decision, defines and

justifies a national strategy for nuclear power. Any pre-feasibility study done during Phase 1 can be a significant input to the comprehensive report, although it is important that the report fully address all 19 infrastructure issues. It should address:

— An analysis of energy demand and energy alternatives;
— An evaluation of the impacts of nuclear power on the national economy, for example gross domestic product and employment;
— A preliminary technology assessment to identify technologies that are consistent with national requirements;
— Consideration of siting possibilities and grid capacity;
— Consideration of financing options, ownership options and operator responsibilities;
— Consideration of long term costs and obligations relating to spent fuel, radioactive waste and decommissioning;
— Consideration of possible human resource needs and external support needs of the regulatory body and owner/operator;
— Recognition that there remains a non-zero possibility of a severe accident, and the country will need to be able to deal with the consequences of such an accident;
— Consideration of the needs of each of the infrastructure issues and a plan for how they will be met in Phase 2.

The report should also address:

— The necessity of ensuring the safety, security and peaceful use of radioactive material and nuclear facilities;
— Joining the appropriate international legal instruments;
— Developing a comprehensive legal framework;
— Having an effectively independent regulatory body;
— Planning for emergencies;
— Developing project management capabilities and human resources;
— Ensuring long term financial resources;
— Funding decommissioning and radioactive waste management;
— Ensuring domestic and international confidence by maintaining open, transparent and timely communication.

3.1.2. National position: Milestone 2 — Ready to invite bids/negotiate a contract for the first nuclear power plant

Phase 2 starts with a policy decision to proceed with the development of a nuclear power programme. The government should formally approve a specific proposed nuclear power programme, based on the Phase 1 comprehensive report, and it should decide on the strategy for developing contract arrangements for the nuclear power plant (e.g. competitive bidding, strategic partnerships, 'build-own-operate' or another alternative).

During Phase 2, the NEPIO then ensures that the approved programme policies and strategies are translated into firm action plans for each of the 19 infrastructure issues and that corresponding responsibilities are assigned to the organizations that will become permanent parts of the overall infrastructure. The remaining subsections of Section 3 give more specifics for each of the issues.

As noted earlier, what is important is that the NEPIO's coordination functions are carried out and that responsibilities are clear. It is recognized that this can be accomplished through various organizational arrangements.

In Phase 2, one key step is the development of an effectively independent regulatory body with all the required expertise, resources and responsibility for all regulatory matters necessary for a nuclear power programme. This is addressed further in Section 3.7.2. A second key step is the designation of an owner[4] that will negotiate the specific contract with the supplier of the nuclear power plant at the beginning of Phase 3. This is addressed further in Sections 3.3.2.

3.1.3. National position: Milestone 3 — Ready to commission and operate the first nuclear power plant

To be ready to commission and operate a nuclear power plant, the country should have established by the end of Phase 3 the infrastructure to regulate and safely operate the plant in compliance with national laws, national regulations and international commitments. It should have developed a competent regulatory body and a competent owner/operator for commissioning and operating the nuclear power plant. It should also have assigned to a specific agency continuing responsibility for the government's role in the nuclear power programme.

---

[4] The reference here to just the owner, rather than the owner/operator, reflects the possibility that a country may prefer that a sole supplier or strategic partner offer operating services as part of its proposals. In those cases, the 'operator' would only be established with the conclusion of the contract negotiations at the beginning of Phase 3.

Over the course of Phase 3, the NEPIO — with representation from the owner/operator, the regulatory body and the specific agency now responsible for the government's role in the nuclear power programme — should ensure the overall development of the infrastructure to meet the national strategy. Areas requiring particular coordination across organizations include:

— Ensuring that the relevant legislation is maintained and amended, as appropriate;
— Ensuring that the owner/operator and the regulatory body are fully funded, staffed with competent personnel and provided with the necessary resources, and have assumed their responsibilities with full authority;
— Ensuring all organizations give appropriate attention to safety, security and safeguards;
— Ensuring funding and implementation of grid developments;
— Ensuring that emergency response plans are established and demonstrated;
— Ensuring that stakeholder involvement remains a priority;
— Ensuring that the financing is sufficient to sustain safe and secure operations, and that mechanisms are available for compensation for nuclear damage;
— Ensuring that the human resource development programmes are sufficient to support continuing safe operation;
— Ensuring that responsibilities have been assigned and an appropriate funding plan has been implemented for waste, long term spent fuel management and decommissioning;
— Ensuring that mechanisms are in place for exchanging information with other nuclear power countries and providing mutual support.

3.2. NUCLEAR SAFETY

Nuclear safety requires commitments by all elements of the government, owner/operator, regulatory body, nuclear technology and equipment suppliers and other organizations to ensure safety in all aspects of the nuclear power programme. Most of the actions described in this publication have some impact upon safety.

Past experience has demonstrated that reliance on engineered safety systems is, by itself, insufficient to ensure nuclear safety. Nuclear safety also requires an infrastructure that ensures vigilance, fosters a safety culture and includes emergency preparedness and response.

3.2.1. Nuclear safety: Milestone 1 — Ready to make a knowledgeable commitment to a nuclear power programme

An integral part of becoming ready to make a knowledgeable commitment to a nuclear power programme is the recognition of the importance of safety. Safety is a necessary component of all activities associated with the design, manufacture, construction, commissioning, operation and decommissioning of a nuclear power facility.

With respect to safety, the studies and report prepared in Phase 1 by the NEPIO should focus on the need to take into account:

— The IAEA safety standards;
— The prime responsibility of the licensee for safety[5];
— An effective legal and regulatory framework for safety, including an independent regulatory body;
— The establishment of effective leadership and management for safety;
— Decommissioning and long term management of spent fuel and radioactive waste;
— Efforts to prevent and mitigate accidents;
— Arrangements for emergency preparedness and response (see Section 3.14.1);
— Siting (see Section 3.12.1).

In addition to the importance of the legislative and regulatory frameworks for a successful nuclear programme, the NEPIO Phase 1 report should stress that it is essential that a safety culture be developed within all organizations involved in the nuclear programme. A safety culture requires that all individuals involved in the programme recognize that safety is intrinsic to every aspect of the programme, accept personal responsibility for safety and perform all their activities with that responsibility in mind.

Building a nuclear power plant implies a long term commitment to participate in the international framework on nuclear safety. The country should plan to become a party to international instruments on safety (see Section 3.5) and to share knowledge and experience through information networks and participation in regional and international organizations. Early membership as a Contracting Party to the Convention on Nuclear Safety, and the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management (Joint Convention) (see Section 3.5), and active participation in the

[5] The Convention on Nuclear Safety and the IAEA safety standards refer to the entity with the prime responsibility for safety as the licensee. A country's legal and regulatory frameworks (see Sections 3.5 and 3.7) will define requirements for becoming a licensee.

associated peer reviews will demonstrate commitment to the global nuclear safety framework.

3.2.2. Nuclear safety: Milestone 2 — Ready to invite bids/negotiate a contract for the first nuclear power plant

Following the policy decision to proceed with the development of a nuclear power programme, in Phase 2 all organizations contributing to the programme should develop a safety culture. This includes government representatives, suppliers, the owner/operator and the regulatory body.

The country will likely have a policy and strategy for nuclear safety covering its current facilities and activities. The government should expand the policy and strategy to cover nuclear power.

Senior positions in the regulatory body should be filled early in Phase 2, and senior positions in the owner/operator should be filled as early as possible. Qualifications for the head of the regulatory body should be defined in the national laws or regulations. The regulatory body should specify requirements on how the competence for owner/operator staff in positions related to safety and security is ensured.

The regulatory body and the owner/operator should develop a detailed understanding of the IAEA safety standards. The intended strategy for developing safety regulations should be established early in Phase 2, as it may have an impact on the choice of technology. The use of proven licensed technology creates the possibility for the country's regulatory body, in establishing its own regulations, to make use of the experience of regulatory bodies from countries that have used the technology.

A protocol for communications about licensing and safety issues between the regulatory body, the owner/operator and the suppliers should be developed and, as needed, implemented by the regulatory body and the owner/operator (see Section 3.7.2).

3.2.3. Nuclear safety: Milestone 3 — Ready to commission and operate the first nuclear power plant

A country's first nuclear power plant may be supplied by a foreign supplier, and the supplier will likely propose a set of codes and standards. The regulatory body and owner/operator should assess the applicability of these codes and standards and their consistency with national safety requirements.

The owner/operator as well as the regulatory body should continue to develop a safety culture in their organizations.

Early in Phase 3, the owner/operator should, with the support of the supplier as appropriate, prepare all documentation required for obtaining the necessary licences in accordance with regulatory requirements. It should maintain good communication with the regulatory body. The documentation should include a safety analysis report, as defined by the national licensing process established by the regulatory body. It should include safety and security analyses of the plant's design.

The owner/operator should also establish mechanisms to maintain the knowledge of the safety design and its configuration management over the lifetime of the plant. In addition, it is suggested that the owner/operator maintain a long term relationship with the nuclear power plant supplier to support safe operation in both normal and emergency situations.

The regulatory body will be responsible for conducting a comprehensive review and independent verification of the owner/operator's safety analysis report to verify compliance with regulatory requirements. Other responsibilities for the regulatory body in Phase 3 are summarized in Section 3.7.3.

3.3. MANAGEMENT

The roles and responsibilities of management will change as the process of developing a national nuclear power programme progresses from study to implementation to operation. Management of a nuclear power programme is demanding, and highly competent managers are vital to success at all stages. Effective management entails strong leadership, management systems, project management, strategy and planning, organization and competence development.

3.3.1. Management: Milestone 1 — Ready to make a knowledgeable commitment to a nuclear power programme

In Phase 1, management requirements for both the country's nuclear power programme and the first nuclear power plant project within that programme will be one of the issues addressed in the comprehensive report prepared by the NEPIO. The NEPIO will need the expertise necessary to address all relevant issues. While gaps in the necessary expertise can be filled by consultants, leadership responsibility and accountability should remain with national institutions.

The NEPIO Phase 1 report should emphasize the need for a commitment to leadership and management systems that will promote a safety and security culture. The national regulatory body for security and radiation safety will be represented in the NEPIO, and the NEPIO report should identify the future management developments required to regulate a nuclear power programme. This

is addressed further in Section 3.7.1. Similarly, the country's major utilities will be represented in the NEPIO and can help to identify management developments required to plan, procure, construct and operate a nuclear power plant.

It is important that the knowledge gained on management issues during the Phase 1 comprehensive study be shared. Those in the NEPIO or engaged by the NEPIO in Phase 1 should ensure the transfer of this knowledge to the future regulatory body and future owner/operator.

3.3.2. Management: Milestone 2 — Ready to invite bids/negotiate a contract for the first nuclear power plant

In Phase 2, the owner/operator should be designated and should begin to implement the defined strategy for the first nuclear power plant and to prepare to negotiate a commercial contract. This publication uses the phrase 'bid invitation specifications', which is applicable to a country using a competitive bidding process. A country using an intergovernmental agreement, strategic partner or sole supplier, instead of a competitive process, should therefore interpret 'bid invitation specifications' as 'specifications for negotiating with a sole supplier'.

During this phase, the owner/operator should:

- Define an organizational structure and recruit appropriate staff;
- Establish an integrated management system;
- Develop, in conjunction with the NEPIO, a financing strategy, a contracting strategy, a fuel supply strategy and a spent fuel and radioactive waste management strategy (see Sections 3.4.2 and 3.16.2);
- Begin staff training to create a safety and security culture;
- Establish a nuclear security programme (see Section 3.15.2);
- Assess alternative technologies to determine which are most appropriate or preferred;
- Complete site selection, site assessment and environmental impact assessment studies (see Sections 3.12.2 and 3.13.2);
- Implement a stakeholder involvement programme (see Section 3.11.2), especially with respect to candidate sites;
- Establish bid invitation specifications and evaluation criteria;
- Build project management capabilities and a competent procurement team, recognizing that different contracting approaches (turnkey, split package or others) will require different levels of competence;
- Establish working relationships with the regulatory body;

— Train staff and establish a project management organization that will emphasize quality management and be able to ensure that all contract requirements are fully met;
— Institute procedures to ensure that knowledge critical to safe and secure operation will always be preserved.

For many of these activities, the national strategy may have already defined the high level decisions, and the NEPIO will look to confirm that the detailed implementation is in accordance with the national strategy. The NEPIO should also ensure that the rationale for the national decision to introduce nuclear power is well understood by all stakeholders.

There are existing and proposed owner/operator arrangements where the owner and the operator are separate entities. Detailed arrangements in such cases will depend on the legal and regulatory regime, the allocation of liabilities and the need to demonstrably meet regulatory requirements for licensees.

The government, during Phase 2, should ensure that relevant government agencies expand their capabilities to be ready to handle expanded demands, for example, for managing environmental protection, immigration, import and export controls, and emergency preparedness and response.

The regulatory body should establish an integrated management system and take the additional associated steps described in Section 3.7.2.

3.3.3. Management: Milestone 3 — Ready to commission and operate the first nuclear power plant

For a country using competitive bidding, the owner/owner designated during Phase 2 should begin Phase 3 by inviting bids, evaluating the bids received and selecting the winning bid(s) in accordance with the bid evaluation criteria. The subsequent activities listed below apply both to countries using competitive bidding and to countries using alternative approaches. Specifically, the owner/operator should:

— Negotiate the contract(s) consistent with the contracting strategy developed in Phase 2;
— Obtain financing consistent with the financing strategy and the contract;
— Prepare a licence application in compliance with the regulatory requirements;
— Initiate and manage the construction contract, including appropriate auditing to verify compliance;
— Complete construction and apply for a licence/authorization to operate the plant;

— Develop the capability for safe and secure operation, including recruiting and training staff, obtaining licences and obtaining certifications as required for any needed external maintenance and support organizations;
— Establish working relationships with international and professional organizations related to nuclear power, for example the World Association of Nuclear Operators;
— Develop procedures for event reporting;
— Contract for a continuing fuel supply;
— Establish mechanisms for turnover responsibility from the main supplier to the owner/operator;
— Maintain public support for the operation of the plant.

By the end of Phase 3, the owner/operator must be capable of assuming full responsibility for safe, secure operation in accordance with national laws and regulations which take into account internationally accepted norms and standards.

