IAEA Nuclear Energy Series

No. NG-T-3.11

Managing Environmental Impact Assessment for Construction and Operation in New Nuclear Power Programmes

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IAEA NUCLEAR ENERGY SERIES PUBLICATIONS

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MANAGING ENVIRONMENTAL IMPACT ASSESSMENT FOR CONSTRUCTION AND OPERATION IN NEW NUCLEAR POWER PROGRAMMES

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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".

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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.

The introduction of a nuclear power programme is a major undertaking, with significant implications for many aspects of national infrastructure, ranging from 'hard' aspects of infrastructure to 'soft' areas such as human resources. In order to facilitate progress towards development of the necessary infrastructure for a State considering the introduction of nuclear power, the IAEA published IAEA Nuclear Energy Series No. NG-G-3.1, Milestones in the Development of a National Infrastructure for Nuclear Power, which describes a three phased approach and covers 19 different infrastructure issues — one of which is environmental protection. Moreover, environmental issues are often related to public perception and acceptance of a certain project. However, most States embarking on a nuclear power programme have no, or little, experience of environmental issues specific to nuclear power programmes.

This publication describes the environmental impact assessment (EIA) process, its utilization and the necessary infrastructure for such a process in order to provide a holistic approach for EIA in new nuclear power programmes. It also emphasizes the environmental aspects unique to a nuclear power programme, assuming that a State embarking on such a programme already has an environmental regulatory framework for the industrial projects in place.

This publication also describes the phased implementation of the EIA programme in accordance with the phases described in IAEA Nuclear Energy Series No. NG-G-3.1.

This publication is addressed to senior managers, project managers or coordinators and technical specialists of government authorities and agencies, including regulatory bodies, operating organizations and supporting industries, and other organizations involved in environmental issues.

The IAEA wishes to acknowledge the assistance provided by the contributors listed at the end and, in particular, V. Anastasov (The former Yugoslav Republic of Macedonia). The IAEA officer responsible for this publication was M. Aoki of the Division of Nuclear Power.

CONTENTS

1. INTRODUCTION

1.1. BACKGROUND

The introduction of a nuclear power programme is a major undertaking, with significant implications for many aspects of national infrastructure, ranging from 'hard' (or material) aspects of infrastructure to 'softer' (or human related) areas. For a State which does not already have nuclear power, it may take up to 10–15 years to develop the necessary infrastructure.

To facilitate the progress towards developing the required infrastructure for a State that is considering the introduction of nuclear power as part of its national energy strategy, the IAEA published IAEA Nuclear Energy Series No. NG-G-3.1, Milestones in the Development of a National Infrastructure for Nuclear Power [1], which describes a three phased approach, covering 19 different infrastructure issues that need to be addressed for each of the phases (see Fig. 1). Environmental protection is one of these 19 issues.

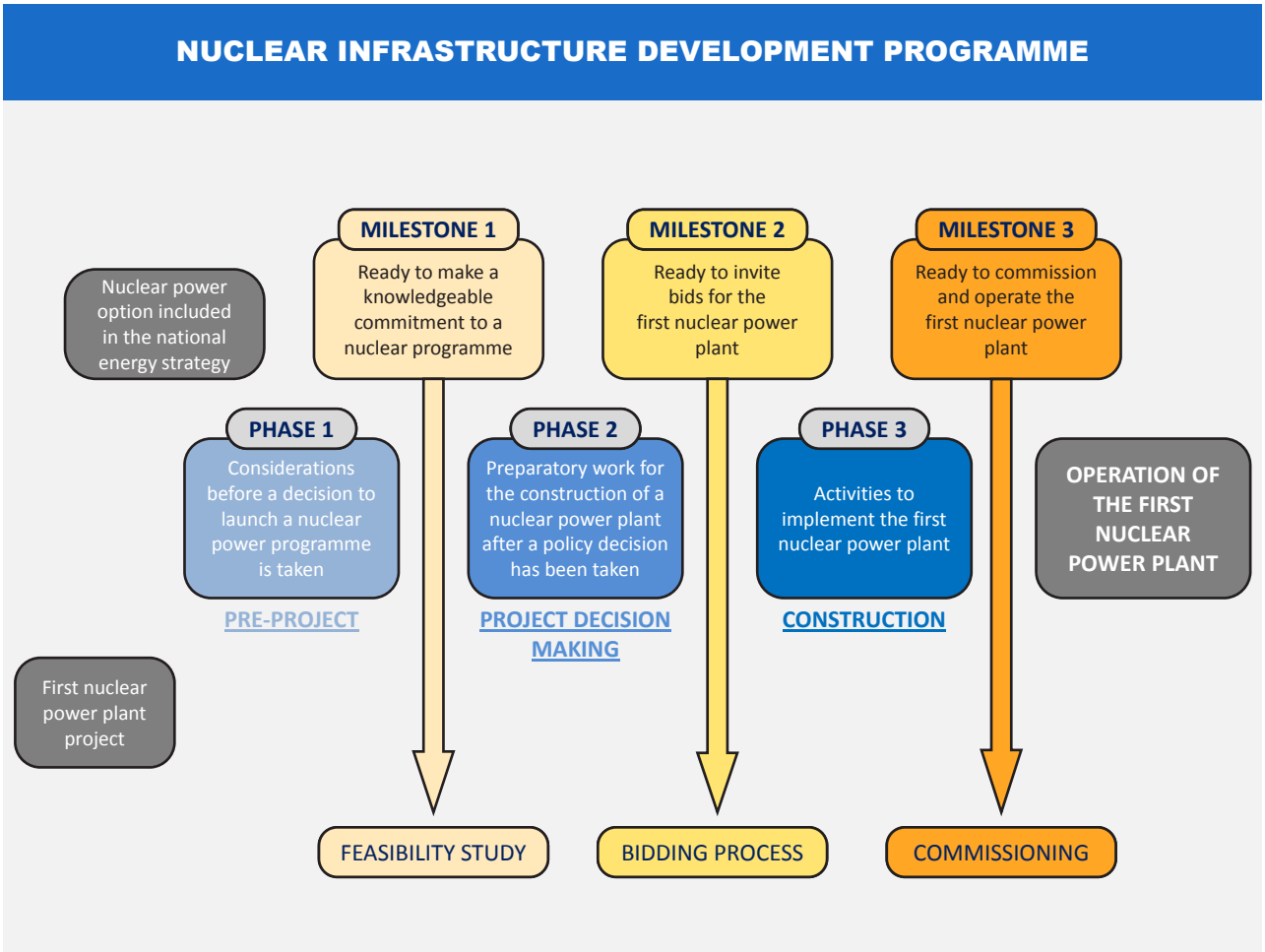

FIG. 1. Major phases and milestones in developing nuclear power.

As States turn to nuclear power to fulfil development goals, deploying a nuclear power programme in an environmentally sound manner is gaining significant importance. Currently, the emphasis on environmental issues is highlighted in many national and international documents on licensing related procedures (e.g. guidance, regulations and permit applications). Moreover, environmental issues often correspond to the public perception and acceptance of a certain project. However, most States embarking on a nuclear power programme ('embarking States') have no, or little, experience of environmental issues specific to nuclear programmes.

This publication provides a holistic approach to environmental protection in new nuclear power programmes. It describes the environmental impact assessment (EIA) process, its utilization and the necessary infrastructure for such a process. The presumption is made that an embarking State already has an environmental regulatory framework, which may not be developed for nuclear power but instead for current industrial projects. Hence, the emphasis of this publication is on the environmental aspects that are unique to a nuclear power plant project.

1.2. INTENDED AUDIENCE

This publication is addressed to senior managers, project managers or coordinators, and other technical specialists from: governmental authorities and agencies, including regulatory bodies; operating organizations and nuclear industries of embarking States; and organizations involved in environmental protection.

1.3. OBJECTIVE

The objective of this publication is to assist States in developing an effective EIA process and correctly using it in a consistent manner with existing IAEA publications. It is intended to cover all topics relevant to the process of addressing environmental issues in implementing nuclear power programmes.

This publication describes actions for each phase of the nuclear power programme dealing with environmental issues, following the approach suggested by IAEA Nuclear Energy Series No. NG-G-3.1 [1]. This publication also explains the process of developing a structured series of environmental reports, which provide information to all stakeholders and contribute to the open and transparent approach to nuclear power programme implementation. Where possible, this publication describes flexible approaches which allow States to adjust the recommendations to fit their existing legislative framework or policy.

1.4. SCOPE

This publication highlights typical environmental implications for nuclear power technology. Awareness of the specifics of nuclear technologies is required by all parties, including the regulators, to understand the unique aspects of implementing a nuclear power programme whilst protecting the environment. This awareness optimizes the planning and preparation phase.