Steps to be taken by the regulatory body in Phase 3 are addressed in Section 3.7.3.

There are a number of government responsibilities in Phase 3 — for example handling finance and tax issues, providing environmental oversight, and managing trade and immigration — which will be distributed to appropriate government ministries.

It is important that the NEPIO continue:

— To maintain momentum and to provide a continuing forum for communication and cooperation among the important organizations;
— To ensure that the roles of the key organizations (i.e. the government, regulatory body and owner/operator) are well defined and understood by all stakeholders;
— To ensure that the key organizations develop in line with the project schedule;
— To ensure that the rationale for the national decision to introduce nuclear power is also well understood by all stakeholders;
— To ensure that decisions made throughout Phase 3 remain consistent with the country's economic development strategy and the joint interests of the important parties.

3.4. FUNDING AND FINANCING

The funding and financing requirements for a nuclear power programme overall, and a nuclear power plant specifically, are very large. In this publication,

'funding' refers to items that are the responsibility of the government (e.g. ensuring resources for regulation). 'Financing' refers to items that are the responsibility of the owner/operator (whether government owned or a private utility), whose costs will be recovered by selling electricity (e.g. the costs of construction, fuel and equipment replacements).[6]

Initial *funding* for infrastructure development will likely come from government sources. Specific items that will require government funding are listed in Section 3.4.1, such as the development of human resources and the establishment of the legal framework, regulatory body and safeguards arrangements. A demonstrated, continuing government commitment to funding all the areas outlined in this subsection will be important in developing the confidence of the financial community to invest in the plant.

Financing for the first nuclear power plant can be pursued in a number of ways, and a typical financing structure for a project will include both debt and equity finance from several sources. One potential source is the host government itself. However, the viability and extent of such financing will depend on the country's overall economic situation, and for some countries the potential for such financing may be severely limited.

Export financing is typically a significant source of debt financing for a nuclear power plant. However, export financing will still cover only part of the overall investment, even though that part may be substantial.

Local or foreign commercial debt financing may also be needed, possibly encouraged by specific government guarantees. Such guarantees may be direct (e.g. a guarantee to lenders that their loans will be repaid) or indirect (e.g. power purchase agreements or electricity market regulation to guarantee sufficient revenue from electricity sales). Perceived creditworthiness will be very important if the government's direct or indirect guarantee is to benefit the project. The country's economic policy, debt management and legal risk sharing mechanisms are all important to creditworthiness.

A country may seek to reduce the extent to which it must provide financing by engaging local or foreign equity partners who invest directly in the project in exchange for a share in the owner/operator profits or electricity supplied at an agreed price. A foreign equity partner may also supply expertise to the jointly owned owner/operator (e.g. in design, manufacturing, construction or operation);

---

[6] Funding and financing sometimes intertwine. For example, if the regulatory body is to be funded partly by fees from the owner/operator, the owner/operator will need to finance these fees through electricity sales. Similarly, the costs of long term storage and disposal of radioactive waste, or of decommissioning, may be covered by building up *funds* that would be *financed* by small percentages of the revenues from electricity sales, rather than *funded* from the government's general revenues.

such a partner is often referred to as a strategic partner. An arrangement in which the country seeks a foreign company or consortium to build, own and operate the plant is one particular type of partnership arrangement.

With any partnership, the country would still have significant funding responsibilities (e.g. for its regulatory body and emergency preparedness), and it might be required to cover some financial risk through, for example, a power purchase agreement or loan guarantees. Strategic partnerships arrangement would be more likely to involve direct negotiations with selected suppliers than the solicitation of competitive bids and could require agreements between the partners' respective governments.

3.4.1. Funding and financing: Milestone 1 — Ready to make a knowledgeable commitment to a nuclear power programme

The comprehensive study conducted by the NEPIO in Phase 1 should review all relevant funding requirements and financing options.

Regarding *funding*, the study should recommend how the following activities will be funded:

— Establishment of the legal framework;
— The regulatory body for safety, security and safeguards;
— The government's stakeholder involvement programme;
— Siting and environmental protection activities that are the responsibility of the government (see Sections 3.12 and 3.13);
— Emergency preparedness and response;
— Education, training and research;
— Any required improvements to the electrical grid if such improvements are the government's responsibility;
— Any proposed incentives and direct government support to promote localization;
— Storage and disposal of radioactive waste, including spent fuel;
— Decommissioning.

Regarding *financing*, the NEPIO's recommendation should identify potential options together with financial and risk management strategies that together (a) create sufficient confidence for lenders and investors to support a nuclear power plant project and (b) ensure the long term viability of the owner/operator to fulfil all its responsibilities. Even if the recommendation does not include the government as a direct sponsor of the project, it should address the government's role in reducing financial risks.

3.4.2. Funding and financing: Milestone 2 — Ready to invite bids/negotiate a contract for the first nuclear power plant

During Phase 2, longer term *funding* plans for the items listed in Section 3.4.1 should be developed by the government and any agencies that have been given responsibility for items on the list, with appropriate coordination by the NEPIO. Funding plans for education, training, research, regulation, spent fuel, emergency preparedness and response, waste and decommissioning may involve important contributions from the owner/operator, which should therefore be directly involved in preparing such funding plans during Phase 2.

Regarding *financing*, the complexity of obtaining financing for a first nuclear power plant will require significant expertise. During Phase 2, the financing plan for the nuclear power plant project should be established together with a strategy for managing associated financial risks. The principal responsibility for this should likely lie with the owner/operator, but the government also has a key role to play. This is likely to be an iterative process as organizations (owner/operator, government and potential investors) seek to develop a viable financing strategy.

Controlling the cost of financing will require attention to many issues. Financing sources seek a return on their loans or investments and confidence in their capital recovery over a reasonable period. This is true for both public and private financing, but public financing may have a higher risk tolerance than private financing. However, common to both approaches is the control of risk.

Nuclear power carries some unique and significant financial risks. There is a risk of a nuclear accident or a nuclear security event that causes substantial damage liability and the loss or permanent shutdown of the facility. There are risks of significantly increased costs and uncertainty because of construction delays, regulatory delays, operational difficulties and delays from public intervention. Possible changes in the electricity price — if it is not guaranteed in a power purchase agreement or by market regulation — during the long period required to recover investment costs could result in low, or negative, returns on the original investment.

A successful financial plan should consider the country's susceptibility to these risks, allocate the management of each risk to the most appropriate organization, consider how to minimize them and, should delays arise nonetheless, determine how any cost overruns will be financed. Factors that are important to financial institutions include the political and economic stability of the country, the degree of stakeholder involvement, prospects for continued economic development, the protection of foreign investment, the promulgation of legislation conducive to nuclear power, the existence of a competent operator and regulatory body, and the capability to manage large capital construction projects. Particularly important considerations for the government

in making the country's financial environment attractive to potential lenders and investors include:

— A strong policy in support of nuclear power;
— Established creditworthiness;
— Good stakeholder involvement to foster sufficient public support;
— A complete legal and regulatory framework to support both the safe, secure and peaceful use of nuclear power and the financial guarantees necessary for the chosen financial approach;
— A competent, effectively independent regulatory body with secure continuing funding;
— Effective nuclear security and safeguards programmes with secure continuing funding;
— A commitment to developing national expertise and human resources to support a long term commitment;
— Plans in place to fully cover the costs of decommissioning, and the costs of long term management and disposal of spent fuel and radioactive waste;
— A structure for electricity tariffs that is sufficient to ensure a return on capital investment.

3.4.3. Funding and financing: Milestone 3 — Ready to commission and operate the first nuclear power plant

Regarding *funding,* it is important that mechanisms be implemented to provide funding for decommissioning, long term spent fuel and radioactive waste management, including disposal. Reliable funding must be ensured for the regulatory body and the government's responsibilities with respect to stakeholder involvement, safeguards, environmental protection, human resources development, improvements to the electrical grid and incentives for localization. It is also important that the operator have insurance to cover a nuclear accident in place before the nuclear fuel is transported to the reactor.

Regarding *financing*, most important in this phase will be the agreement about the financing arrangements based on the contract and financing negotiations. It will also be important that there be a high level of confidence that electricity tariffs will be sufficient to ensure both a return on capital investment and the safe operation of the plant. If support for financing was part of the competitive

bidding process, the evaluation of proposed financing arrangements will be a key aspect of the owner's[7] evaluation of bids at the beginning of Phase 3.

3.5. LEGAL FRAMEWORK

The legal framework for nuclear power should establish the responsibilities of all organizations necessary for a successful nuclear power programme.

National legislation should comprehensively cover all aspects of nuclear law (i.e. nuclear safety, nuclear security, safeguards and civil liability for nuclear damage). It should implement international legal instruments to which the country is a party or intends to become a party. Box 1 lists the international instruments adopted under IAEA auspices that are relevant to the establishment of a nuclear power programme.

Experience has proven that safety and credibility are best served by institutionally separating the enabling and regulatory aspects of nuclear power. Legislation should therefore separate the functions of the nuclear regulatory body from those of any other body or organization promoting or using nuclear power.

As noted in Section 2.2, any country considering nuclear power would probably already have an infrastructure for radiation safety that covers the country's existing facilities and activities, including radioactive waste management and transport. In overseeing the development of the legal framework for a nuclear power programme, the government should make use of the experience and knowledge gained in developing and implementing the existing infrastructure.

Nuclear law is a specialized field. Professional input from experts is essential to correctly formulate appropriate legislation. The legislation should be consistent with national legal practices, institutions, economic circumstances, the level of technological development and cultural values.

---

[7] The reference here to just the owner, rather than the owner/operator, reflects the possibility that a country may prefer that a sole supplier or strategic partner offer operating services as part of its proposals. In those cases, the 'operator' would only be established with the conclusion of the contract negotiations at the beginning of Phase 3.

BOX 1: RELEVANT INTERNATIONAL LEGAL INSTRUMENTS ADOPTED UNDER IAEA AUSPICES

Convention on Early Notification of a Nuclear Accident (INFCIRC/335)

Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency (INFCIRC/336)

Convention on Nuclear Safety (INFCIRC/449)

Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management (INFCIRC/546)

Convention on the Physical Protection of Nuclear Material (INFCIRC/274) and Amendment thereto (GOV/INF/2005/10-GC(49)/INF/6)

Vienna Convention on Civil Liability for Nuclear Damage (INFCIRC/500)

Protocol to Amend the Vienna Convention on Civil Liability for Nuclear Damage (INFCIRC/566)

Convention on Supplementary Compensation for Nuclear Damage (INFCIRC/567)

Joint Protocol Relating to the Application of the Vienna Convention and the Paris Convention (INFCIRC/402)[a]

Comprehensive safeguards agreement — based on The Structure and Content of Agreements Between the Agency and States Required in Connection with the Treaty on the Non-Proliferation of Nuclear Weapons (INFCIRC/153 (Corrected))

Additional protocol — following the provisions of Model Protocol Additional to the Agreement(s) Between States(s) and the International Atomic Energy Agency for the Application of Safeguards (INFCIRC/540 (Corrected))

Revised Supplementary Agreement Concerning the Provision of Technical Assistance by the IAEA

[a] The Convention on Third Party Liability in the Field of Nuclear Energy (Paris Convention) is another relevant legal instrument under the auspices of the Organisation for Economic Co-operation and Development.

3.5.1. Legal framework: Milestone 1 — Ready to make a knowledgeable commitment to a nuclear power programme

A fundamental understanding of the requirements for a legal framework should be developed by the NEPIO and discussed with the appropriate government institutions. The knowledge and experience of the regulatory body for the control of radiation sources will be valuable, and the existing legal framework for radiation safety, security and emergency response should be taken into account. An understanding of the relevant international legal instruments and their implications for national legislation will be needed.

The NEPIO's comprehensive Phase 1 report should include the need to put in place legislation to establish an independent nuclear regulatory body with adequate human and financial resources and a system of authorization, inspection and enforcement. The legislation should clearly delineate the responsibilities of all authorities involved in the nuclear power programme and cover all areas of nuclear law, for example radiation protection, the safety and security of nuclear facilities and radioactive material including physical protection, emergency preparedness and response, mining and milling, transport, radioactive waste and spent fuel management, decommissioning, nuclear liability and coverage, safeguards, and export and import controls.

The report should also identify all additional legislation that may affect the nuclear programme, including legislation which would need to be enacted or amended. This could include, for example, legislation on environmental protection, emergency preparedness and response, occupational health and safety, foreign investment, financial guarantees or other financial legislation.

3.5.2. Legal framework: Milestone 2 — Ready to invite bids/negotiate a contract for the first nuclear power plant

During Phase 2, as outlined in Section 3.5.1, the country should enact comprehensive national legislation covering all aspects of nuclear safety, nuclear security, safeguards and civil liability for nuclear damage. It should also put in place all legislation that may affect the nuclear power programme. The legislation should be in force prior to inviting bids for the first nuclear power plant. Failure to do so significantly increases the risk of subsequent costly delays. Because nuclear legislation is complex and specialized, the country should be sure to allow sufficient time and devote sufficient resources to completing it on schedule.

Also during Phase 2, the country should take the necessary steps to adhere to the international legal instruments in Box 1.

3.5.3. Legal framework: Milestone 3 — Ready to commission and operate the first nuclear power plant

By the beginning of Phase 3, comprehensive nuclear legislation and all other legislation that may affect the nuclear power programme should be in force, together with mechanisms to ensure compliance. During Phase 3, all actions to implement the relevant international legal instruments should be completed. The legal framework should be maintained, reviewed and amended as necessary during the lifetime of the nuclear power programme.

3.6. SAFEGUARDS

There are a number of international treaties and agreements, such as the Treaty on the Non-Proliferation of Nuclear Weapons (NPT), in which parties undertake to accept safeguards. In the case of the NPT, the safeguards accepted by each party are set forth in an agreement concluded with the IAEA for verifying the fulfillment of the country's obligations. The objective is to prevent the diversion of nuclear material from peaceful uses.

A country contemplating a nuclear power programme should have a clear commitment to its international non-proliferation obligations and safeguards agreement with the IAEA. It should have a clear understanding that with the introduction of nuclear power, there will be a substantial jump in the capabilities required to meet its safeguards obligations. The size of the jump will partly depend on the country's technological and fuel cycle choices (e.g. plans for the number of reactors, options for the front and back ends of the fuel cycle, and whether refuelling is on-line or off-line).