IAEA publications are available for siting, safety, security, stakeholder involvement and emergency planning. Therefore, this publication only briefly reviews these topics, referencing the appropriate IAEA publications for further information.

1.5. STRUCTURE

Section 1 introduces the background, the objective, the scope and structure, and the targeted users of this publication. Section 2 presents general considerations for an environmental programme, including a roadmap for addressing environmental issues and an interface with other milestone issues. It examines the necessary expertise required to appropriately administer an environmental programme for nuclear power plant projects, and describes issues unique to nuclear EIAs.

Section 3 offers an overview of the necessary legislative, regulatory and organizational aspects that affect the environmental protection component of the new nuclear power programme. Section 4 is dedicated to the steps taken throughout the EIA process — from initial environmental information collection, through the environmental scoping report (ESR) to completion of the EIA report. Section 5 reviews the use of EIA reports in nuclear technology bid specification, the licence and permit processes, and the development of an environmental management plan (EMP) and an environmental monitoring programme.

Annex 1 provides a brief overview of some of the international legal instruments on environmental law. Annex 2 details the main technical sources of information required to prepare a nuclear power plant EIA.

Case studies on the role of public participation and communication, and environmental monitoring are given in Annexes 3 and 4, respectively.

2. GENERAL CONSIDERATIONS FOR THE ENVIRONMENTAL PROGRAMME

2.1. ROADMAP FOR ADDRESSING ENVIRONMENTAL ISSUES IN NEW NUCLEAR POWER PROGRAMMES

In the first phase of a nuclear power programme, a State considers the environmental issues pertaining to an informed decision for a nuclear programme. Typical actions would be:

— Reviewing the suitability of the existing framework and organizational structure responsible for environmental protection, with an action plan on how to address the identified deficiencies;
— Initiating a siting survey, which would also include initial environmental information collection and analysis.

The second phase should encompass essential preparatory work for the deployment of nuclear power, leading to the formulation of a specification to accompany the bid invitation to vendors. Ideally, a State would:

— Implement the action plan on legal, regulatory and organizational improvements for environmental protection;
— Allocate responsibilities and establish decision making and licensing processes;
— Complete the EIA process, with development of the three reports: initial environmental information analysis, the ESR and the EIA report;
— Incorporate the EIA results to prepare the bid invitation specification or contract.

The third phase follows the bid invitation specification and concludes with the nuclear power plant ready for operation. During this phase:

— All the various licences and permits for environmental requirements should be obtained.
— Environmental monitoring programmes are developed and fully implemented, and, if required by the State, an EMP is developed, all of which aim to respond to the scientific uncertainty of the EIA.

Figure 2 depicts the phased implementation of the environmental protection programme. Each step of the process is described briefly below and examined in more detail in Section 4.

The strategic environmental assessment (SEA) is a high level consideration of the issues likely to be significant to a particular project. The SEA is based on information available early in the process and is used for early decision making regarding the environmental feasibility of a project. States may perform an SEA as the first step in terms of environmental protection.

During the site survey stage, when many sites are screened, initial environmental information is collected to support the choice of candidate sites. Typically, the information is from a desktop survey and collection of all available data of environmental relevance, such as the protection status of terrestrial ecosystems and aquatic environment, their characteristics and aquifer sensitivity. Subsurface data collection is not required at this stage. An analysis of information describing each site's environmental suitability for a nuclear power plant may be presented as part of a site survey report or as a separate document.

The ESR is a plan for how the EIA is to be carried out. It may also be called by some States the 'terms of reference for the EIA' or the 'EIA programme'. It builds on the information provided in the initial environmental information report and identifies the requirements for additional information and analysis in order to complete a comprehensive EIA report. The ESR also aims to identify all aspects for which there may be impacts to be assessed in the EIA. The ESR provides a stakeholder participation and communication plan and identifies key stakeholders.

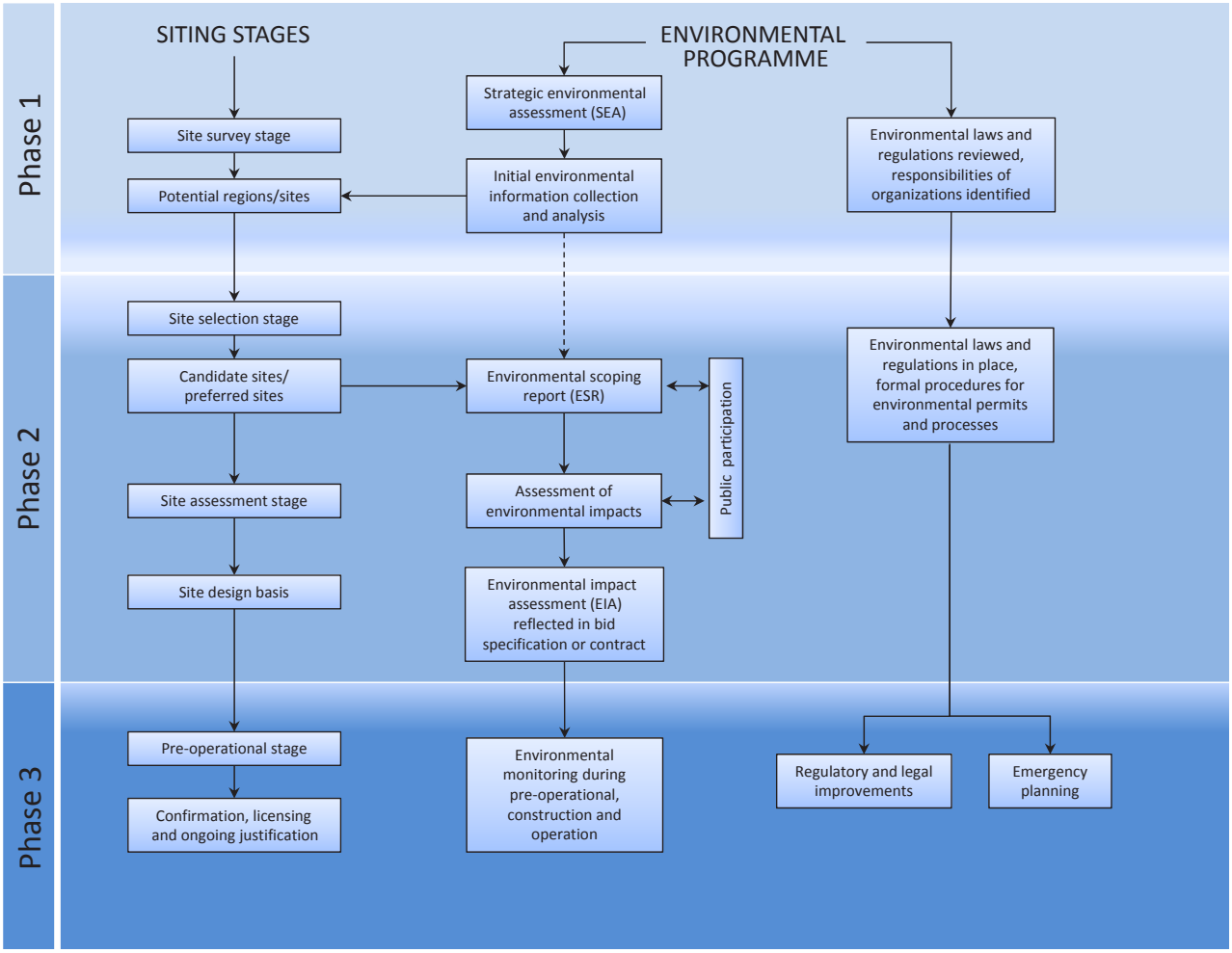

FIG. 2. Phased approach to address environmental issues in new nuclear power programmes.

The EIA is a process to identify and to assess all the environmental and socioeconomic impacts of the nuclear power plant. Its objective is to satisfy questions regarding impacts of the project on environmental and human health. It adds critical information to the licence and permit decision making process. In addition to the primary operating licence, it may be used by some stakeholders (e.g. financing institutions) in their own specific decision making processes. Therefore, it is important to understand the requirements associated with the specific uses of the EIA. The process also has the practical function of increasing the interaction among the project developer and stakeholders, as environmental issues are brought to light, discussed and resolved.

The EIA report presents the analysis and findings of the process in a holistic manner. It describes the baseline conditions of the environment and surrounding population, identifies the impacts of the project in all its phases on the environment and population, and analyses whether the impacts are significant. If the impacts are significant, the EIA report presents mitigation measures to address the impacts and a monitoring plan designed to keep track of the actual impacts during project development and operation.

The EIA also includes draft environmental monitoring for necessary mitigating measures when the monitored impacts exceed expected limits. The EIA report represents a holistic description of the project's environmental consequences to decision makers and increases the transparency of the nuclear development process. The report is a companion document to the safety analysis report (SAR)[1], which addresses the safety aspects of the site and the proposed project. In short, the EIA report is the leading document for the site permit request, while the SAR is the document submitted to the regulatory body for requesting the site licence.