3.6.1. Safeguards: Milestone 1 — Ready to make a knowledgeable commitment to a nuclear power programme

Non-nuclear-weapon States that are party to the NPT are required to have a comprehensive safeguards agreement (CSA) and associated Subsidiary Arrangements conforming to INFCIRC/153 (Corrected) in force with the IAEA. Many countries with a CSA have also concluded an additional protocol on the basis of INFCIRC/540 (Corrected), providing for the implementation of the IAEA's strengthened safeguards system. The country should be aware of the obligations of the Additional Protocol and, if it intends to ratify and has not already done so, a plan should be in place by the end of Phase 1 for timely ratification. The CSA and the Additional Protocol contain specific rights and

obligations undertaken by the country and the IAEA to provide for the effective implementation of safeguards.

Many countries that do not have any nuclear facilities have concluded small quantities protocols (SQPs), which have the effect of temporarily suspending many of the detailed provisions of the CSA. However, if the country currently has an SQP in force, by the end of Phase 1 it should have in place a plan for rescinding the protocol in a timely manner.

In order to exercise the required State control and to facilitate cooperation with the IAEA in implementing the provisions of its CSA and Additional Protocol, the country should establish and maintain an effective State system of accounting for and control of nuclear material (SSAC). This is an obligation under the CSA, independent of the amount of nuclear material or the extent of nuclear applications in the country. Establishing an SSAC includes designating, as part of the country's nuclear law, the responsible regulatory body. Making the regulatory body for safety and/or security also responsible for the SSAC offers potential synergies.

The NEPIO's comprehensive report at the end of Phase 1 should cover the country's additional efforts that will be needed with the introduction of nuclear power to ensure the required:

— Cooperation between the country, facility operator and the IAEA in safeguards implementation;
— Completeness and correctness of the country's declaration in order to ensure effective independent verification by the IAEA;
— Preparations by entities likely to be involved in the programme to meet their reporting obligations to the designated regulatory body.

3.6.2. Safeguards: Milestone 2 — Ready to invite bids/negotiate a contract for the first nuclear power plant

In the preliminary stages of the development of a nuclear programme, the SSAC and its regulatory oversight might involve only one or two individuals, whose primary objective would be to provide information to the IAEA and to implement activities required by the applicable safeguards agreement, for example early provision of initial design information to the IAEA. The country should consider including in the bid invitation specifications requirements on safeguards design features that would facilitate effective safeguards implementation.

As the nuclear programme develops, the SSAC organizational and functional responsibility should be adjusted as required for the country to fulfil its safeguards obligations most effectively. In addition, the terms of all international and regional instruments to which the government is a party, or intends to become a party, should be examined to ensure that its national legislation is consistent with the obligations in those instruments. The country may need to prepare new legislation, rules, regulations and procedures. For example, development of the nuclear power programme may require adjustments in the country's import–export controls. Plans for the effective implementation and enforcement of such legislation should be completed during Phase 2.

If a country plans to develop enrichment, fuel fabrication or reprocessing capabilities, it should provide early information on its plans to the IAEA. If it is party to conventions or agreements requiring early notifications about its plans, it should comply with such requirements.

3.6.3. Safeguards: Milestone 3 — Ready to commission and operate the first nuclear power plant

In non-nuclear-weapon States party to the NPT, safeguards measures are applied to all nuclear material and facilities, and most nuclear related activities, under the jurisdiction of a country. During Phase 3, the IAEA will work closely with facility personnel and the regulatory body to verify the design information provided to the IAEA, to install IAEA equipment for containment and surveillance, and to put clear communication mechanisms in place for the fulfillment of all agreements between the country and the IAEA. All elements of the safeguards infrastructure at the facility should be in place and ensured for the long term prior to fuel arriving at the first nuclear power plant. This includes trained and fully equipped staff, procedures for the accounting and control of nuclear materials, an accounting system that can be verified by the IAEA and established reporting mechanisms to the regulatory body.

3.7. REGULATORY FRAMEWORK

A competent, effectively independent, well resourced nuclear regulatory body that has the strong support of the government is crucial to the long term success of a national nuclear power programme and the confidence of the public and international community. The development of such a body should be given high priority by the NEPIO, either as a new regulatory body or as an extension of the existing regulatory body. The development of competent human resources is as important for the regulatory body as it is for the owner/operator. The

technical capabilities of the regulatory body should be sufficient for evaluating regulatory compliance and nuclear and radiation safety, security and safeguards issues involving all aspects of the nuclear power programme.

The structure of the regulatory framework for nuclear power varies from country to country and may reflect the country's existing regulatory framework for the regulation of radiation sources and radiological facilities. In some countries, there may be different regulatory bodies responsible for nuclear security and nuclear safety. Thus, as noted earlier, statements about the 'regulatory body' should generally be read as the 'regulatory body or bodies'.

As noted in Section 3.5, experience proves that safety and credibility are best served by institutionally separating the enabling and regulatory aspects of nuclear power. For developing the infrastructure for a nuclear power programme, however, separation does not mean that the regulatory body should not take part in the communication, engagement and cooperation fostered by the NEPIO. Any existing regulatory body should be represented in the NEPIO in Phase 1, and in subsequent phases the regulatory body for the nuclear power programme should continue to be part of the NEPIO while maintaining its full independence.

Countries introducing nuclear power may consider building on the infrastructure already in place for radiation safety and nuclear security while recognizing that regulating nuclear power is significantly more complex than regulating radiation sources. Expanding an existing regulatory body to cover nuclear power may be a more efficient use of resources — particularly human resources — that are likely to be limited in many countries.

The body of regulations to fully support a nuclear power programme is extensive. If a country is only considering a single reactor design, it may be helpful to base its regulations largely on those of a country that has experience with that design. The advantages of this approach are that the buyer country's regulatory body might be able to finalize its regulations more quickly and the supplier would already be familiar with the regulations. If a country chooses to adopt the regulations of another country, it is essential that the country fully understand them and be competent to implement them. It should also adapt the regulations to reflect specific national requirements and to ensure that the IAEA safety standards are adequately incorporated.

3.7.1. Regulatory framework: Milestone 1 — Ready to make a knowledgeable commitment to a nuclear power programme

The NEPIO's recommendations at the end of Phase 1 should include plans to develop a regulatory framework in Phase 2 that matches the proposed nuclear power programme and takes account of the existing regulatory framework for

radiation safety and nuclear security. The fundamental elements of a regulatory framework include:

— Designation of an effectively independent competent regulatory body with clear authority, adequate human and financial resources and strong government support;
— Assignment of core safety, security and safeguards regulatory functions for developing regulations, review and assessment, authorization, inspection, enforcement and public information;
— Authority and resources to obtain technical support as needed;
— A clear definition of the relationship of the regulatory body to other organizations;
— Clearly defined responsibilities of licensees;
— Authority to implement international obligations, including IAEA safeguards;
— Authority to engage in international cooperation;
— Provisions to protect proprietary, confidential and sensitive information;
— Provisions for stakeholder involvement and communication with the public.

In developing its recommendations, the NEPIO should ensure communication and cooperation among all important parties, including the country's major utilities, the regulatory body for security and radiation safety, other relevant government agencies, public stakeholders, legislative representatives and other decision makers. As the regulatory body will need to be established early in Phase 2, prospective senior managers should be identified in Phase 1.

3.7.2. Regulatory framework: Milestone 2 — Ready to invite bids/negotiate a contract for the first nuclear power plant

Early in Phase 2, the country should establish a licensing system and an effectively independent regulatory body with sufficient competence to evaluate licence applications and to make safety, safeguards and security decisions. The legal framework (see Section 3.5) will define the scope of the regulatory body's authority.

Early in Phase 2, the regulatory body will need to define siting requirements. It should determine criteria for approving nuclear power plant designs and establish a licensing process prior to the definition of the bid invitation specifications for the first nuclear power plant.

The regulatory body should establish with all stakeholders mechanisms for open communications that are transparent and demonstrate the independence of the regulatory body. As the licensing process is developed, it should be publicized, so it is clear to all stakeholders. The regulatory body and the owner/operator should develop and, as needed, implement a protocol for communications about licensing and safety, security and safeguards issues between the regulatory body, the owner/operator and the suppliers. This should include arrangements for the transmittal of information, correspondence, agreement of actions and formal meetings at a range of levels of seniority.

During Phase 2, the priority issues for regulatory attention are:

— Overall organization, staffing and training;
— Management systems within the regulatory body and training to create a safety and security culture;
— Establishment of technical support arrangements and international relationships with other regulatory bodies to, among other things, expand the technical support available to the regulatory body;
— The import/export, transshipment, transport, storage and handling of nuclear material and other radioactive material;
— The safety of nuclear material and other radioactive material in use, storage and transport;
— Nuclear security, including physical protection of nuclear material and nuclear facilities;
— Safeguards;
— Radiation protection;
— Regulations, codes and standards for siting, design and construction necessary for licensing a nuclear power plant;
— Emergency preparedness requirements and emergency response responsibilities (site, off-site and national)[8];
— The formal licensing process;
— The oversight process for regulated activities that includes inspections and enforcement.

[8] Off-site emergency arrangements are not necessarily the responsibility of the regulatory body. Responsibilities for off-site emergency preparedness and response should be defined in legislation, and the government should establish procedures for coordination between the owner/operator and other response organizations. Response organization is an organization designated or recognized by a State as being responsible for managing or implementing any aspect of an emergency response. It includes the operator in addition to other response organizations such as disaster management agencies, civil protection authorities, medical emergency services and fire brigades.

The framework will ultimately need to cover all phases of the programme, including operation, decommissioning and spent fuel and radioactive waste management, but at this stage some aspects may be covered by future work plans.

Sufficient competent staff should be in place with adequate financial resources:

— To license or approve sites;
— To review, assess and license nuclear plant designs and/or project activities as called for in the national legal and regulatory framework;
— To inspect and oversee nuclear construction and to enforce compliance with regulations;
— To ensure sufficient communication and stakeholder involvement.

The regulatory body should have plans to augment the staff as necessary to perform its functions during licensing, construction, commissioning and operation.

3.7.3. Regulatory framework: Milestone 3 — Ready to commission and operate the first nuclear power plant

In Phase 3, the independent regulatory body should continue staff development, conduct safety and security reviews of the proposed nuclear power plant, conduct licensing and inspection activities, and develop an operational oversight plan.

Once the nuclear power plant supplier has been chosen, the regulatory body should consider cooperation with regulatory bodies in countries that have regulated similar plants, whether provided by the same supplier or by others.

By the beginning of Phase 3, all regulations, codes and standards for nuclear facility construction should be in place, and staffing should be sufficient for efficiently licensing the nuclear power plant and providing regulatory oversight.

Prior to fuel arriving on-site, staffing should be sufficient for carrying out the regulatory body's emergency response role.

Regulatory requirements for operator training and certification should have been developed, and the regulatory body should confirm that the licensee has demonstrated compliance.

The regulatory body's plans to maintain competent staff and develop future staff should be in place. Open communications with appropriate stakeholders should be well established, including the government, the owner/operator, the public and international organizations.

Prior to commissioning, the regulatory body should issue the appropriate licence or approvals. By the end of Phase 3, the regulatory body should have

developed comprehensive programmes for inspection and enforcement, and competent staff should be in place to provide regulatory oversight of the operation and maintenance of the plant by conducting inspections and enforcing regulations in accordance with these programmes.

3.8. RADIATION PROTECTION

This subsection covers protection of workers and the public on-site during planned operation. Radiation protection from off-site releases from planned operation is addressed in Section 3.13, and protection from accidental releases is addressed in Section 3.14.

As noted earlier, because of medical, industrial and research applications of ionizing radiation, a country considering nuclear power would likely already have a national infrastructure for radiation safety. While the radiation protection aspects of a nuclear power programme require additional consideration, they will likely best be addressed by building on the existing infrastructure. Appropriate expansion to cater for the special needs of a nuclear power programme would then take place.

The IAEA safety standards provide guidance in establishing the necessary radiation protection requirements and practices. The IAEA safety standards take into account the guidelines of the International Commission on Radiological Protection, and they incorporate the latest knowledge on the consequences of radiation exposure as presented in the United Nations Scientific Committee on the Effects of Atomic Radiation.

3.8.1. Radiation protection: Milestone 1 — Ready to make a knowledgeable commitment to a nuclear power programme

The NEPIO should develop an understanding of the additional hazards presented by nuclear power plant operation over and above those posed by medical, industrial and research applications of ionizing radiation. In its report at the end of Phase 1, the NEPIO should identify how existing programmes will need to be enhanced to address nuclear power plant operation, transport, storage and radioactive waste management.

3.8.2. Radiation protection: Milestone 2 — Ready to invite bids/negotiate a contract for the first nuclear power plant

Although the radiation risk associated with nuclear power plant operation will not be present for some time, plans need to be prepared in Phase 2, and

preliminary actions taken, to develop programmes to control and monitor the exposure of individuals on-site before any radioactive material arrives on-site. This includes:

— Developing specific regulations by the regulatory body;
— Planning by the owner/operator for monitoring and protecting workers and the public;
— Establishing mechanisms to involve and communicate transparently with all stakeholders;
— Reflecting radiation protection plans in the plant's design requirements;
— Planning for associated staff recruitment and training and the procurement of equipment and services.

3.8.3. Radiation protection: Milestone 3 — Ready to commission and operate the first nuclear power plant

It is necessary to have all radiation monitoring and protection programmes implemented prior to the time radioactive material first arrives on-site. Therefore, by the time of initial fuel delivery, the owner/operator should have:

— Radiation monitoring equipment in place on-site;
— Radiation dosimetry requirements in place for all workers;
— Programmes in place to minimize radiation exposure during plant operation and maintenance.

The regulatory body should have reviewed the owner/operator's radiation protection programmes and verified their compliance with regulatory requirements, including requirements for procedures and equipment to protect workers and responders during severe accidents.

3.9. ELECTRICAL GRID

Nuclear power plants are most efficiently and safely run as base load generation, and the grid should be large enough to make that possible. In addition, the system frequency is difficult to control if more than 10% of the grid's capacity is suddenly taken off-line, as might happen if there were a reactor trip in a unit that large. As a result, if a new nuclear reactor were to account for more than 10% of the total grid capacity at the time it were connected, detailed studies would need to establish that the system frequency could be reliably controlled after a reactor trip. In addition to its size, the grid's reliability is also important,

since the off-site power it provides for safety systems needs to be highly reliable. Therefore, an early step in considering the introduction of nuclear power is an assessment of the electrical grid's current and planned size and reliability. For this reason, the grid operator should be represented in the NEPIO.

3.9.1. Electrical grid: Milestone 1 — Ready to make a knowledgeable commitment to a nuclear power programme

The NEPIO Phase 1 study should address the following in connection with the electrical grid:

— The capabilities of the existing grid in relation to the available nuclear power plant technology, including its ability to reliably take a nuclear power plant's base load output, its ability to withstand a loss of the plant's output and its ability to reliably supply off-site power during outages and in an emergency;
— The anticipated future growth of grid capacity;
— The historical reliability of the electrical grid;
— The potential for local or regional interconnections to improve grid characteristics.

3.9.2. Electrical grid: Milestone 2 — Ready to invite bids/negotiate a contract for the first nuclear power plant

In Phase 2, the grid operator should identify the requirements for connecting a nuclear power plant. The grid operator, in cooperation with the owner/operator, should undertake detailed studies to determine any expansion, upgrade or improvement necessary to accommodate the size, technology and site that are anticipated for the new plant.

The grid operator, again in cooperation with the owner/operator, should have in place by the end of Phase 2:

— Plans for enhancing or expanding the grid to be compatible with the new nuclear power plant;
— Plans to increase or strengthen regional interconnections to achieve acceptable grid reliability;
— Plans to provide redundant, reliable sources of off-site power for the nuclear power plant;
— Funding and/or financing to ensure that these plans are implemented on schedules compatible with the new nuclear power plant.

3.9.3. Electrical grid: Milestone 3 — Ready to commission and operate the first nuclear power plant

The execution of the plans adopted in Section 3.9.2 should create the necessary conditions to successfully commission and operate a nuclear power plant. During Phase 3, the grid operator, in conjunction with the owner/operator should:

— Develop arrangements to ensure coordination of grid operations with power plant operations;
— Verify the completion of all upgrades and enhancements to the grid and interconnections;
— Continue to analyse and improve the reliability of the grid;
— Install and test the redundant off-site power supplies to the nuclear power plant.

The owner/operator and regulatory body should ensure that there is a contingency plan for timely restoration of off-site power in the event of a major loss of grid capability.

3.10. HUMAN RESOURCE DEVELOPMENT

The knowledge and skills necessary to introduce nuclear power include much of the knowledge and skills needed for other large power plants. They include management and administrative skills and technical skills spread across most scientific and engineering disciplines. There are also specific needs for nuclear power, for example expertise in reactor, nuclear and atomic physics and nuclear materials science. This applies to the regulatory body, the owner/operator, technical support organizations and other relevant organizations.

In addition to their fundamental scientific and technical education, staff typically require special training in safety, security and radiation protection. A nuclear power programme requires all individuals to recognize that safety, security and safeguards are intrinsic to every aspect of the programme, to accept personal responsibility for these issues and to perform all their activities with that responsibility in mind.

Human resource needs will depend on the scope of the nuclear power programme, for example the number and variety of envisioned facilities and technologies. How to fill those needs, both initially and in the longer term, will depend on the balance the country chooses between engaging foreign expertise and building up its own expertise, and how quickly it plans to shift that balance

over time. Building up national capabilities will require significant education and training, and that national personnel gain practical experience. This can be achieved in a variety of ways, for example by hiring experienced foreign staff to work alongside national personnel and by sending national personnel to work in foreign organizations.

Certain roles will require several years of specialized training and experience in the design and operation of the specific technology chosen for deployment. Specialized education and training can be obtained from the suppliers of the nuclear system. To ensure a sustainable workforce, it is important for a country to expand its own education and training capabilities and to develop a strategy to retain skilled human resources.

3.10.1. Human resource development: Milestone 1 — Ready to make a knowledgeable commitment to a nuclear power programme

At the beginning of Phase 1, the NEPIO's first human resource concern will be its own staffing. As noted in Section 3.1.1, it is important that the NEPIO be given the necessary resources, staff and any training required. It may well use consultants, but it is critical for leadership to remain with the NEPIO.

During Phase 1, the NEPIO should identify the knowledge and skills needed for a nuclear power programme. Its comprehensive report at the end of Phase 1 should review human resource development options and recommend an outline of the principle features of a national human resource development plan. Even if the country will initially make extensive use of knowledge and skills from other countries, it should consider how it would develop its own long term knowledge and skills.

Important areas for consideration by the NEPIO include:

— Identifying the full range of scientific, technical, managerial and administrative disciplines that will be needed, and assessing their availability within the country;
— Assessing the domestic and foreign capacity for educating and training the people who will be needed;
— Identifying specialized recruiting and training that will be needed in, for example, nuclear safety, nuclear security, safeguards, radiation protection, management systems and emergency preparedness and response;
— Assessing the domestic and foreign availability of specialized education and training;
— Assessing the domestic research capabilities that may need to be developed;

— Outlining workforce plans to either develop or import the human resources needed by the owner/operator, the regulatory body and other involved organizations in order to implement the nuclear power programme;
— Aligning recommendations on human resource development with recommendations about the country's policy on industrial involvement (see Section 3.18).

3.10.2. Human resource development: Milestone 2 — Ready to invite bids/negotiate a contract for the first nuclear power plant

The owner/operator should develop sufficient knowledgeable staff during Phase 2 to prepare for negotiating the contract. While operation and maintenance staff will not be in place in Phase 2, some knowledge of operational and maintenance requirements will be needed.

During Phase 2, the regulatory body will need to develop its competence, as by the end of Phase 2, the majority of the human resources for the regulatory body will need to be in place and competent to fulfil their licensing functions. In view of the high value placed on licensing and inspection experience, the regulatory body should investigate opportunities for its staff to gain experience through cooperative arrangements with foreign regulatory bodies. Arrangements with those experienced in regulating the reactor technologies that the country will most likely acquire would be particularly valuable.

In Phase 2, the NEPIO should establish both a policy on national participation in the manufacturing, construction, operation and support of the nuclear power plant and a plan to put that policy into effect. The policy and the plan will affect human resource development plans.

All organizations should identify the knowledge and skills they will need in Phase 3 and beyond and establish workforce plans to develop them. The plans should identify future organizational structures as well as staff requirements and include recruitment and training plans based on capacity gap analyses.

The NEPIO should coordinate the plans of the different organizations, including the owner/operator, regulatory body, research and technical support organizations, to optimize the country's efforts as much as possible. The coordinated plans should cover education, training and experience requirements, and should consider bilateral and international training activities. For all organizations, the intended senior staff should be in place or identified as soon as possible during Phase 2. For the regulatory body, this will need to be early in Phase 2.

Depending on the country's acquisition strategy, human resource needs in Phase 2 may include:

— Engineering, operational, legal, contracting and procurement expertise to prepare for contract negotiations;
— The technical and scientific expertise needed to manage and review the site assessment;
— The technical and regulatory expertise to develop and implement regulations, codes and standards for nuclear safety, site approval, plant licensing, radiation protection, safeguards, nuclear security (including physical protection systems), emergency preparedness and response, spent fuel and radioactive waste management, and decommissioning;
— Design safety assessment expertise as part of the three bullet points above;
— Expertise in stakeholder involvement;
— Business and technical expertise for fuel cycle procurement and management;
— Expertise in systematic approach to training (SAT) to develop and conduct training programmes.

3.10.3. Human resource development: Milestone 3 — Ready to commission and operate the first nuclear power plant

While significant planning of human resource development is needed in the earlier phases, the main task of staff development for the owner/operator organization takes place in Phase 3. At the start of the phase, its main focus will be on project management, and by the end of Phase 3, all the necessary human resources should be in place and competent to commission and operate the first nuclear power plant. In addition, education and training programmes to develop a continuing flow of qualified people to all areas of the programme should be well under way, and the government should continue to promote educational and industrial development for national participation in the nuclear programme.

The owner/operator should acquire, or have access to, a plant specific, full scope simulator for training control room operators, and their initial training should be completed prior to fuel being loaded. Initial training for the rest of the staff should be completed by the end of Phase 3. (Training will be ongoing throughout the lifetime of the plant and, in that sense, never completed.) If possible, the owner/operator should arrange with the supplier or other owner/operators for training of the operating team on existing similar plants. All organizations involved in the nuclear power programme should have a systematic way of categorizing, disseminating and retaining knowledge, including training material, obtained through international cooperation and contracted commercial

services. The start of operation may involve significant support from an existing nuclear power country with plans to transfer knowledge. It is important that the plans for that knowledge transfer be clearly defined and resourced in order to ensure a smooth transfer of capability and responsibility.

Specific human resource requirements include:

— The technical and scientific expertise needed to prepare a licence application, including the required safety analysis report;
— Technical and management expertise in construction project management and the management system required to control and supervise the plant's construction and commissioning;
— The technical and regulatory expertise to develop and implement regulations, codes and standards for operator licensing;
— Full competent staffing for the regulatory body covering all aspects of authorization, inspection and enforcement;
— Full competent staffing for nuclear power plant operation, maintenance and technical support;
— Workforce succession and personnel development planning to sustain competence in all areas of the national nuclear power programme;
— Enhanced educational opportunities for nuclear science and technology.

3.11. STAKEHOLDER INVOLVEMENT

Strong, continuing government support is necessary through all phases of a nuclear power programme. Government support is facilitated by stakeholder support, which is in turn facilitated by effective stakeholder involvement. Effective stakeholder involvement addresses concerns early and explains the nuclear power programme's rationale, plans and progress.

Stakeholders include the general public, legislators, government agencies and decision makers, and, as the nuclear power programme progresses, the owner/operator, the regulatory body, potential suppliers, workers, communities near possible sites, neighbouring countries and non-governmental organizations.

Stakeholder involvement is best achieved through an open dialogue between the government, owner/operator and all stakeholders. The most influential stakeholders and societal opinion leaders will vary across countries and could include national and local government officials, heads of business and industry, the media, and leaders of non-governmental organizations. However, all concerned citizens should be provided with the relevant information and opportunities to be involved.

While open information programmes are important, sustained, successful sociopolitical involvement will depend on the competence and credibility of the organizations and individuals responsible for the nuclear power programme. The competence of the regulatory body and the owner/operator is vital to maintaining public confidence.

3.11.1. Stakeholder involvement: Milestone 1 — Ready to make a knowledgeable commitment to a nuclear power programme

Each of the three key organizations — the government, the owner/operator and the regulatory body — will eventually need its own stakeholder involvement strategy and plan. In Phase 1, however, the government and the NEPIO are the ones with major roles. It is important that they understand the importance of gaining and keeping the confidence of the country and the international community by maintaining open and timely interaction regarding all aspects of the programme.

The government and the NEPIO should begin to address this commitment from the very beginning. Expert consultants in the areas of public communication and education may be employed to assist. However, national leaders are in the best position to understand the social norms of their society and provide the necessary guidance. Effective public communication is a skilled discipline and those involved should receive professional training.

During Phase 1, the NEPIO should take initial steps:

— To conduct surveys to determine the public's knowledge and receptiveness to nuclear power;
— To develop public information tools that respond to the results of the surveys and to explain the government's interest in, and the potential benefits from, nuclear power;
— To develop and begin implementing a plan of interaction with all stakeholders, including neighbouring countries[9];
— To train senior staff to interact with stakeholders in response to any request.

The NEPIO's comprehensive Phase 1 report should take account of the views of stakeholders involved in the Phase 1 process and propose a stakeholder involvement plan based on transparency and openness. This should be designed to make the public and other stakeholders familiar with nuclear technology,

[9] States party to conventions or agreements such as the Convention on Nuclear Safety and the UNECE Convention on Environmental Impact Assessment in a Transboundary Context have obligations regarding foreign stakeholders.

nuclear power, its benefits and its risks, including the non-zero potential for severe accidents.

3.11.2. Stakeholder involvement: Milestone 2 — Ready to invite bids/negotiate a contract for the first nuclear power plant

As the country begins to implement the plan recommended in the Phase 1 report, the three key organizations should establish stakeholder involvement programmes as they are created. Different organizations will have different messages, mechanisms and principal stakeholders, and the NEPIO should provide a continuing forum for communication and cooperation among the key parties and ensure clarity about the roles and responsibilities of each organization in stakeholder involvement.

The government should continue public information and consultation activities according to the plan developed in Phase 1. The regulatory body and the owner/operator should each develop, and begin to implement, its own stakeholder involvement programme.

Appropriate actions in Phase 2 are that:

— The government continues to communicate the reasons for, and expected benefits of, nuclear power and to respond to concerns raised by stakeholders.
— The government communicates the national process used for site selection, supporting the owner/operator, who should engage local stakeholders and address their issues.
— The regulatory body explains its independent role in licensing, inspection and compliance.
— The regulatory body establishes and communicates the formal process for public participation in licensing.
— The owner/operator explains the basic technology being employed, its construction plans, its safety responsibilities and the impact on, and benefits for, the local community.
— All organizations conduct knowledge and opinion surveys as part of their stakeholder involvement programmes.
— All organizations ensure that senior staff who communicate with the public are trained.
— All organizations openly discuss issues and how they are being addressed.
— Public information centres are established as appropriate.

3.11.3. Stakeholder involvement: Milestone 3 — Ready to commission and operate the first nuclear power plant

By the start of construction, each of the organizations involved should have established credibility with all stakeholders. The communication efforts should continue throughout the construction and preparation for operation, and the NEPIO should continue to provide a forum for communication and cooperation among the key parties.

Appropriate actions in Phase 3 are that:

— All organizations continue to conduct surveys as part of their stakeholder involvement programmes.
— The government continues to communicate the reasons for, and expected benefits of, nuclear power and respond to concerns raised by stakeholders.
— The owner/operator routinely communicates the construction progress and preparations for operation.
— The regulatory body continues to communicate its role and provides information on its licensing, inspection and enforcement programmes.
— The regulatory body provides opportunities for public involvement in licensing, inspection and enforcement according to the process established in Phase 2.
— Governmental agencies (e.g. for environmental protection, emergencies, and public and occupational health) communicate on issues relevant to their responsibilities.
— The regulatory body and owner/operator communicate their plans for routine communication, once the nuclear power plant is operational, with all stakeholders, including local communities.
— The government, regulatory body and owner/operator communicate the on-site and off-site emergency response plans.
— All organizations continue to openly discuss issues and how they are being addressed.