[1] The SAR is used here to mean either the preliminary SAR or the final SAR, depending on the timing of the application process in the discussion. Generally, only the preliminary SAR is active during the entire EIA process until the EIA report is completed. The regulatory body uses the SAR to evaluate independently the safety of the plant. It typically includes some information also required in the EIA, so some coordination is generally needed to avoid duplication of effort.

A bid invitation specification will incorporate the environmental commitments, limitations and conditions resulting from EIA report approval to support the vendor evaluation. Environmental permits and licence applications, such as site, construction and operating licences, will also include relevant information and conclusions from the EIA process.

The environmental monitoring programme is compiled in the permit phase, utilizing recommendations made in the EIA report. The monitoring plan is approved by relevant authorities, either separately or as part of the relevant permits. The objective of monitoring is to provide ongoing information on significant impacts, so that mitigating steps can be taken if the monitored impacts exceed expected limits.

The EMP is a comprehensive document on all requirements for maintaining environmental protection, including monitoring, reporting, mitigation measures and processes for implementing corrective actions. Some States may not require such a combined document but instead may require individual plans for specific issues.

2.2. SIGNIFICANCE AND INTERACTION WITH OTHER MILESTONE ISSUES

Environmental issues span all aspects of a nuclear power programme. This section describes their significance related to the following milestone issues[2]:

— Nuclear safety;
— Site and supporting facilities;
— Funding and financing;
— Electric power grid;
— Emergency planning;
— Nuclear fuel cycle and radioactive waste;
— National position;
— Stakeholder involvement.

2.2.1. Nuclear safety

There are areas of overlap between the EIA and the safety analysis, particularly with regards to nuclear power plant parameters and site characterization and analysis. IAEA safety standards are developed to protect people and the environment from harmful effects of ionizing radiation. Environmental safety, which is addressed in the IAEA safety standards (see Fig. 3), is analogous to environmental protection in the new nuclear power programmes reviewed in this publication.

The relationship between the SAR and the EIA report should be noted. The SAR is a detailed demonstration of the safety of the nuclear power plant, reviewed and assessed by the regulatory body and in accordance with clearly defined procedures. The SAR contains accurate and sufficiently precise information on the plant and its operating conditions, including information on, for example, safety requirements, the design basis, site and plant characteristics, operational limits and conditions, and safety analyses, in such a way that the regulatory body will be able to evaluate independently the safety of the plant [2].

Information in the SAR, which is required in the EIA, includes:

— Geography of the site, including restricted settlement areas;
— Demography such as nearby and regional populations, including sensitive subpopulations;
— External hazards that could impact the site;
— Meteorology, including discussion of the characteristics describing dispersion of airborne contamination.

Also included is a description of surface water and groundwater, including modelling showing pathways for water based contaminant transport. The SAR also contains information on local and regional geological and geotechnical parameters, and descriptions of seismic potential and faults. Most, if not all, of this provides the

[2] The infrastructure issues indispensable to supporting environmental protection (e.g. the legislative and regulatory framework) are examined in depth in Section 3.

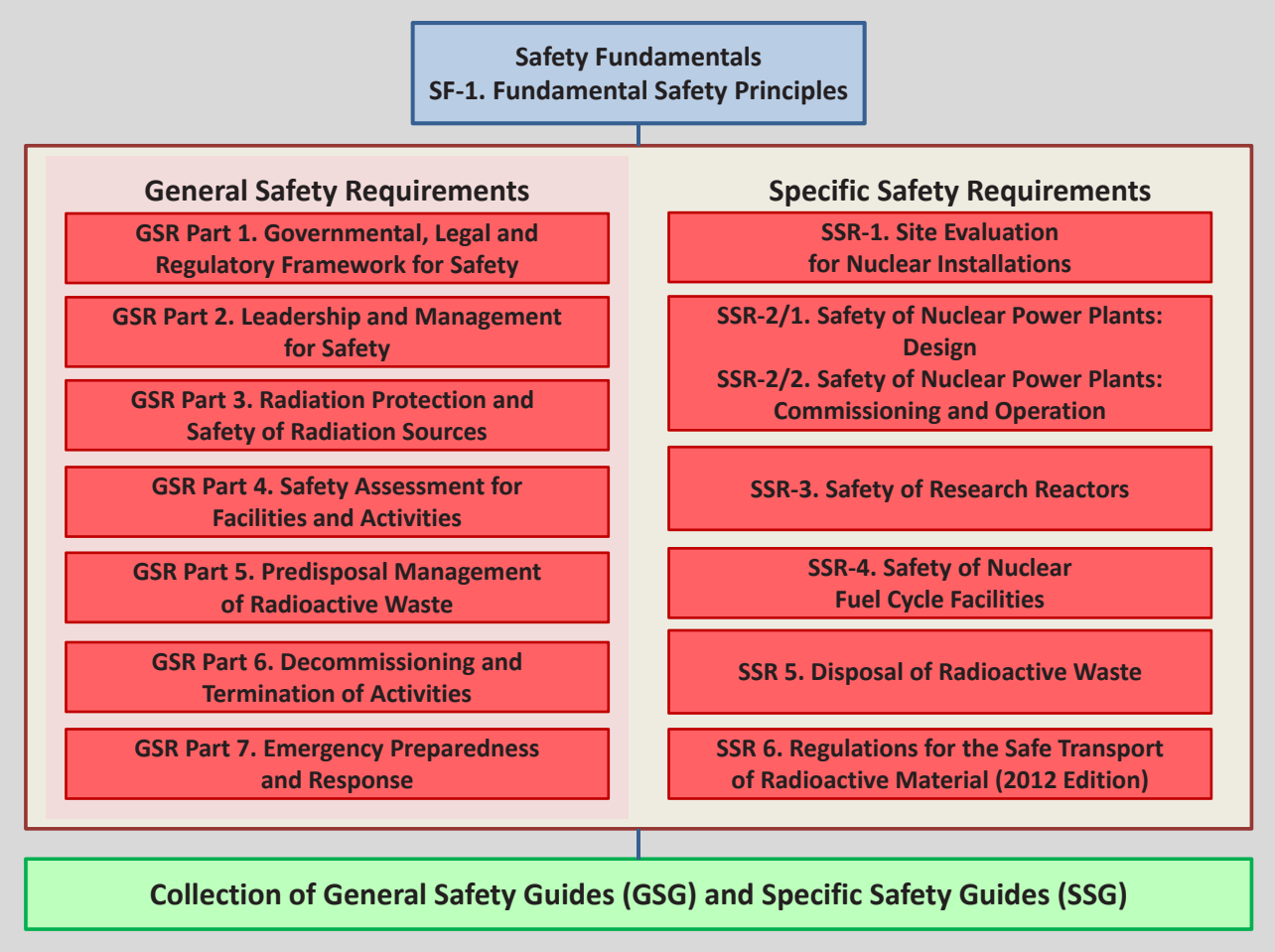

FIG. 3. The long term structure of the IAEA Safety Standards Series.

baseline physical information about the site and its vicinity, and supports the EIA analysis of the impacts of the nuclear power plant on the surrounding environment.

If the data required or intended for the SAR are available for stakeholder review by the time the EIA report is prepared and published, the EIA could refer to the data contained in the SAR. Otherwise, the EIA report contains enough of the SAR information relevant to site characterization to support its analyses and conclusions. Care should be taken throughout the entire EIA programme to ensure consistency between the EIA report and the SAR.

2.2.2. Siting

There is a clear connection between environmental protection and the site selection process. In fact, the siting process for nuclear power plants is strongly influenced by specific environmental considerations for the regions or sites of interest. These considerations for environmental protection and the environmental analysis typically include the protection of air, water, wildlife and cultural resources. They are among the factors influencing the site survey through the site selection criteria. The siting process narrows down the site options according to the available published environmental and safety related information, but the EIA process later enables considerable additional information to be collected and detailed analysis to be conducted. Consideration of environmental issues early in the site selection process should result in a selected site that is acceptable with regards to the environmental and socioeconomic impacts, with no other site significantly superior. Not just the environmental impacts, but also safety and other factors are considered in the site selection process. IAEA Nuclear Energy Series No. NG-T-3.7, Managing Siting Activities for Nuclear Power Plants [3], provides more guidance on the potential non-radiological environmental impacts on siting.

2.2.3. Funding and financing

A thorough analysis of environmental protection requirements, including required mitigation solutions, helps to reduce the uncertainty associated with the financial risks. By including the environmental protection requirements and mitigation solutions in the bid invitation specification, the possibility of unplanned and costly environmental protection measures impacting the design is minimized. Environmental protection requirements may also influence directly the choice of technology and design, with their associated costs. Many financial institutions require the completion of an EIA as a condition for a financing arrangement.