3.12. SITE AND SUPPORTING FACILITIES

Siting studies involve several stages. To ensure that each stage builds smoothly on its predecessor, it is essential to maintain a validated, referenced databank with all information collected on all the sites that are considered. Good data management is important not just for selecting and licensing the best site, but also to help to resolve possible future issues that arise during operations

and require further justification. It also facilitates future siting studies for future nuclear power plants.

In addition to the site for the nuclear power plant, sites for other facilities, such as interim spent fuel storage or other fuel cycle and waste processing facilities, should also be studied. The possibility of siting a low level waste disposal facility near the new nuclear power plant should be considered, as it would reduce waste transport. Other important considerations are transport options between facilities, physical infrastructure to house workers, ready access for equipment delivery, the availability of water and electricity, and ways to minimize impacts on local communities.

Involving all stakeholders early, substantively and frequently in the site selection process contributes to the success of the project.

Important elements of site study and characterization are:

— Ease of integration into the electric system;
— Demography;
— Land use;
— Geology and tectonics;
— Seismology and volcanology;
— Other external natural hazards;
— Heat removal options;
— Hydrology;
— Meteorology;
— Oceanography;
— Nuclear safety and radiation protection;
— Nuclear security;
— Environmental impacts and environmental monitoring;
— Risks from human induced events;
— Availability of local infrastructure;
— Ease of access;
— Legal constraints;
— Public interaction;
— Emergency planning.

3.12.1. Site and supporting facilities: Milestone 1 — Ready to make a knowledgeable commitment to a nuclear power programme

Siting activities need to begin early. In Phase 1, these will be the responsibility of the NEPIO. The first step is a site survey, which should investigate potential regions and sites and reject unsuitable sites through a screening analysis. To screen potential sites, the NEPIO will need to identify exclusion

and avoidance criteria[10] covering safety, security, cost, socioeconomic issues, engineering, environmental impacts, and the possible impact of external hazards on security and emergency response capabilities. The site survey should include consultations with stakeholders early in the process and before any substantive decisions are made. It should identify one or more candidate sites for the NEPIO to recommend in its comprehensive report at the end of Phase 1. If acceptable candidate sites cannot be identified, the programme cannot go forward.

3.12.2. Site and supporting facilities: Milestone 2 — Ready to invite bids/negotiate a contract for the first nuclear power plant

Early in Phase 2, the regulatory body will need to define siting requirements that should be taken into account by the owner/operator in the site selection and assessment.

The owner/operator should then carry out the additional ranking analysis needed for site selection, which narrows the list of candidate sites to a shorter list of preferred candidate sites. The selection should be justified against clearly defined siting criteria covering safety, engineering, security, environmental impacts, emergency response and socioeconomic aspects. The next stage after site selection is site assessment to justify the acceptability of the preferred sites based on detailed investigations and site characterizations. The site assessment results in the derivation of the site related design basis, which should be reflected in the bid invitation specifications for the nuclear power plant.

Other actions to be completed in Phase 2 include:

— Ensuring the availability and integrity of the preferred sites;
— Identifying local legal, political and public acceptance issues and resolutions implemented or planned;
— Identifying necessary improvements and developing implementation plans for local infrastructure at the preferred site or sites, such as access, services and facilities;
— Initiating environmental monitoring to establish site baselines.

[10] 'Exclusion' criteria identify features that would absolutely preclude a site from consideration. 'Avoidance' criteria identify features that make a site less attractive, while recognizing that it might still be suitable if it has sufficient compensating benefits.

3.12.3. Site and supporting facilities: Milestone 3 — Ready to commission and operate the first nuclear power plant

Phase 3 includes the formal confirmation of the site's suitability and the completion of all licensing and approval processes established by the nuclear regulatory body. It includes ongoing monitoring of the site before operation to confirm its acceptability. Monitoring will continue subsequently to confirm that the site continues to meet the design intent.

3.13. ENVIRONMENTAL PROTECTION

This subsection addresses impacts on people and the environment from small releases of gaseous and liquid radioactive effluents during normal plant operation. Large radionuclide releases are low probability events, which are treated through the nuclear safety programme, although there will need to be some discussion of potential accidents in the environmental impact assessment. This subsection also addresses land use, water use, water quality and other more conventional environmental impacts.

3.13.1. Environmental protection: Milestone 1 — Ready to make a knowledgeable commitment to a nuclear power programme

During Phase 1, the NEPIO should consider land use, water use, water quality, and impacts on people and the environment from low level radioactive effluents associated with the normal operation and maintenance of a nuclear power plant and related facilities.

The NEPIO should review the suitability of the country's existing framework for environmental protection and its international obligations, and it should collect and analyse initial environmental information in connection with the site survey described in Section 3.12.

The NEPIO's comprehensive report at the end of Phase 1 should reflect the initial environmental information and the exclusion and avoidance criteria discussed in Section 3.12. It should also include recommendations about possible enhancements or clarifications in existing environmental laws, regulations and responsibilities.

3.13.2. Environmental protection: Milestone 2 — Ready to invite bids/negotiate a contract for the first nuclear power plant

Based on the recommendations from Phase 1, any desired enhancements or clarifications in existing environmental laws, regulations and responsibilities should be implemented in Phase 2. The country's environmental regulatory body for the nuclear power programme should develop the skills and resources required to fulfil its responsibilities, and the interface between it and the nuclear regulatory body should be clearly established.

The owner/operator should study the prospective impacts on people and the environment as needed to select its preferred candidate sites and to ensure that they can comply with the country's environmental laws and regulations.

Important issues to be considered include:

— Pathways for effluent transport and concentration in the surrounding environment;
— Predominant plant and animal life and their particular sensitivities;
— Local demographics and trends;
— Predominant land use;
— Water use and the possible need for cooling towers;
— Impacts of construction activities on the local environment.

For its preferred candidate site or sites, the owner/operator should conduct environmental assessments according to the country's environmental laws and regulations. Based on such assessments, it should include, in the bid invitation specifications developed in Phase 2, a comprehensive specification of the environmental site conditions, factors, characteristics and data for the sites.

3.13.3. Environmental protection: Milestone 3 — Ready to commission and operate the first nuclear power plant

In Phase 3, the owner/operator will complete all licensing and approval processes established by the nuclear regulatory body and the environmental regulatory body for the nuclear programme. The licensing conditions for facility operation should include any specific environmental requirements identified in the environmental studies and assessments carried out in Phases 1 and 2.

In Phase 3, an environmental monitoring programme should be implemented, including the establishment of baseline data.

3.14. EMERGENCY PLANNING

Nuclear power plant safety systems are designed to minimize the probability of a large release of radioactive material from the plant. The probability is not zero, however, and previous accidents have demonstrated that emergency planning for the protection of plant personnel, emergency workers and the public beyond the site boundary is a necessary element of overall plant safety. Emergency planning ensures the capability to take actions that will effectively mitigate the consequences of an emergency.

3.14.1. Emergency planning: Milestone 1 — Ready to make a knowledgeable commitment to a nuclear power programme

The NEPIO should develop an appreciation of the requirements for emergency planning. Its comprehensive report at the end of Phase 1 should evaluate the status of the country's emergency preparedness and response (EPR) and ensure that the government is aware of:

— Any expansion of EPR capabilities that will be required to support a nuclear power programme;
— The resources that will be needed to develop, maintain and demonstrate an emergency response capability;
— Its responsibility for EPR and the need to define clear responsibilities for all organizations involved.

The evaluation should address any need for new arrangements at an international level, including participation in international legal instruments and cooperation with neighbouring countries, the IAEA and other international organizations. The Phase 1 site survey discussed in Section 3.12.1 should cover site characteristics important for EPR.

3.14.2. Emergency planning: Milestone 2 — Ready to invite bids/negotiate a contract for the first nuclear power plant

In Phase 2, the evaluation and recommendations in the NEPIO Phase 1 report about the country's EPR status and needs should be used as the basis for enhancing EPR capabilities. In the course of Phase 2:

— The government should specify the response organizations at national, regional and local levels with responsibilities for EPR and establish a national coordination mechanism.

— It should specify the general approach for EPR on the basis of the probability and severity of possible emergencies, both safety related and security related, and establish regulations governing all EPR requirements.[11]
— It should start implementing new arrangements as identified in Phase 1 for strengthening EPR infrastructure. Gaps in existing national and local institutions and communication networks should be identified and filled or included in an action plan to be implemented in Phase 3.

3.14.3. Emergency planning: Milestone 3 — Ready to commission and operate the first nuclear power plant

Before the first nuclear fuel arrives on-site, emergency arrangements should be completed and tested. Actions to be taken during Phase 3 are the following.

The government should prepare a national plan for dealing with emergencies irrespective of their causes (i.e. accidents or nuclear security events) that includes:

— International cooperation;
— Dealing with multiple external initiating events;
— Severe accident management on-site;
— Protecting workers, emergency workers and the public;
— Radioactive waste management.

Consistent with this plan:

— The owner/operator should implement an emergency preparedness programme for the nuclear power plant.
— The government should implement emergency preparedness programmes at the local, national and international level.
— The government should ensure that the emergency response plan of the nuclear power plant is coordinated with the plans of other national institutions involved in emergency response and with neighbouring countries.
— The regulatory body should verify the compliance of the on-site emergency arrangements with regulatory requirements.
— The government, the regulatory body and the owner/operator should demonstrate emergency response capabilities by conducting exercises including local authorities and communities.

[11] As noted in Section 3.7.2, off-site emergency arrangements are not necessarily the responsibility of the regulatory body. Off-site regulations should be established according to responsibilities defined in legislation.

3.15. NUCLEAR SECURITY

Nuclear security concerns the prevention of, detection of, and response to, intentional unauthorized acts related to nuclear material, other radioactive material, and associated facilities and activities.

The responsibility for nuclear security rests entirely with the country. Its nuclear security regime comprises its legal and regulatory frameworks and administrative measures governing nuclear security, the organizations responsible for nuclear security, and the nuclear security measures themselves. The nuclear security regime is part of the country's overall security regime.

For its nuclear security regime to be effective, all organizations assigned responsibilities for nuclear security must first be fully aware of the importance of nuclear security and ensure the development of a nuclear security culture. There are 12 essential elements:

— Government responsibility;
— Definition of nuclear security responsibilities;
— Legislative and regulatory frameworks for nuclear security;
— Protection of nuclear material and other radioactive material during international transport;
— Definitions of offences and associated penalties related to nuclear security;
— International cooperation and assistance in nuclear security;
— Assessment of nuclear security threats;
— Assessment of targets and potential consequences;
— Use of risk informed approaches;
— Detection of nuclear security events;
— Planning for, preparedness for and response to nuclear security events;
— Measures to sustain the nuclear security regime.

3.15.1. Nuclear security: Milestone 1 — Ready to make a knowledgeable commitment to a nuclear power programme

The NEPIO's comprehensive Phase 1 report should prepare recommendations concerning the national policy and strategy for nuclear security, roles and responsibilities of government agencies for nuclear security and international legal instruments relevant to nuclear security. It should identify the elements of a legal framework for nuclear security and evaluate the country's human resource needs and the availability of institutions to develop competence in nuclear security.

3.15.2. Nuclear security: Milestone 2 — Ready to invite bids/negotiate a contract for the first nuclear power plant

The nuclear security regime should use a graded approach based on assessments of the credibility and potential consequences of both internal and external nuclear security threats.

In the course of Phase 2, the following actions should be implemented:

— The legislative and regulatory frameworks for nuclear security should be put in place (see Sections 3.5 and 3.7).
— Nuclear security requirements for the physical protection of nuclear material and nuclear facilities should be defined through the development of design basis threat(s); such requirements should ensure security is maintained even during severe accidents.
— Programmes for the management of sensitive information, promotion of a nuclear security culture and trustworthiness of personnel should be put in place.
— Roles and responsibilities should be assigned for preparing for, detecting and responding to nuclear security events.
— A programme should be put in place to develop competencies to approve nuclear security plans and to inspect facilities to verify the plans' effectiveness.

3.15.3. Nuclear security: Milestone 3 — Ready to commission and operate the first nuclear power plant

Security arrangements will need to come progressively into place during Phase 3 in order to secure the plant during construction and the fuel once it arrives on-site. The required timing of activities should be agreed by the main organizations. The main actions to be completed in Phase 3 are:

— Construction, testing and acceptance of the physical protection system by the owner/operator as approved by the regulatory body;
— Ensuring good coordination between safety, security and safeguards arrangements;
— Approval of the security plan (including a contingency plan[12]) by the regulatory body;

[12] A contingency plan is a predefined set of actions to counter suspected sabotage or theft. The contingency plan is one component of the security plan.

— Implementation of nuclear security requirements for protecting nuclear material and facilities, and the inspections, verification and on-site exercises needed to demonstrate the physical protection system's effectiveness;
— Implementation of the national response plan, including arrangements with outside response forces to supplement on-site response, as well as training and exercises.

3.16. NUCLEAR FUEL CYCLE

A country should choose its fuel cycle strategy relatively early, as the choice will influence its selection of a specific nuclear technology. The fuel cycle has two components. The front end comprises activities prior to using the fuel in a nuclear power plant. The back end comprises activities after the fuel is removed from the reactor. The front end consists of mining, milling, chemical conversion, enrichment and fabrication. The back end consists of spent fuel storage, transport and either the disposal of spent fuel or reprocessing and disposal of high level radioactive waste. Enrichment and reprocessing technologies are sensitive from the point of view of proliferation.

All front end services can be routinely purchased in the international nuclear market, which reduces the need to develop a national fuel cycle infrastructure. Back end functions are generally provided nationally, and some can also be provided internationally. On-site and interim storage are generally the responsibility of the owner/operator. Technologies for spent fuel storage are mature, with multiple suppliers available to respond to specific needs. Ultimate disposal is generally a national responsibility, either of the government or the owner/operator. There are also some opportunities for international reprocessing of spent fuel.

3.16.1. Nuclear fuel cycle: Milestone 1 — Ready to make a knowledgeable commitment to a nuclear power programme

In Phase 1, the NEPIO should develop a broad knowledge of the steps in the nuclear fuel cycle and identify approaches that may be feasible for the country. Investments and human resource needs will vary considerably across options. For most countries, the development of a completely indigenous nuclear fuel cycle concurrent with the first nuclear power plant would be difficult and unlikely to yield economic benefits. However, a country with abundant uranium may decide to embark on mining and milling operations, while purchasing conversion, enrichment and fabrication services.

In Phase 1, the NEPIO should also analyse the country's energy security concerns and the desirable levels for fresh fuel inventories.

Regarding the back end, it will be necessary to provide on-site spent fuel storage for at least ten years of cooling time, irrespective of future plans for the fuel. It is also likely that interim spent fuel storage, whether on-site or off-site, will be needed for several decades. The NEPIO should analyse possible alternative options for spent fuel and radioactive waste management so that decisions taken at the end of Phase 1 are well informed about the challenges that spent fuel and waste create for a nuclear power programme. The issue of ultimate disposal is discussed in Section 3.17.

The NEPIO Phase 1 report should provide thorough information on:

— The individual steps in the nuclear fuel cycle;
— Potential sources of supplies and services for each step;
— National natural resources and capabilities with respect to each step;
— Feasible options for a national fuel cycle strategy covering all steps in both the front and back ends;
— Security and non-proliferation implications of different fuel cycles;
— Human resource requirements.

3.16.2. Nuclear fuel cycle: Milestone 2 — Ready to invite bids/negotiate a contract for the first nuclear power plant

Decisions on the fuel cycle strategy should be made in Phase 2, since the chosen strategy will influence the bid invitation specifications to be prepared in Phase 2. These need to cover:

— Arrangements for purchasing the first reactor core;
— The additional fuel inventory to be contracted with the first nuclear power plant;
— The specific fuel cycle services that will be either purchased or developed domestically as part of the nuclear power programme;
— The long term strategy with respect to purchasing or developing fuel cycle capabilities;
— The long term strategy with respect to reprocessing;
— The capacity of the on-site spent fuel storage to be contracted along with the first nuclear power plant;
— The strategy for interim spent fuel storage, transport and ultimate disposal.

3.16.3. Nuclear fuel cycle: Milestone 3 — Ready to commission and operate the first nuclear power plant

During Phase 3, the fuel for the initial core will be delivered to the site, provisions for the additional fuel inventory, in accordance with the national strategy, will have been contractually committed and on-site spent fuel storage will have been constructed as part of the nuclear power plant. The ultimate waste disposal strategy is discussed in Section 3.17.

During Phase 3, it will also be necessary to develop plans to implement the interim storage strategy, including identifying a suitable location, transport capabilities and funding arrangements. The plans for interim spent fuel storage will need to be consistent with the on-site storage capabilities.

3.17. RADIOACTIVE WASTE MANAGEMENT

The management and disposal of all radioactive waste is an essential aspect of nuclear power. Such waste needs to be properly managed to avoid imposing undue burdens on future generations. The Joint Convention stipulates that radioactive waste should be disposed of in the country in which it is generated. However, it also allows the possibility of waste being disposed of elsewhere in the interests of safety and efficiency.

Radioactive waste is divided into six levels, three of which require particular attention when developing the infrastructure for a nuclear power programme: low, intermediate and high.[13] The ability to manage low level waste (LLW) and intermediate level waste (ILW) exists in many countries in conjunction with medical, industrial and research applications. Programmes and technology for LLW and ILW minimization and processing have been implemented in many countries, and some countries have also developed disposal capacity for LLW and ILW. Even in these cases, however, a country introducing nuclear power will need to understand the additional volume and the different spectrum of radioactive isotopes in LLW and ILW associated with nuclear power.

No disposal facility for high level waste (HLW) (including spent fuel that is not intended for reprocessing) is yet in operation. The most advanced projects are scheduled for operation after 2020. In the meantime, the demonstrated capability to store spent fuel safely for decades provides time for developing final disposal strategies. Nevertheless, waste disposal is often a subject of public

[13] The other three levels are exempt waste, very short lived waste and very low level waste.

concern, and early consideration should therefore be given to the country's final disposal strategy. Currently, the most common strategy for HLW is planned disposal in deep geological formations.

3.17.1. Radioactive waste management: Milestone 1 — Ready to make a knowledgeable commitment to a nuclear power programme

The NEPIO Phase 1 report should identify all additional responsibilities for radioactive waste that will come with a nuclear power programme. It should emphasize the need to communicate effectively about the options for safely and securely dealing with radioactive waste and should consider:

— The country's existing capabilities, regulatory framework and experience with radioactive waste handling, storage, transport and disposal;
— The additional volume of LLW and ILW, and the variety of isotopes expected from nuclear power facilities;
— Technological options and research on the ultimate disposal of spent fuel and HLW from reprocessing;
— Options for financing spent fuel and HLW management and disposal;
— The benefits of becoming a party to the Joint Convention if the State is not yet a party;
— The human resource and other infrastructure development needs associated with radioactive waste management for a nuclear power programme.

3.17.2. Radioactive waste management: Milestone 2 — Ready to invite bids/negotiate a contract for the first nuclear power plant

During Phase 2:

— The government should lead national planning for waste disposal, including LLW, ILW and HLW. It should establish policies, identify a responsible organization or agency to lead the national planning and give it clear terms of reference.
— The national planning for radioactive waste disposal should consider the extent to which geological conditions exist in the country to allow disposal of all types of radioactive waste and/or the potential for contracting for waste disposal with other countries.
— National strategies should be established for all expected radioactive waste streams, and the government should revise as needed the laws and regulations for radioactive waste management.

— Plans should be established to fully finance long term radioactive waste management, radioactive waste disposal and decommissioning as noted in Section 3.4.2.
— The owner should develop, for inclusion in the bid invitation specifications, provisions for minimizing radioactive waste volumes and toxicity, requirements for associated facilities and requirements for a decommissioning plan.
— The government and owner/operator should plan to begin or enhance the country's radioactive waste disposal programmes and facilities to accommodate operation of the first nuclear power plant.

3.17.3. Radioactive waste management: Milestone 3 — Ready to commission and operate the first nuclear power plant

LLW and ILW will be generated as soon as the reactor begins operation. Therefore, towards the end of Phase 3:

— Existing, enhanced or new facilities for the storage or disposal of LLW and ILW should be fully operational and prepared to receive radioactive waste from the nuclear power plant.
— The responsible organization and funding system should be in place.
— An initial decommissioning plan should have been developed as part of the licensing of the design, and appropriate funding arrangements should be in place.

The organization leading the national planning for radioactive waste disposal should continue to follow international progress on HLW disposal, and national policy should be revised as appropriate.

3.18. INDUSTRIAL INVOLVEMENT

Many commodities, components and services are required to construct and support the operation of nuclear facilities. Such supporting activities can be a source of jobs and economic growth for the country. They can also help to transfer technology to the country. However, supplying equipment and services to nuclear facilities requires an industry that can comply with nuclear codes, standards and quality requirements, and may well require government commitment and investment. In the early stages of developing the country's nuclear power programme, the NEPIO should establish a policy on developing industrial capabilities and technology transfer. As the programme proceeds, the policy

should lead to plans and their eventual implementation to develop the desired level of industrial involvement.[14]

3.18.1. Industrial involvement: Milestone 1 — Ready to make a knowledgeable commitment to a nuclear power programme

The NEPIO Phase 1 study should assess opportunities for national and local industrial involvement in the nuclear power programme. Its Phase 1 report should explain the qualifications necessary to provide nuclear equipment and services, and nuclear quality standards, which are more stringent than for other industrial operations. Before agreeing to participation by the domestic industry, a nuclear power plant supplier would need to be assured that the domestic industry is able to meet nuclear standards. It is important that the NEPIO carry out a realistic assessment of the country's capabilities. A country's first nuclear power plant may be constructed with limited local industrial involvement, but there may well be plans to expand that involvement as the programme develops.

The NEPIO Phase 1 report should:

— Assess national and local industrial capabilities and potentials, including the training and development needs to realize those potentials;
— Assess industry's interest in participating in the nuclear power programme;
— Assess the level and likelihood of the investments required to upgrade industrial facilities and programmes;
— Recommend targets for short term and long term industrial participation and policies to reach those targets.

3.18.2. Industrial involvement: Milestone 2 — Ready to invite bids/negotiate a contract for the first nuclear power plant

Based on the short term and long term targets recommended in the NEPIO Phase 1 report, the government and industry should establish programmes to transition to national and local suppliers as their capabilities develop.

The owner/operator and/or the government should assess directly, or through the supplier, the national and local capabilities to supply on schedule, at competitive prices and with appropriate quality controls and assurance, commodities, components and services for building and operating a nuclear power plant. The results should be taken into account in the bid invitation specifications and evaluation criteria developed during Phase 2, which may

[14] Another term for increasing national and local participation is 'localization'.

include incentives to encourage bids promoting domestic industrial involvement. Whatever the desired degree of national industrial participation may be, it is important that the actual level of involvement should be within the domestic industry's ability to meet schedule and quality requirements on time and within budget. Construction delays can greatly increase costs and decrease regulatory and public confidence.

Thus in Phase 2, the owner/operator should consider:

— Which national or local suppliers can reliably supply commodities, components or services to the nuclear related or non-nuclear portions of the nuclear power plant;
— Which upgrades in skills and capabilities are realistic in the time frame that would be required to support nuclear construction.

Decisions should be made about using national or foreign sources for commodities, components and services, and these should be reflected in any localization criteria in the bid invitation specifications developed in this phase.

3.18.3. Industrial involvement: Milestone 3 — Ready to commission and operate the first nuclear power plant

The government, in Phase 3, should continue to promote educational and industrial development for national participation in the nuclear programme. As the construction phase of the nuclear power programme nears completion, a reassessment of the supply sources to support operation can be undertaken. If the national and local industrial structure has progressed sufficiently, the supply of spare parts, consumable supplies, maintenance services and calibration services can be allocated accordingly. However, the same supplier qualification necessary for facility construction by the owner/operator is also needed for operational support, and in some cases the operational requirements may be even more stringent.

3.19. PROCUREMENT

This publication assumes that a country will procure its first nuclear power plant via a turnkey contract. Section 3.3 addresses the capability needed for procurement of the nuclear power plant. This subsection, therefore, only addresses the procurement of specific equipment that has requirements beyond those of standard procurement and the procurement of services for a nuclear

facility. It is important that the owner/operator specify the quality requirements and verify that the supplier meets those requirements.

3.19.1. Procurement: Milestone 1 — Ready to make a knowledgeable commitment to a nuclear power programme

The NEPIO should:

— Be aware of the unique requirements associated with purchasing equipment and services for nuclear facilities;
— Recognize the level of competence required to procure equipment and services for a nuclear facility.

Its comprehensive report at the end of Phase 1 should recommend a procurement policy that reflects these considerations and is consistent with the report's overall recommendations for the nuclear power plant strategy and industrial involvement policy.

3.19.2. Procurement: Milestone 2 — Ready to invite bids/negotiate a contract for the first nuclear power plant

As noted above, the assumed strategy for a new owner/operator is to procure the plant via a turnkey contract. Nonetheless, in Phase 2 the owner/operator will need to establish a procurement capability for certain services. It should develop the capability to procure required services for pre-project activities (e.g. environmental impact assessment, siting and consulting), in particular:

— To ensure suppliers have appropriate expertise and experience;
— To prepare formal specifications for the services required;
— To include quality standards in the service specifications.

3.19.3. Procurement: Milestone 3 — Ready to commission and operate the first nuclear power plant

In preparing for nuclear power plant operation and maintenance, it is likely that the owner/operator will establish its own procurement organization with the programmes and skills necessary to conduct ongoing purchasing of equipment and services. In doing so, it should consider not only procurement for normal operation and for emergency equipment to be pre-positioned on-site, but also procedures for the urgent procurement of additional supplies and equipment as needed in emergency situations. To prepare for such activities,

it is recommended that the owner/operator develop a plan to ensure the required competence and procedures are available before the end of Phase 3. Part of this should include arranging for procurement staff to work alongside the supplier procurement team in order to gain the experience required.

BIBLIOGRAPHY

National position

INTERNATIONAL ATOMIC ENERGY AGENCY, Initiating Nuclear Power Programmes: Responsibilities and Capabilities of Owners and Operators, IAEA Nuclear Energy Series No. NG-T-3.1, IAEA, Vienna (2009).

INTERNATIONAL ATOMIC ENERGY AGENCY, Responsibilities and Capabilities of a Nuclear Energy Programme Implementing Organization, IAEA Nuclear Energy Series No. NG-T-3.6, IAEA, Vienna (2009).

INTERNATIONAL ATOMIC ENERGY AGENCY, Preparation of a Feasibility Study for New Nuclear Power Projects, IAEA Nuclear Energy Series No. NG-T-3.3, IAEA, Vienna (2014).

Nuclear safety

EUROPEAN ATOMIC ENERGY COMMUNITY, FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS, INTERNATIONAL ATOMIC ENERGY AGENCY, INTERNATIONAL LABOUR ORGANIZATION, INTERNATIONAL MARITIME ORGANIZATION, OECD NUCLEAR ENERGY AGENCY, PAN AMERICAN HEALTH ORGANIZATION, UNITED NATIONS ENVIRONMENT PROGRAMME, WORLD HEALTH ORGANIZATION, Fundamental Safety Principles, IAEA Safety Standards Series No. SF-1, IAEA, Vienna (2006).

INTERNATIONAL ATOMIC ENERGY AGENCY, Establishing the Safety Infrastructure for a Nuclear Power Programme, IAEA Safety Standards Series No. SSG-16, IAEA, Vienna (2011).

Management

INTERNATIONAL ATOMIC ENERGY AGENCY, The Management System for Facilities and Activities, IAEA Safety Standards Series No. GS-R-3, IAEA, Vienna (2006).

INTERNATIONAL ATOMIC ENERGY AGENCY, Project Management in Nuclear Power Plant Construction: Guidelines and Experience, IAEA Nuclear Energy Series No. NP-T-2.7, IAEA, Vienna (2012).