2.2.4. Electric power grid

Consideration of the impact due to upgrades of the electric power grid is more likely to be included in a separate EIA, which is often performed by someone other than the nuclear power plant developer. However, the environmental impact of the transmission corridor and substations associated with the introduction of the nuclear power plant may need to be included in the nuclear power plant EIA, and the assessment can influence decisions about the development of the electric power grid.

2.2.5. Emergency planning

Although in some States emergency planning is covered in the SAR, it may use some of the data from the EIA to develop an effective emergency response programme. The data allow the identification of critical contamination paths in case of accidents so that emergency notification systems and procedures can be optimized. The connection between environmental monitoring and emergency situations is examined in more detail in IAEA Safety Standards Series No. RS-G-1.8, Environmental and Source Monitoring for Purposes of Radiation Protection [4].

2.2.6. Nuclear fuel cycle and radioactive waste

A nuclear power programme may require consideration of the environmental aspects of mining, enrichment, fuel fabrication, reprocessing and disposal as part of the overall environmental protection process. Some of these steps are located outside the State, therefore the regulatory agencies should provide guidance on the level of detail required to address this in the overall EIA process. There is flexibility when States may address the issue — starting from early in the programme up to later in the process (after the construction licence has been issued).

2.3. STAKEHOLDER INVOLVEMENT IN THE ENVIRONMENTAL IMPACT ASSESSMENT PROCESS

The EIA addresses many issues of practical concern to stakeholders because it provides transparency and ensures that interested parties with insights and concerns have the opportunity for meaningful participation in a broad range of issues. Therefore, the EIA is regarded as one of the mechanisms for stakeholder involvement.

Sharing information on the development of a nuclear power programme starts with the involvement of the government and the nuclear energy programme implementing organization (NEPIO) when the overall expectations for the nuclear power programme and the purpose of the EIA are established. Information sharing should be continual, developing further the ability of the general public to understand the EIA process. Part of this information dissemination during the early stages is to reassure stakeholders that further information will be gathered as the process progresses, and that it will be analysed before firm decisions are made. When a specific site and an owner, or operator, are identified, then responsibility for stakeholder involvement in the EIA generally becomes the obligation of the owner or operator.

Stakeholder participation facilitates the overall EIA process and improves the comprehensive nature of the environmental assessment. Various stakeholders have different roles in the process. A useful distinction is between ‘statutory’ and ‘non-statutory’ stakeholders. Statutory stakeholders, primarily government agencies, are considered to be those organizations and bodies that, by law, are required to be involved in any planning, development or operational activity. Non-statutory stakeholders are additional stakeholders which may be affected, directly or indirectly, by the activity and therefore have an interest in the EIA (see Ref. [5]). Additionally, depending on the

policy and law of the State, international stakeholders may be either statutory or non-statutory, with international hearings and consultations performed as part of the EIA process.

The main purpose in involving the stakeholders in the process is to identify and to consider all the environmental issues that are of significance to the various stakeholders. A two way communication approach should be taken, making the environmental reports public, and then having a process to receive comments from statutory and non-statutory stakeholders for further consideration. All the comments received should be evaluated and recorded, although some may be irrelevant and therefore would not be addressed in the ESR and EIA report.

A competent authority may be designated as a focal point to coordinate the stakeholder involvement for the ESR and EIA report, making them available first to the statutory stakeholders for review and report revision, and then to the general public. The competent authority should also be the clearing house for receiving all the comments from the stakeholders and organizing them before forwarding to the proponent of the ESR or EIA report.

This competent authority should be identified under phase 1 activities, and is designated, or otherwise recognized, by the law during phase 2. It should have the quality of an 'independent party' (i.e. not responsible for the development of the project itself). The time frame for establishing the roles and responsibilities of other statutory stakeholders in the EIA process, including required competencies and their development, should coincide with the competent authority's time frame. The nature of the involvement of non-statutory stakeholders is defined in each State differently.

A time limit for the process should be established and publicized as part of the overall process explanation to the stakeholders. If the EIA process includes consultations with other States based on the policy and legislation of the State, the timelines for stakeholder involvement would have to take into account the differences between the legal and regulatory systems of neighbouring States. For example, the stakeholder process that is familiar to a neighbouring State may be subject to different regulations regarding stakeholders, or may have different timelines for completion. The time required for document translation may also significantly affect the overall schedule. In planning the stakeholder involvement process, the competent authority should consider these complex issues. A modification in the stakeholder regulations may be required to allow the transboundary input to be taken into account for the EIA process. Information on the general approach to stakeholder involvement can be found in Refs [1, 5].

2.4. ADDRESSING UNCERTAINTIES IN THE ENVIRONMENTAL IMPACT ASSESSMENT PROCESS

The purpose of the EIA process is to support project decision making with the help of environmental and socioeconomic information and analyses. In order to use this information in decision making, it should naturally be available before any significant decisions are made (e.g. selection of site, plant size or technology). It is common that an EIA report is required prior to a definitive decision on the site or nuclear power technology.

This implies that the EIA process in its various phases always involves assumptions and generalizations because sufficient information on environmental or socioeconomic conditions or technical parameters is rarely available at key decision making points. This information accumulates during the process and enables well grounded decisions to be made in each step (e.g. selecting the candidate sites from the potential sites or selecting between direct and indirect cooling). In spite of this, however, the information is not exact or complete. Consequently, the EIA process becomes based on accumulating, but deficient, information.

To address the specific issue of uncertainty in the final design of the plant technology, including that the vendor may not be identified at the time of the EIA report preparation, the plant parameter envelope (PPE) concept was developed. The PPE addresses all technologies under consideration and attributes a value for each technology for the aspects identified to lead to a potential environmental impact. The PPE includes the important physical and chemical parameters that may affect the environment (e.g. water requirements, land use and emissions) for the considered plants, and identifies the parameters with the highest impact value or range of values for each parameter. These 'bounding parameters' which are included in the PPE are then used for environmental analysis in the EIA process. When the final design is known, a comparison is made between the actual value for each aspect and the bounding value initially identified. If the ranges of actual values for the parameter are lower than, or equal to, values on which the environmental analysis is based, then further environmental assessment is not required. Otherwise, a new environmental assessment will be required.

Other sources of uncertainty, for example insufficient data, should be identified, and their impact on the reliability and accuracy of the assessment should be evaluated in the EIA report.

2.5. NECESSARY EXPERTISE FOR ENVIRONMENTAL IMPACT ASSESSMENTS

The EIA is a complex, holistic analysis, and hence, it involves a great deal of knowledge, skills and data interpretation. To review the EIA report effectively, the competent authority has either to develop its capacity in these areas or to utilize the expertise of other relevant organizations. Examples of the types of expertise that may be called upon in evaluating EIA topics range far beyond radiological subjects (see Table 1).

TABLE 1. TYPES OF EXPERTISE REQUIRED FOR ENVIRONMENTAL IMPACT ASSESSMENT REVIEWS

Sciences	Engineering	Social sciences	Other disciplines
Environmental science	Environmental engineering	Demography	Emergency planning
Biology, including human health	Geotechnology	Law	Security
Meteorology	Visual engineering	Economics	Project management
Oceanography	Acoustics	Environmental justice	Quality management
Hydrology	Developed land use	Archaeology and culture studies	Stakeholder involvement
Geology	Grid infrastructure		Permit and licence management
Seismology	Electromagnetism		
Volcanology	External human induced events		

Some of the experts in these areas are involved throughout the EIA process, starting from the initial environmental information stage, while others are involved only after the ESR in the preparation and final review of the EIA report (e.g. monitoring, geotechnology, visual engineering, emergency planning, acoustics and security). The level of their involvement increases throughout the process. Some of this expertise is primarily applied to the SAR rather than the EIA report, although it is used during the EIA to evaluate data.

2.6. UNIQUE ISSUES IN NUCLEAR ENVIRONMENTAL IMPACT ASSESSMENTS

The process of conducting an EIA for a nuclear power project is, in many respects, quite similar to other industry EIAs. This section examines the issues that are unique to the experience of an embarking State conducting such an assessment.

Nuclear power technology possesses unique characteristics that affect the environment, such as routine and accidental radiological releases, principally to air and water. Specialized techniques for modelling these potential releases have been developed, with particular methodologies for impact assessment. Radioactive waste and spent fuel management is also specific for a nuclear EIA, and would need to be addressed, despite the fact that separate EIA reports will be required. As part of the baseline environmental data collection programme, radiological measurements need to be made. Radiological monitoring is also required throughout operation and decommissioning.