Funding and financing

INTERNATIONAL ATOMIC ENERGY AGENCY, Issues to Improve the Prospects of Financing Nuclear Power Plants, IAEA Nuclear Energy Series No. NG-T-4.1, IAEA, Vienna (2009).

INTERNATIONAL ATOMIC ENERGY AGENCY, Financing of New Nuclear Power Plants, IAEA Nuclear Energy Series No. NG-T-4.2, IAEA, Vienna (2008).

Legal framework

STOIBER, C., BAER, A., PELZER, N., TONHAUSER, W., Handbook on Nuclear Law, IAEA, Vienna (2003).

STOIBER, C., CHERF, A., TONHAUSER, W., DE LOURDES VEZ CARMONA, M., Handbook on Nuclear Law: Implementing Legislation, IAEA, Vienna (2010).

Safeguards

INTERNATIONAL ATOMIC ENERGY AGENCY, International Safeguards in the Design of Nuclear Reactors, IAEA Nuclear Energy Series No. NP-T-2.9, IAEA, Vienna (2014).

INTERNATIONAL ATOMIC ENERGY AGENCY, International Safeguards in Nuclear Facility Design and Construction, IAEA Nuclear Energy Series No. NP-T-2.8, IAEA, Vienna (2013).

Regulatory framework

INTERNATIONAL ATOMIC ENERGY AGENCY, Governmental, Legal and Regulatory Framework for Safety, IAEA Safety Standards Series No. GSR Part 1, IAEA, Vienna (2010).

Radiation protection

EUROPEAN COMMISSION, FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS, INTERNATIONAL ATOMIC ENERGY AGENCY, INTERNATIONAL LABOUR ORGANIZATION, OECD NUCLEAR ENERGY AGENCY, PAN AMERICAN HEALTH ORGANIZATION, UNITED NATIONS ENVIRONMENT PROGRAMME, WORLD HEALTH ORGANIZATION, Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards, IAEA Safety Standards Series No. GSR Part 3, IAEA, Vienna (2014).

Electrical grid

INTERNATIONAL ATOMIC ENERGY AGENCY, Electric Grid Reliability and Interface with Nuclear Power Plants, IAEA Nuclear Energy Series No. NG-T-3.8, IAEA, Vienna (2012).

Human resource development

INTERNATIONAL ATOMIC ENERGY AGENCY, Workforce Planning for New Nuclear Power Programmes, IAEA Nuclear Energy Series No. NG-T-3.10, IAEA, Vienna (2011).

Stakeholder involvement

INTERNATIONAL ATOMIC ENERGY AGENCY, Stakeholder Involvement Throughout the Life Cycle of Nuclear Facilities, IAEA Nuclear Energy Series No. NG-T-1.4, IAEA, Vienna (2011).

Site and supporting facilities

INTERNATIONAL ATOMIC ENERGY AGENCY, Managing Siting Activities for Nuclear Power Plants, IAEA Nuclear Energy Series No. NG-T-3.7, IAEA, Vienna (2012).

INTERNATIONAL ATOMIC ENERGY AGENCY, Site Evaluation for Nuclear Installations, IAEA Safety Standards Series No. NS-R-3, IAEA, Vienna (2003).

Environmental protection

INTERNATIONAL ATOMIC ENERGY AGENCY, Managing Environmental Impact Assessment for Construction and Operation in New Nuclear Power Programmes, IAEA Nuclear Energy Series No. NG-T-3.11, IAEA, Vienna (2014).

Emergency planning

INTERNATIONAL ATOMIC ENERGY AGENCY, Considerations in Emergency Preparedness and Response for a State Embarking on a Nuclear Power Programme, EPR-Embarking 2012, IAEA, Vienna (2012).

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS, INTERNATIONAL ATOMIC ENERGY AGENCY, INTERNATIONAL LABOUR ORGANIZATION, OECD NUCLEAR ENERGY AGENCY, PAN AMERICAN HEALTH ORGANIZATION, UNITED NATIONS OFFICE FOR THE CO-ORDINATION OF HUMANITARIAN AFFAIRS, WORLD HEALTH ORGANIZATION, Preparedness and Response for a Nuclear or Radiological Emergency, IAEA Safety Standards Series No. GS-R-2, IAEA, Vienna (2002).

Nuclear security

INTERNATIONAL ATOMIC ENERGY AGENCY, Establishing the Nuclear Security Infrastructure for a Nuclear Power Programme, IAEA Nuclear Security Series No. 19, IAEA, Vienna (2013).

INTERNATIONAL ATOMIC ENERGY AGENCY, Objective and Essential Elements of a State's Nuclear Security Regime, IAEA Nuclear Security Series No. 20, IAEA, Vienna (2013)

INTERNATIONAL ATOMIC ENERGY AGENCY, Nuclear Security Recommendations on Physical Protection of Nuclear Material and Nuclear Facilities (INFCIRC/225/Revision 5), IAEA Nuclear Security Series No. 13, IAEA, Vienna (2011).

Nuclear fuel cycle

INTERNATIONAL ATOMIC ENERGY AGENCY, Nuclear Fuel Cycle Objectives, IAEA Nuclear Energy Series No. NF-O, IAEA, Vienna (2013).

INTERNATIONAL ATOMIC ENERGY AGENCY, Safety of Nuclear Fuel Cycle Facilities, IAEA Safety Standards Series No. NS-R-5 (Rev. 1), IAEA, Vienna (2014).

Radioactive waste management

INTERNATIONAL ATOMIC ENERGY AGENCY, Options for Management of Spent Fuel and Radioactive Waste for Countries Developing New Nuclear Power Programmes, IAEA Nuclear Energy Series No. NW-T-1.24, IAEA, Vienna (2013).

INTERNATIONAL ATOMIC ENERGY AGENCY, Radioactive Waste Management Objectives, IAEA Nuclear Energy Series No. NW-O, IAEA, Vienna (2011).

INTERNATIONAL ATOMIC ENERGY AGENCY, Policies and Strategies for Radioactive Waste Management, IAEA Nuclear Energy Series No. NW-G-1.1, IAEA, Vienna (2009).

ABBREVIATIONS

CSA	comprehensive safeguards agreement
EPR	emergency preparedness and response
HLW	high level waste
ILW	intermediate level waste
Joint Convention	Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management
LLW	low level waste
NEPIO	nuclear energy programme implementing organization
NPT	Treaty on the Non-Proliferation of Nuclear Weapons
SQP	small quantities protocol
SSAC	State system of accounting for and control of nuclear material

CONTRIBUTORS TO DRAFTING AND REVIEW

Bazile, F.	Commissariat à l'énergie atomique, France
Benazza, Mohd. El Hafed	Commissariat à l'énergie atomique, Algeria
Bermudez-Samiei, M.	International Atomic Energy Agency
Bolme, A.B.	Turkish Atomic Energy Authority, Turkey
Braguine, V.	International Atomic Energy Agency
Bruno, N.	International Atomic Energy Agency
Buglova, E.	International Atomic Energy Agency
Burkart, A.	Department of State, United States of America
Calpena, S.	International Atomic Energy Agency
Caruso, G.	International Atomic Energy Agency
Chemini, R.	SONATRACH, Algeria
Cherf, A.	International Atomic Energy Agency
Clapper, M.	Department of Energy, United States of America
Clark, C.R.	International Atomic Energy Agency
Danker, W.	International Atomic Energy Agency
Deboodt, P.	International Atomic Energy Agency
Ding, J.	Beijing Institute of Nuclear Engineering, China
Ek, D.	International Atomic Energy Agency
El-Asiry, M.A.	Nuclear Power Plants Authority, Egypt
El-Hamid Mostafa, H.A.	Nuclear Power Plants Authority, Egypt
Evans, S.	International Atomic Energy Agency
Facer, R.I.	International Atomic Energy Agency
Forsström, H.	International Atomic Energy Agency

Graves, D.	International Atomic Energy Agency
Gregoric, M.	International Atomic Energy Agency
Gueorguiev, B.	International Atomic Energy Agency
Hamouda, R.	Ministère de l'énergie et des mines, Algeria
Han, K.-I.	Korea Power Engineering Company, Republic of Korea
Hezoucky, F.	International Atomic Energy Agency
Hutchings, R.	Permanent Mission of Australia, Vienna
Jurkowski, M.	National Atomic Energy Agency, Poland
Kazennov, A.	International Atomic Energy Agency
Le Heron, J.	International Atomic Energy Agency
Lederman, L.	International Atomic Energy Agency
Lignini, F.	International Atomic Energy Agency
Lyons, J.	Nuclear Regulatory Commission, USA
Mazour, T.	International Atomic Energy Agency
Mikhalevich, A.	Scientific Center on Energy Efficiency, Belarus
Mohammedi, D.	SONELGAZ, Algeria
Mrabit, K.	International Atomic Energy Agency
Murphy, J.	National Nuclear Security Administration, United States of America
Neerdael, B.	International Atomic Energy Agency
Nicholas, M.	International Atomic Energy Agency
Nicic, A.	International Atomic Energy Agency
O'Donnell Torroba, P.	International Atomic Energy Agency
Omoto, A.	International Atomic Energy Agency

Paliukhovich, V.	Nuclear Safety of the Ministry of Emergencies, Belarus
Pellechi, M.	International Atomic Energy Agency
Phillips, J.	International Atomic Energy Agency
Pieroni, N.	International Atomic Energy Agency
Rasin, W.	Consultant, United States of America
Remadna, M.	Ministry of Energy and Mining, Algeria
Sajaroff, P.	Nuclear Regulatory Authority, Argentina
Shalabi, A.	Permanent Mission of Canada, Vienna
Sollychin, R.	International Atomic Energy Agency
Stern, W.	International Atomic Energy Agency
Tellería, D.	International Atomic Energy Agency
Tonhauser, W.	International Atomic Energy Agency
Toth, F.	International Atomic Energy Agency
Vergara, J.	Comisión Chilena de Energía Nuclear, Chile
Viktorsson, C.	International Atomic Energy Agency
Villalibre, P.	International Atomic Energy Agency
Weinstein, E.	International Atomic Energy Agency
Yanko, L.	Atomstroyexport, Russian Federation
Zhu, R.	International Atomic Energy Agency

Contributors to drafting and review for Revision 1

Agu, M.N.	Nigeria Atomic Energy Commission, Nigeria
Akbar, M.S.	Bangladesh Atomic Energy Commission, Bangladesh
Allotey, N.K.	Nuclear Power Center, Ghana
Anzhar, K.	National Nuclear Energy Agency, Indonesia

Aoki, M.	International Atomic Energy Agency
Araj, K.	Jordan Atomic Energy Commission, Jordan
Artisiuk, V.	Rosatom Central Institute for Continuing Education and Training, Russian Federation
Asaduzzaman, K.M.	Ministry of Science and Technology, Bangladesh
Ashaiekh, M.A.E.	Sudan Atomic Energy Commission, Sudan
Barrientos Riveros, C.	Chilean Nuclear Energy Commission, Chile
Bastos, J.	International Atomic Energy Agency
Boogard, J.	International Atomic Energy Agency
Boussaha, A.	International Atomic Energy Agency
Burkart, A.	United States Department of State, United States of America
Bychkov, A.	International Atomic Energy Agency
Cañadas, V.	National Atomic Energy Commission, Argentina
Cherf, A.	International Atomic Energy Agency
Chesire, E.K.	Kenya Nuclear Electricity Board, Kenya
Cisar, V.	International Atomic Energy Agency
Clark, R.	International Atomic Energy Agency
Colgan, T.	International Atomic Energy Agency
Crété, J.-M.	International Atomic Energy Agency
Cristobal Polo, M.	International Atomic Energy Agency
Daifuku, K.	Électricité de France, France
Das, A.	International Atomic Energy Agency
de Grosbois, J.	International Atomic Energy Agency
Delattre, D.	International Atomic Energy Agency
Djermouni, B.	International Atomic Energy Agency

Dromgoole, L.	International Atomic Energy Agency
Duskas, A.	United States Department of Energy, United States of America
Elhag, Y.	Ministry of Water Resources and Electricity, Sudan
Evans, R.	International Atomic Energy Agency
Evans, S.	International Atomic Energy Agency
Faltejsek, J.	International Atomic Energy Agency
Ferrari, M.	International Atomic Energy Agency
Flory, D.	International Atomic Energy Agency
Forsström, H.	Swedish Nuclear Fuel and Waste Management Company, Sweden
Gest, P.	International Atomic Energy Agency
Gibbs, R.	International Atomic Energy Agency
Gillespie, M.	Permanent Mission, United States of America
Graves, D.	International Atomic Energy Agency
Gross, J.	United States Department of Energy, United States of America
Harper, M.	International Atomic Energy Agency
Herschel, H.	Direction générale de l'énergie et du climat, France
Hill, C.	Permanent Mission, France
Hughes, P.	International Atomic Energy Agency
Jalal, I.	International Atomic Energy Agency
Jam, S.	Malaysia Nuclear Power Corporation, Malaysia
Kang, K.-S.	International Atomic Energy Agency
Kilic, N.	International Atomic Energy Agency
Kim, J.Y.	International Atomic Energy Agency

Kinker, M.	International Atomic Energy Agency
Kishida, K.	JAIF International Cooperation Center, Japan
Kobetz, T.	International Atomic Energy Agency
Koenick, S.	International Atomic Energy Agency
Kolomiiets, V.	International Atomic Energy Agency
Korinny, A.	International Atomic Energy Agency
Koshy, T.	International Atomic Energy Agency
Kovachev, M.D.	JSC Rosatom Overseas, Russian Federation
Lafortune, J.	International Atomic Energy Agency
Lee, J.K.	International Atomic Energy Agency
Lekoma, T.P.	Department of Trade and Industry, South Africa
Lepouzé, B.	International Atomic Energy Agency
Lewinski, M.	Ministry of Economy, Poland
Lipar, M.	International Atomic Energy Agency
Lyons, J.	International Atomic Energy Agency
Mallick, S.	International Atomic Energy Agency
Mansoux, H.	International Atomic Energy Agency
Matu, L.	Kenya Nuclear Electricity Board, Kenya
McDonald, A.	Consultant
Mele, I.	International Atomic Energy Agency
Mishevska, A.	Radiation Safety Directorate, The former Yugoslav Republic of Macedonia
Moeller, K.	International Atomic Energy Agency
Molloy, B.	International Atomic Energy Agency
Mortin, S.	Consultant