Although thermal and chemical releases are addressed in conventional power plant EIAs, the power rating of most nuclear power plants dictates an increased level of concern for these two types of impact. Depending on the type of plant cooling water system, thermal discharge limits set to protect the environment typically have an impact on the cost efficiency of the plant, and therefore, they are the subject of intense interest. If the plant is designed with a once through cooling system, then water intake impacts may also be significant, including entrainment of aquatic organisms.

In order to allay international concerns with nuclear power plant project development, the EIA process should meet international practice. Even if a State has an existing nuclear power programme, it should not be presumed that the process for conducting the EIA has remained the same. In any event, a State's EIA requirements are unlikely to have all of the components currently expected for evaluating a nuclear power programme. Since environmental concerns are location specific, the EIA report associated with a reference nuclear power plant from another location is not going to be suitable for the new plant.

However, it should be kept in mind that radiological impacts constitute only one type of effect, and, in most cases, may not be the dominant impact of the nuclear power plant during normal operation. Furthermore, there are complex impact interrelations, which need to be assessed in an integrated manner (see Ref. [6]). Nonetheless, the potential impact of the authorized radioactive discharge on humans and the environment should be assessed (see Ref. [7]).

The nuclear power plant project may well be more complex than any other industrial project a State assesses. Its complexity, the amount of land and time required for construction, the distance of cooling water intake and discharge channels (for a once through cooling system), requirements for heavy haul roads or barge transport and unloading, the international interest, quality assurance requirements and the time from initial project planning to active power generation all require new expertise to assess impacts adequately.

Radioactive waste management, from low level to high level waste, as well as spent nuclear fuel management, should be presented in the nuclear EIA report. An overview of the possible technical options for managing radioactive waste is given in IAEA Nuclear Energy Series NW-G-1.1, Policies and Strategies for Radioactive Waste Management [8]. A specific EIA report should be developed for the disposal facilities and the final disposal of spent nuclear fuel.

Another unique issue for nuclear power plants is decommissioning. This complex process requires a dedicated EIA report, treatment or disposal of contaminated construction materials, and monitoring of the situation until release from regulatory control. Since decommissioning may happen 100 years after the start of operation, it is not addressed in detail in the EIA report for construction and operation of a plant, but it is described in principle, with the currently available possibilities for decommissioning. EIAs relating to decommissioning strategies are examined in more detail in IAEA Nuclear Energy Series No. NW-G-2.1, Policies and Strategies for the Decommissioning of Nuclear and Radiological Facilities [9].

Owing to the international and public attention given to the potential impacts of a nuclear power plant project (both radiological and non-radiological), States should expect to spend significantly more resources and time on EIAs relating to nuclear power plant projects than those associated with other industries.

3. FRAMEWORK FOR ENVIRONMENTAL PROTECTION PROGRAMMES

When establishing a nuclear power programme, embarking States need to ensure that their legal and regulatory framework appropriately accounts for the unique safety and environmental aspects of the programme. It is expected that environmental laws and regulations will need to be developed or supplemented. Additionally, newcomer States will need to ensure that organizations responsible for implementing environmental laws and regulations applicable to the nuclear power programme have sufficient technical capacity and clear responsibility. This section addresses the basic legal, regulatory and organizational requirements necessary for a comprehensive EIA programme for nuclear power facilities.

3.1. ENVIRONMENTAL PROTECTION LAWS

It is generally acknowledged that the legal framework for the protection of the environment from the impact of nuclear activities has two distinct bodies of law: nuclear law, which mostly covers aspects related to radioactivity; and environmental law, which covers all types of hazard but may also include requirements for the protection of the environment against the harmful effects of ionizing radiation.

It is expected that most embarking States will have an existing environmental protection framework, and any nuclear facility developed as part of the programme will need to comply with all existing, applicable environmental laws. Although certain laws may need to be supplemented, or new laws may be required to address fully the environmental issues resulting from a nuclear power programme, it is important to keep in mind that nuclear facilities impact the environment in a manner similar to other large industrial facilities (e.g. thermal and chemical releases). While radiological impacts will be mainly covered by nuclear laws, they may not address all environmental impacts and therefore additional environmental laws may be required to ensure adequate protection of the environment.

Many States have a comprehensive law requiring assessment of environmental impacts for major projects. However, such a law generally lacks detail, and States often look to other laws and regulations to implement the requirement fully. For example, separate laws may address the protection of human health, water (groundwater, surface fresh water and sea water), land and soil, air and the atmosphere, and biodiversity and ecosystems. Additionally, laws on cultural heritage, environmental justice and socioeconomic issues are important aspects of the legal framework for environmental protection. Therefore, laws addressing the full range of environmental impacts should be in place — or under development — before a knowledgeable decision is made to proceed with the nuclear power programme.

When augmenting environmental laws, States should give consideration to the harmonization of both nuclear and non-nuclear related environmental laws, and any ambiguities between them should be identified and clarified. In this manner, the programme development will not be impeded later on by conflicting or duplicate legal requirements. A sound legal framework provides developers and investors with a clear understanding of expectations, thus helping to reduce project risk.

3.2. INTERNATIONAL LEGAL INSTRUMENTS ON ENVIRONMENTAL PROTECTION

The body of international environmental conventions and treaties includes instruments with different objectives. Some focus on the development of general principles and decision making practices; others are designed to protect specific environmental media (e.g. air and the atmosphere, oceans and seas, freshwater resources, and soil), particular geographical areas, wildlife and natural resources, and prevent specific types of pollution, including the dispersion of radionuclides.

Many of the most important environmental impacts of a nuclear power plant project are not radiological in nature. For States that are party to conventions, treaties or regional agreements on environmental protection, the non-radiological aspects are often dealt with under such international legal instruments. It should be noted that although these instruments are obligatory only to the States Parties, it might be useful for States that are not party to consider the ethics and principles defined by the relevant instruments for possible positive use in the development of a national nuclear power programme. An examination of those environmental legal instruments is not within the scope of this publication, but further information on international environmental conventions and instruments is provided in Annex I. It should be noted that instruments of paramount importance to the regulation of nuclear activities, such as the IAEA safety standards, contain fundamental provisions in this field. The IAEA safety standards are understood to provide protection to the environment from regulated activities. IAEA Safety Standards Series No. GSR Part 3 (Interim), Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards [6], reports the trend in “the need to be able to demonstrate (rather than to assume) that the environment is protected against effects of industrial pollutants, including radionuclides” (para. 1.33).

International nuclear legal instruments concerning radiological protection of the environment include:

— Convention on Nuclear Safety;
— Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management;
— Convention on Early Notification of a Nuclear Accident;
— Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency.

To the extent that they address compensation for nuclear damage to the environment in case of accidents, nuclear liability conventions can also be considered significant in the context of environmental protection. Examples include the Vienna Convention on Civil Liability for Nuclear Damage, and the Convention on Supplementary Compensation for Nuclear Damage.

3.3. REGULATORY FRAMEWORK

Following the establishment of a legal framework, regulations on the activities required by law should be implemented. Regulations set requirements on how to comply with laws. EIA regulations generally address such topics as:

— EIA process and methodology;
— EIA scope;
— EIA report content (e.g. public participation, baseline monitoring and socioeconomic issues);
— Cumulative impact assessment;
— EMP;
— Required interfaces with other legislation.

The assumption is made here that an EIA for a nuclear power plant fits within the existing EIA regulatory framework, although, as noted earlier, some modifications may be required to address unique aspects of nuclear projects (see Section 2.6). If the State is not very familiar with evaluating EIA reports for large, complex industrial projects, then significant revisions to the existing laws and regulations covering the EIA may be required. A review of this is outside the scope of this publication.

The development and implementation of regulations is the responsibility of an operational regulatory body competent on issues related to environmental aspects of nuclear power.

3.4. ORGANIZATIONAL ASPECTS

IAEA Nuclear Energy Series No. NG-G-3.1 [1] suggests that in phase 1, the focus is put on assessing the capability of national organizations to deal with issues such as the preparation of guidelines, responsibilities and capacity for reviewing EIA related work, necessary authorization steps and interfaces, and coordination of environmental activities. The NEPIO, the nuclear regulatory body — if it exists — and the environmental protection authority are usually involved in this step, and an action plan to resolve deficiencies should be developed. The action plan would also identify who would develop and implement the legal and regulatory requirements, taking into account the necessary independence, as well as procedural relations among the suggested responsible organizations. These are important elements in minimizing potential conflicts of interest that may affect the programme's environmental protection.

Phase 2 entails the NEPIO acceeding environmental protection to a designated competent authority. In terms of activities, this phase is related to the actual creation of guidelines, capacity building for review activities, and implementation of authorization procedures for activities and processes related to the nuclear power programme. During phase 2, the majority of the EIA process is conducted with significant organizational requirements for stakeholder involvement, process approvals, and data and assessment finding reviews.

A fully implemented organizational structure to address the nuclear power facility EIA is likely to require modifications to the environmental protection authority structure, capacity and implementing procedures to provide appropriate coverage for radiological environmental protection. However, clear distinctions should be made with the nuclear regulatory body to avoid duplication of authority and effort. The current organizational capacities of States for a new nuclear power programme vary greatly. This section explains the principles of organizational structure and the approach to administering environmental protection requirements.

Environmental protection is achieved through guidance and control performed by various organizations, although one organization typically has overall responsibility for the EIA process. This organization, sometimes referred to as the competent authority, takes the lead on providing coordination with other agencies that may share responsibility for environmental protection. Formal agreements, such as memoranda of understanding, should be developed between responsible organizations in order to define the working arrangements, responsibilities and accountabilities. This would be the case in a number of States where the implementation of nuclear laws is controlled by the nuclear regulatory body, while an environment agency is responsible for the implementation of environmental laws.

In order for the EIA developers, the competent authority, the reviewers and other stakeholders to understand their role in developing a sound EIA report, the process should be clearly described, with all of its steps and interfaces, as well as stakeholder responsibilities and obligations (e.g. financial). A sound report should entail processes and procedures that result in collecting information of sufficient quality to enable informed decision making.

Early in the nuclear power programme, the environmental competent authority grants authorization to the developer, for example an initial (or early) siting permit, to proceed specifically with regards to assessing environmental issues. Since overall, nuclear power project time constraints may be greater than those experienced for other types of project, the requirements for organizational capacity should be developed early and take into account the project schedule requirements. Timely initiation of the EIA is important, as it is frequently the initial step in the nuclear power programme, owing to data collection requirements. Acceptance of the environmental impacts as identified and assessed in the EIA report may be a necessary part for approval of the site and the project itself, although this is not always the case. Timely approval of the report will be of importance for procurement of nuclear power plant components, since this requires significant lead time for planning, manufacture, delivery and installation.

Competent authority organizational capacity is also of crucial importance when regulatory issues arise. Although not all the required regulations may be in place, it is important to have an organization ready to tackle new issues in a timely and adequate manner throughout construction, operation and decommissioning. The independence of the competent authority from the promotion of nuclear power should be ensured.

4. PROCESS DESCRIPTION FOR CONDUCTING NUCLEAR ENVIRONMENTAL IMPACT ASSESSMENTS

As introduced in Section 2, the EIA process broadly consists of several steps that result in the development of three reports:

(1) Initial environmental information report;
(2) Environmental scoping report (ESR);
(3) Environmental impact assessment (EIA).

The initial environmental information report contains the available information gathered without new site specific sample collection. It is used to support the selection of the site from among other candidate sites during the initial site selection process. This part of the process is examined further in IAEA Nuclear Energy Series No. NG-T-3.7 [3].

The ESR uses the initial environmental information as the starting point for planning the scope of the detailed EIA report. The ESR contains an analysis of the data gaps which need to be filled to permit a comprehensive analysis of the environmental impacts of the planned project. For this reason, stakeholder involvement is required to adequately capture potential impacts from many perspectives. At a minimum, the statutory stakeholders are involved, with coordination by the competent authority. It is also encouraged to include the non-statutory stakeholders in the ESR process.

The process also includes communication with regulatory authorities and stakeholders, and culminates in the finalization of each report and the acceptance by the competent authority (see Fig. 4). The interactive nature of the communications is shown by double-headed arrows.

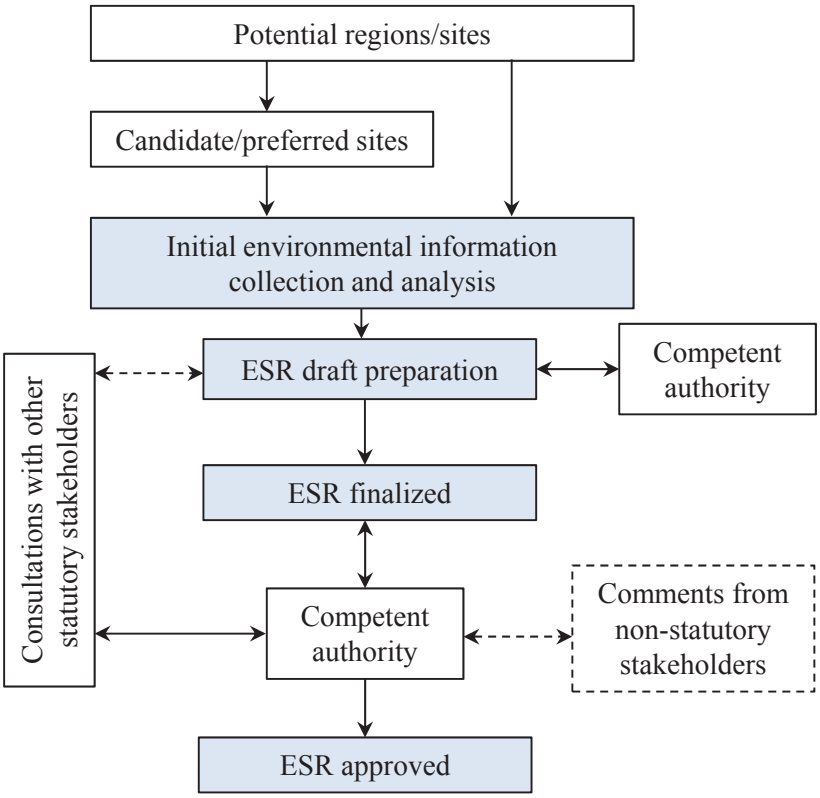

FIG. 4. The ESR development process.

During the ESR planning phase, all available data sources are identified (if they have not already been completed in the initial environmental information report), relevant issues are determined and taken into consideration, study areas are defined, and general methodologies for additional data collection and analysis are specified. Generally speaking, the ESR specifies how the EIA is to be conducted, including methodologies, issues of special interests, legal and regulatory interfaces, and stakeholders to be consulted.

After the initial draft ESR is prepared for review by the statutory stakeholders, consultations are held with the competent authority and perhaps some other agencies. Once their comments have been incorporated into a revised draft, the State may involve the public to gather comments on the draft version. After all the comments have been received and considered, the report is finalized and approved by the competent authority. The ESR provides a roadmap for conducting the environmental assessment and preparation of the EIA report.

Preparation of the EIA report consists of several steps (see Fig. 5). Using the ESR as the basis, environmental monitoring and baseline information collection are fully implemented according to the approved protocols. The results form the basis for the assessment of impacts, which is also conducted according to the methodologies identified in the ESR.

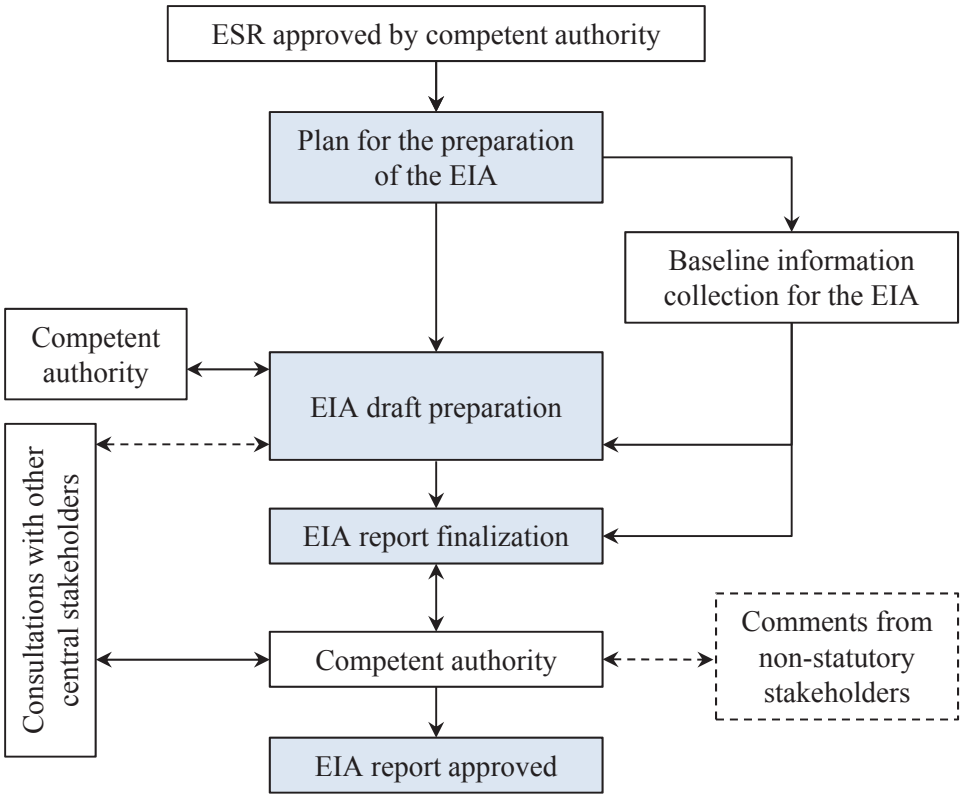

FIG. 5. The EIA report development process.