Naeem Iqbal, M.	Directorate of Nuclear Power Engineering Structure, Pakistan
Nestoroska Madjunarova, S.	International Atomic Energy Agency
Nguyen, T.Y.N.	Vietnam Atomic Energy Agency, Viet Nam
Nkong-Njock, V.	International Atomic Energy Agency
Omondi, E.	Kenya Nuclear Electricity Board, Kenya
Ousmane Manga, A.	Department of Physics, Abdou Moumouni University, Niger
Pagannone, B.	International Atomic Energy Agency
Painter, C.L.	International Atomic Energy Agency
Park, I.S.	Korea Hydro & Nuclear Power Company, Republic of Korea
Park, J.K.	International Atomic Energy Agency
Petrosyan, A.	Ministry of Energy and Natural Resources, Armenia
Phillips, J.	International Atomic Energy Agency
Proehl, G.	International Atomic Energy Agency
Ranguelova, V.	International Atomic Energy Agency
Rasin, W.	Consultant
Rotaru, I.	Elcomex IEA Romania
Samaddar, S.	International Atomic Energy Agency
Sanda, I.G.	International Atomic Energy Agency
Sbaffoni, M.	International Atomic Energy Agency
Scott, M.	United States Department of Energy, United States of America
Siraky, G.	International Atomic Energy Agency
Sokolov, Y.	Rosatom, Russian Federation
Sta. Rita, M.G.	National Power Corporation, Philippines

Starz, A.	International Atomic Energy Agency
Stevens, R.	International Atomic Energy Agency
Stolberg, Z.	International Atomic Energy Agency
Tatar, F.C.	Nuclear and Radioactive Waste Agency, Romania
Telleria, D.	International Atomic Energy Agency
Toba, A.	JAIF International Cooperation Center, Japan
Tonhauser, W.	International Atomic Energy Agency
Troshchenko, Y.	International Atomic Energy Agency
Ugbor, U.	International Atomic Energy Agency
Van Haastrecht, C.	Permanent Mission, Canada
Van Sickle, M.	International Atomic Energy Agency
Vierovkina, N.	Ministry of Energy and Coal Industry, Ukraine
Vincze, P.	International Atomic Energy Agency
Warren, P.	International Atomic Energy Agency
Weightman, M.	Consultant
Wells, P.	International Atomic Energy Agency
Wetherall, A.	International Atomic Energy Agency
Yagi, M.	International Atomic Energy Agency
Yang, J.S.	International Atomic Energy Agency

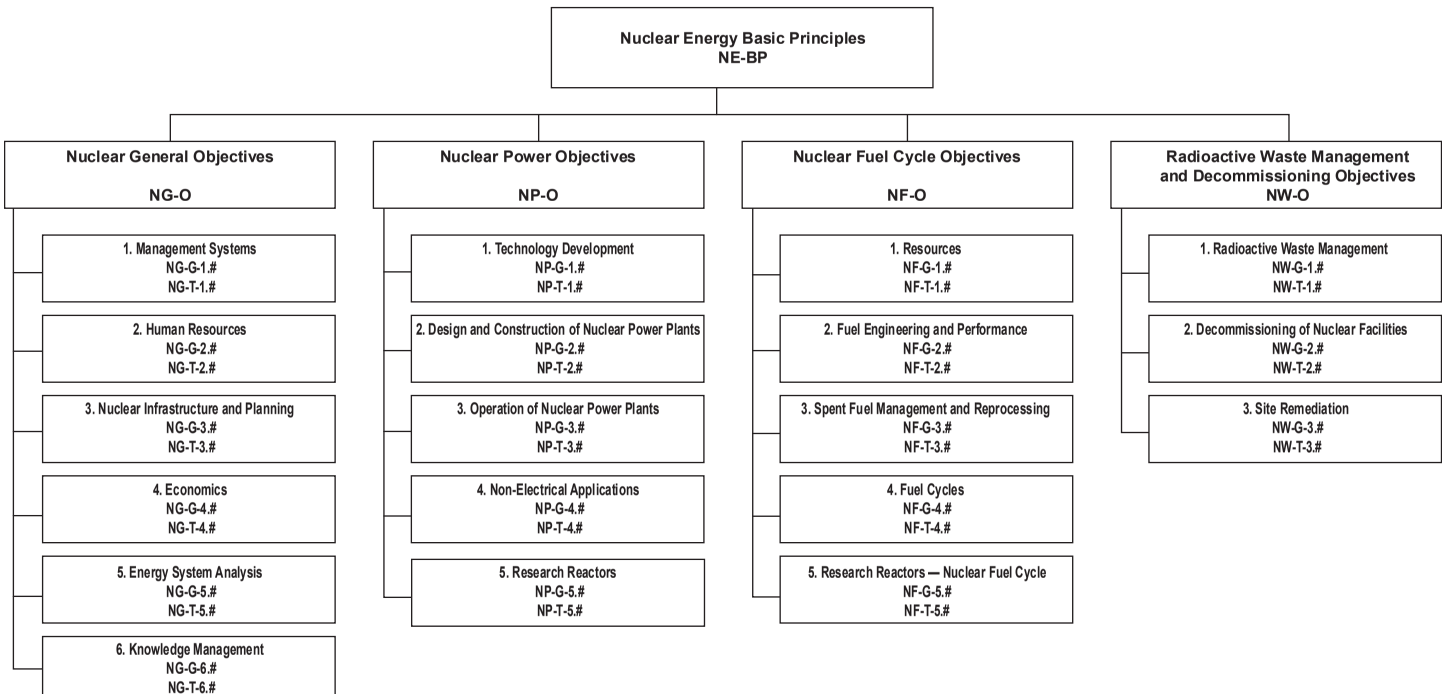
Consultants Meetings

Vienna, Austria: 22 October 2012, 15 February 2013, 8–12 July 2013,
3–14 February 2014, 26–30 May 2014, 7–11 July 2014, 6–17 October 2014

Technical Meeting

Vienna, Austria: 28–30 May 2014

Structure of the IAEA Nuclear Energy Series



Key

BP: Basic Principles
O: Objectives
G: Guides
T: Technical Reports
Nos 1-6: Topic designations
#: Guide or Report number (1, 2, 3, 4, etc.)

Examples

NG-G-3.1: Nuclear General (**NG**), Guide, Nuclear Infrastructure and Planning (topic **3**), **#1**
NP-T-5.4: Nuclear Power (**NP**), Report (**T**), Research Reactors (topic **5**), **#4**
NF-T-3.6: Nuclear Fuel (**NF**), Report (**T**), Spent Fuel Management and Reprocessing (topic **3**), **#6**
NW-G-1.1: Radioactive Waste Management and Decommissioning (**NW**), Guide, Radioactive Waste (topic **1**), **#1**

IAEA
International Atomic Energy Agency

No. 23

ORDERING LOCALLY

In the following countries, IAEA priced publications may be purchased from the sources listed below or from major local booksellers.

Orders for unpriced publications should be made directly to the IAEA. The contact details are given at the end of this list.

AUSTRALIA
DA Information Services
648 Whitehorse Road, Mitcham, VIC 3132, AUSTRALIA
Telephone: +61 3 9210 7777 • Fax: +61 3 9210 7788
Email: books@dadirect.com.au • Web site: http://www.dadirect.com.au

BELGIUM
Jean de Lannoy
Avenue du Roi 202, 1190 Brussels, BELGIUM
Telephone: +32 2 5384 308 • Fax: +32 2 5380 841
Email: jean.de.lannoy@euronet.be • Web site: http://www.jean-de-lannoy.be

CANADA
Renouf Publishing Co. Ltd.
5369 Canotek Road, Ottawa, ON K1J 9J3, CANADA
Telephone: +1 613 745 2665 • Fax: +1 643 745 7660
Email: order@renoufbooks.com • Web site: http://www.renoufbooks.com

Bernan Associates
4501 Forbes Blvd., Suite 200, Lanham, MD 20706-4391, USA
Telephone: +1 800 865 3457 • Fax: +1 800 865 3450
Email: orders@bernan.com • Web site: http://www.bernan.com

CZECH REPUBLIC
Suweco CZ, spol. S.r.o.
Klecakova 347, 180 21 Prague 9, CZECH REPUBLIC
Telephone: +420 242 459 202 • Fax: +420 242 459 203
Email: nakup@suweco.cz • Web site: http://www.suweco.cz

FINLAND
Akateeminen Kirjakauppa
PO Box 128 (Keskuskatu 1), 00101 Helsinki, FINLAND
Telephone: +358 9 121 41 • Fax: +358 9 121 4450
Email: akatilaus@akateeminen.com • Web site: http://www.akateeminen.com

FRANCE
Form-Edit
5 rue Janssen, PO Box 25, 75921 Paris CEDEX, FRANCE
Telephone: +33 1 42 01 49 49 • Fax: +33 1 42 01 90 90
Email: fabien.boucard@formedit.fr • Web site: http://www.formedit.fr

Lavoisier SAS
14 rue de Provigny, 94236 Cachan CEDEX, FRANCE
Telephone: +33 1 47 40 67 00 • Fax: +33 1 47 40 67 02
Email: livres@lavoisier.fr • Web site: http://www.lavoisier.fr

L'Appel du livre
99 rue de Charonne, 75011 Paris, FRANCE
Telephone: +33 1 43 07 50 80 • Fax: +33 1 43 07 50 80
Email: livres@appeldulivre.fr • Web site: http://www.appeldulivre.fr

GERMANY
Goethe Buchhandlung Teubig GmbH
Schweitzer Fachinformationen
Willstätterstrasse 15, 40549 Düsseldorf, GERMANY
Telephone: +49 (0) 211 49 8740 • Fax: +49 (0) 211 49 87428
Email: s.dehaan@schweitzer-online.de • Web site: http://www.goethebuch.de

HUNGARY
Librotrade Ltd., Book Import
PF 126, 1656 Budapest, HUNGARY
Telephone: +36 1 257 7777 • Fax: +36 1 257 7472
Email: books@librotrade.hu • Web site: http://www.librotrade.hu

INDIA

Allied Publishers

1st Floor, Dubash House, 15, J.N. Heredi Marg, Ballard Estate, Mumbai 400001, INDIA
Telephone: +91 22 2261 7926/27 • Fax: +91 22 2261 7928
Email: alliedpl@vsnl.com • Web site: http://www.alliedpublishers.com

Bookwell

3/79 Nirankari, Delhi 110009, INDIA
Telephone: +91 11 2760 1283/4536
Email: bkwell@nde.vsnl.net.in • Web site: http://www.bookwellindia.com

ITALY

Libreria Scientifica "AEIOU"

Via Vincenzo Maria Coronelli 6, 20146 Milan, ITALY
Telephone: +39 02 48 95 45 52 • Fax: +39 02 48 95 45 48
Email: info@libreriaaeiou.eu • Web site: http://www.libreriaaeiou.eu

JAPAN

Maruzen Co., Ltd.

1-9-18 Kaigan, Minato-ku, Tokyo 105-0022, JAPAN
Telephone: +81 3 6367 6047 • Fax: +81 3 6367 6160
Email: journal@maruzen.co.jp • Web site: http://maruzen.co.jp

NETHERLANDS

Martinus Nijhoff International

Koraalrood 50, Postbus 1853, 2700 CZ Zoetermeer, NETHERLANDS
Telephone: +31 793 684 400 • Fax: +31 793 615 698
Email: info@nijhoff.nl • Web site: http://www.nijhoff.nl

SLOVENIA

Cankarjeva Zalozba dd

Kopitarjeva 2, 1515 Ljubljana, SLOVENIA
Telephone: +386 1 432 31 44 • Fax: +386 1 230 14 35
Email: import.books@cankarjeva-z.si • Web site: http://www.mladinska.com/cankarjeva_zalozba

SPAIN

Diaz de Santos, S.A.

Librerias Bookshop • Departamento de pedidos
Calle Albasanz 2, esquina Hermanos Garcia Noblejas 21, 28037 Madrid, SPAIN
Telephone: +34 917 43 48 90 • Fax: +34 917 43 4023
Email: compras@diazdesantos.es • Web site: http://www.diazdesantos.es

UNITED KINGDOM

The Stationery Office Ltd. (TSO)

PO Box 29, Norwich, Norfolk, NR3 1PD, UNITED KINGDOM
Telephone: +44 870 600 5552
Email (orders): books.orders@tso.co.uk • (enquiries): book.enquiries@tso.co.uk • Web site: http://www.tso.co.uk

UNITED STATES OF AMERICA

Bernan Associates

4501 Forbes Blvd., Suite 200, Lanham, MD 20706-4391, USA
Telephone: +1 800 865 3457 • Fax: +1 800 865 3450
Email: orders@bernan.com • Web site: http://www.bernan.com

Renouf Publishing Co. Ltd.

812 Proctor Avenue, Ogdensburg, NY 13669, USA
Telephone: +1 888 551 7470 • Fax: +1 888 551 7471
Email: orders@renoufbooks.com • Web site: http://www.renoufbooks.com

United Nations

300 East 42nd Street, IN-919J, New York, NY 1001, USA
Telephone: +1 212 963 8302 • Fax: 1 212 963 3489
Email: publications@un.org • Web site: http://www.unp.un.org

Orders for both priced and unpriced publications may be addressed directly to:

IAEA Publishing Section, Marketing and Sales Unit, International Atomic Energy Agency
Vienna International Centre, PO Box 100, 1400 Vienna, Austria
Telephone: +43 1 2600 22529 or 22488 • Fax: +43 1 2600 29302
Email: sales.publications@iaea.org • Web site: http://www.iaea.org/books

15-13941

The development and implementation of an appropriate infrastructure to support the successful introduction of nuclear power and its safe, secure, peaceful and sustainable application is an issue of central concern, especially for countries that are considering and planning their first nuclear power plant. In preparing the necessary nuclear infrastructure, there are several activities that need to be completed. These activities can be split into three progressive phases of development. This publication provides a description of the conditions expected to be achieved by the end of each phase to assist with the best use of resources. 'Milestones' refer to the conditions necessary to demonstrate that the phase has been successfully completed.

INTERNATIONAL ATOMIC ENERGY AGENCY
VIENNA
ISBN 978–92–0–104715–1
ISSN 1995–7807