The draft EIA report is submitted to the competent authority to verify that the collected baseline data and the assessment methodologies are in line with the ESR and that, consequently, the EIA report adequately addresses the project issues. It may be that the information made available during environmental monitoring highlights some issues that were previously unknown, and consultations therefore have to clarify the assessment approach. Additional baseline data may need to be collected to address these issues. Before the draft EIA report is ready for public comment, none of the issues, however, should be left open.

Good practice in stakeholder involvement is that the draft EIA report is also submitted to other key or central stakeholders for comment. Depending on the State, these central stakeholders may include other organizations and agencies that usually support the competent authority or public associations interested in the project.

After all comments from the competent authority and other key stakeholders have been received and addressed, the final draft EIA report is submitted for comments to both the competent authority and the public. As this report will generate significant public debate, it is essential that the roles, responsibilities and authorities of the stakeholders are clearly defined much earlier in the process (as discussed in Section 2.3). During the public comment process, adjustments and amendments to the EIA report may be requested by the stakeholders and required by the competent authority, but in general, if the ESR/EIA process is properly implemented, there should not be a major overhaul of the report.

The final approval by the competent authority represents acceptance of the analyses and conclusions in the EIA report regarding the environmental impacts and environmental feasibility of the nuclear power plant project. The report will also identify the environmental sensitivities that should be addressed in the bid invitation specification, where unique plant design provisions or construction techniques may be necessary to focus on these sensitivities [1]. The report will also be used in licensing and permitting as well as detailed planning for the required environmental monitoring during the construction and operation of the nuclear power plant. Greater detail on the use of the report is provided in Section 5.

4.1. SCHEDULE

The overall EIA process requires time to be completed in a satisfactory manner (normally years). The schedule is affected by many variables, including: specific State requirements; the time to collect and to evaluate the necessary data; and the amount of stakeholder involvement, including international participation. The schedule for the EIA should be taken into consideration when organizing the interface among the legislative and regulatory processes, overall project development and the stakeholders.

Each State progresses through a nuclear power programme at its own pace, taking into account its own specific situation, dependent on various needs, interests and capacity. Certain milestones within the EIA process require decisions to be made by the competent authority or government, which may affect the schedule. However, the process is a continuum, and, ideally, all of the steps should be completed before a construction licence is issued. However, as noted earlier, some environmental aspects might be addressed prior to issue of the operating licence. The time to complete the general steps of the EIA can be expected to be as follows:

(a) Site survey: This is the initial step preceding the site selection and site assessment stages. The initial environmental information analysis should be included in the site scope of the survey and is instrumental at this stage, capturing relevant information on environmental issues. This stage will typically take about 9–12 months after establishing the siting core team, although it could be longer, allowing for the government decision process [3].
(b) ESR finalization: When site selection has been concluded and the site, or sites, has been chosen for the detailed EIA, all available information is collected and incorporated into the ESR. Preparation of the draft ESR (described in detail below) may be expected to take approximately 6–12 months. Additional time is required for public comments and review by the competent authority. Revision and finalization of the ESR take further time.
(c) EIA report finalization: Following the approval of the ESR, the site assessment stage commences with the implementation and preparation of the EIA report. This is a complex process, with discrete steps that include a minimum of 12 months to collect baseline data and subsequent time for analysis, evaluation of impacts, development of required monitoring and mitigation programmes, and preparation of the EIA report for stakeholder comments. Additional time is required for competent authority review and any necessary revisions of the draft report. The total time from approval of the ESR through to approval of the EIA report depends on many factors, including the experience of the State in evaluating the EIA, and may vary from two to four years.

Some parts of these processes may run in parallel, such as the collection of baseline information prior to finalization of the ESR, shortening the overall schedule duration. Earlier involvement of the public in reviewing the ESR is also likely to improve the overall schedule duration. The review times can vary widely due to issues specific to the State or its appropriate competent authorities, but should be taken into account by the EIA developers when planning the EIA process. Furthermore, when the EIA report is finalized, it may be used for a number of purposes that will have their own schedules.

However, since the construction licence cannot be issued until the EIA report is finalized[3], it is important that the EIA process starts as early in the nuclear power programme as possible. The following sections provide greater detail on the specific stages of the process.

4.2. INITIAL ENVIRONMENTAL INFORMATION

In the first phase, among the activities dedicated to environmental protection in new nuclear power programmes is the early commencement of environmental studies. The first objective of the initial environmental information is to help to identify the most suitable potential nuclear power plant sites within the scope of the site survey (see Ref. [3] for more details). As the number of sites being scrutinized against exclusionary and avoidance

[3] Though specific to each State, view adopted in this publication is that an integrated EIA may provide a more comprehensive overview to evaluate the project's impacts on people and the environment.

criteria is reduced, the amount of environmental information collected for each remaining site may increase. When the final candidate sites are identified, the initial environmental information should represent a thorough compilation of all the existing data to be used later on in the ESR. Data gaps will be identified in the ESR and later filled in the EIA process.

The initial environmental information process extends from phase 1, with the data gathered to evaluate the suitability of a potential site, to the early stages of phase 2, when the study intensifies with collection of additional data and interpretation, providing further guidance to selection of the preferred site or sites and a basis for the development of the ESR. All available archived data on land use, historical and cultural resources, meteorology and air quality, geology, hydrology, ecology, socioeconomics and environmental justice, the radiological and chemical environment, and related national projects should find its place in the initial environmental information report. Ideally, sufficient information is required to be available to describe all the known environmental sensitivities (e.g. animal and plant species, sites of a scientific and cultural value, and visual pollution). In most cases, however, there are significant gaps in the data on the site itself, even if general information about a topic is available.

In addition to its role in developing the EIA report, and use in the site selection process, the analysis of the initial environmental information may also be used in the preparation of a pre-feasibility or a feasibility study for the project, should these studies be required in the State's decision making process prior to the report. The environmental analysis in these studies does not assess all the aspects of the initial environmental information; rather, its focus is on identifying significant environmental issues and feasible measures for overcoming them. By highlighting the key environmental issues of the nuclear power project at this early stage, the use of initial environmental information may indicate areas of concern and information that needs to be gathered for further analysis or assessment prior to completion of phase 1 (decision to proceed with the project).

As the initial environmental information analysis takes place in phase 1, and possibly in early phase 2, its development would typically be the responsibility of the NEPIO. The gathered information and analysis would then be made available for the drafting of the ESR by the developer.

4.3. ENVIRONMENTAL SCOPING REPORT

4.3.1. Purpose of the environmental scoping report

The purpose of the ESR is to provide the necessary guidance to conduct the EIA study. In order to do so, the ESR should review all of the known environmental information and the project scope. It also identifies the data gaps that should be filled to enable a complete assessment of environmental impacts anticipated to be associated with the project. The ESR identifies the baseline information that should be collected and the general methodology to do so, as well as the nuclear power plant technical information and methodology to be used to evaluate the data, assess impacts and address them in the EIA report. A useful example of the typical types of information required for the preparation of the report is provided in Annex II.

The draft ESR is reviewed in the stakeholder involvement process, and stakeholder input is considered when finalizing it. The competent authority responsible for the EIA process should approve the ESR.

4.3.2. Typical content of the environmental scoping report

While the format of an ESR may vary depending on State requirements or preferences, it should, at a minimum, include the following sections.

4.3.2.1. Introduction

This should provide a site description, a brief project outline, and the purpose and objectives of the ESR.

4.3.2.2. Project justification

A statement outlining the necessity of the proposed project should be provided, including the requirement for additional power, and it should be consistent with the State's development goals and energy policies.

4.3.2.3. Description of the EIA process

The ESR clearly describes the steps to be taken in preparing the EIA report, including the timelines and the scope of work included in each step, and a list of regulatory required permits and licences throughout the steps. The ESR also describes the intended public participation process and lists stakeholders to be involved in each step.

4.3.2.4. Description of the project

The project should be described in as much detail as possible based on the information available at that time. Both construction and operational aspects should be described, particularly interfaces with the environment (impacts on the environment and impacts of the environment on the project). In many cases, the nuclear power vendor technology, size or even location of the plant will not have been decided at the time of development of the ESR and the EIA report. However, the environmental assessment process can progress using the PPE principle, as described in Section 2.4. If the vendor technology was not known at the time of preparing the EIA report, then the report will have to be reviewed after the vendor design is known to ensure that it adequately addresses the plant impacts.

4.3.2.5. Alternative options to be considered

The objective to be met by construction of the project may be met by other means. Therefore, these alternatives need to be agreed for further discussion in the EIA, as well as the consequences of not constructing the project (the zero option). In order to have a meaningful comparison, the selected alternatives should be reasonable — that is, implementable and technologically feasible. In addition, the project may have alternative ways of implementation such as alternative sites, alternative sizes, cooling options and plant technologies. The alternatives should be carefully designed, and their number should be limited to a feasible level for evaluation, often between two and five.

4.3.2.6. Scope of the environmental impact assessment report

In addition to the site itself and its environs, the ESR should define whether the EIA report is to include an assessment of additional items such as the nuclear fuel cycle front end, back end, transmission lines and roads.

4.3.2.7. Available baseline environmental information

This section contains a description of the study area based on all available information, most of which is collected as part of the initial environmental information. As much as possible, the baseline information should be presented in maps, figures and tables. The objective of this section is to provide a clear picture of the existing environmental resources and values for which the impacts should be considered. Data gaps (which vary widely depending on whether the site has been studied before and upon the type of resource being evaluated) should be identified in order to enable the design of a data collection programme.

4.3.2.8. Baseline environmental data collection

The methodology to gather the required information to fill data gaps is described in sufficient detail to ensure that sufficient data, of appropriate quality, is collected. This includes a description of sampling locations and frequency, but also the general time schedule for data collection, since some types of data can be collected even before the ESR receives final approval, while others may require extended time frames for collection. A baseline environmental data collection programme includes all of the elements required for a comprehensive industrial EIA report. However, the sampling programme is more extensive than that typically required for an industrial EIA report. In addition, evaluation of the radiological background of the site, which typically covers radiological parameters such as total alpha, beta or gamma radiation, and an evaluation of radioactive elements usually associated with nuclear projects are required.

4.3.2.9. Methodologies for the environmental impact assessment study

For the purposes of clarity and uninterrupted process flow, the ESR should also define the methodologies to be used in the EIA — that is, a definition of how to assess the significance of the impacts and how the data will be used. This section should also address how uncertainties are handled, including technology design.

4.3.2.10. Public participation plan

The ESR should identify the statutory and non-statutory stakeholders, and address the process for stakeholder involvement, as described further in Section 4.3.3.

4.3.3. Stakeholder involvement in the environmental scoping report

It is recommended that the statutory stakeholders are contacted early in the process of developing the ESR, and their views taken into consideration, so that the ESR includes all the items deemed important by those designated responsible by law. Participation in the creation and review process is not just limited to authorities that have licensing rights; it involves all governmental organizations whose scope of work is (or should be) reflected in the ESR.

In that sense, public participation in the process is recommended after the governmental organizations have provided their initial input (of course, additional inputs by governmental organizations are provided, as necessary, throughout the process). The level of public participation depends on the practices and regulations in the particular State.

Following the response of the EIA developer to the comments and remarks, the revised ESR is sent back to the responsible competent authority. When the revised version is found to be satisfactory, the competent authority provides approval, marking the beginning of the EIA report development stage.

4.4. ENVIRONMENTAL IMPACT ASSESSMENT

4.4.1. Purpose of the environmental impact assessment report

The Principles of Environmental Impact Assessment Best Practice [10] defines the EIA as:

> "The process of identifying, predicting, evaluating and mitigating the biophysical, social, and other relevant effects of development proposals prior to major decisions being taken and commitments made" (para. 2.1).

Objectives of the EIA are [10]:

> "—To ensure that environmental considerations are explicitly addressed and incorporated into the development decision making process;
> "—To anticipate and avoid, minimize or offset the adverse significant biophysical, social and other relevant effects of development proposals;
> "—To protect the productivity and capacity of natural systems and the ecological processes which maintain their functions; and
> "—To promote development that is sustainable and optimizes resource use and management opportunities" (para. 2.2).

The EIA report should identify all environmental and socioeconomic impacts, including their nature, probability, duration, magnitude and significance. It considers the entire project development programme, from construction through to decommissioning. The report is used for several purposes as described in Section 5, but its primary use is by decision makers to assess whether the suggested nuclear power plant project is environmentally acceptable at the selected site.

Once the EIA report is approved by the competent authority, the document which further on should address the possibility for adverse impacts is the EMP, already outlined in the EIA report. Should the environmental monitoring or new scientific information suggest any negative effects from the construction or operation of the nuclear power plant, mitigation measures should be defined within the framework of this plan (see Section 5).

4.4.2. Typical contents of a nuclear environmental impact assessment report

The content of an EIA report for a nuclear power plant can be considered, to a large extent, to be similar to that of any other large industrial project EIA. The typical content varies depending on the project and the State in which the nuclear power plant is being built, but the general issues concerned are similar for new projects. Therefore, the EIA is likely to contain the following sections.

4.4.2.1. Summary

This section provides a non-technical summary of the EIA report, including a general description of the project, its justification, EIA procedure, magnitude and probability of significant impacts during construction, operation (normal and irregular), principles for decommissioning, as well as mitigation measures. The summary should also provide conclusions which serve as inputs to decision makers and planners.

4.4.2.2. Introduction

This section provides a description of the background of the proposed project, objective of the EIA, scope, national and international legislative framework, and the use of the document for the nuclear power permit and decision making.

4.4.2.3. Environmental impact assessment procedure and communication and participation

This section describes the EIA procedure (objectives and main stages) as well as the stakeholder involvement (e.g. public meetings and audit group work) carried out during the procedure.

4.4.2.4. Description of the project

This section contains identification of the responsible party, evaluated project alternatives (including the zero option) and project timetable, including pre-construction, construction, operation and decommissioning.

4.4.2.5. Description of the plant

This section describes the technical aspects of the nuclear power plant or reference plant, general operation principles, construction work to be carried out and best available technology principles. It may contain a list of stressors, including PPE data, for consideration during the impact analysis step:

— Radiological and non-radiological emissions (both atmospheric and liquid);
— Water and waste issues;
— Chemicals potentially to be used on-site;
— Transportation and traffic connections.

This section can also contain a description of the nuclear fuel supply and management of spent nuclear fuel. The level of detail required varies depending on the legislative and other requirements of the State.

4.4.2.6. Nuclear safety

This section includes a review of the nuclear related aspects of the safety of the plant. It describes nuclear safety requirements and principles as well as their implementation in the design, construction and operation of a nuclear power plant.

4.4.2.7. Description of the environment

This section provides a description of the present condition of key affected environmental components as baseline information for future analysis, including:

— Meteorology and air quality;
— Land use, buildings and land use plans;
— Soils, geology and hydrogeology;
— Water resources and quality;
— Terrestrial ecology;
— Aquatic ecology;
— Existing radiological and conventional contamination;
— Socioeconomic characteristics of the areas that may be affected by the nuclear power project.

4.4.2.8. Environmental impact assessment for the project

This section describes the analysis used to estimate the magnitude and important characteristics of the impact. The assessment is performed by identifying the gap between the projected environmental quality condition due to project implementation and the baseline condition without the project, within a defined period of time and using the required method for estimating the impact. The method should identify the impact flow mechanism among the various environmental components directly or indirectly during the construction, operation and decommissioning phases. Therefore, this section generally includes the following aspects:

(a) Impact during construction of the nuclear power plant: This provides a description of direct significant impacts of construction work on soil, bedrock, groundwater, flora and fauna, land use and landscape, noise, air quality, people and society. The activities that might cause potential impacts include, but are not limited to:
    (i) Mobilization of material;
    (ii) Human resources;
    (iii) Construction of the base camp;
    (iv) Workshop building;
    (v) Land preparation, land cut and fill;
    (vi) Transportation of project material;
    (vii) Construction.
(b) Impact during normal operation of the nuclear power plant: This provides a description of direct and indirect impacts on people and the environment due to plant operation. The activities that might create a potential impact include the additional workforce at the nuclear reactor and the operational activities themselves, which could generate heat release, radioactive release, chemical material release from laboratories, sanitation waste and maintenance activities.
(c) Impact during decommissioning of the nuclear power plant: This provides a general description of the impact of the project on the environment during the decommissioning period. Some of the activities that might create a potential impact include removal of the spent fuel element from the reactor core, dismantling of reactor components and the decontamination process. Most of the analysis is only described in this EIA and is not assessed (decommissioning requires a separate EIA in the end phase of the plant life cycle, i.e. after 60–80 years). Considerations at the design and construction phase that later influence decommissioning and the various approaches that are hence stipulated may be found in IAEA-TECDOC-1657, Design Lessons Drawn from the Decommissioning of Nuclear Facilities [11].

Specific impacts on components of the environment should be addressed in each section, including, but are not limited to, the following impacts on:

(a) Air, soil and water quality due to nuclear and non-nuclear releases to the environment: This provides a description of radioactive and non-radioactive emissions (normal and abnormal operation) as well as other emissions (emergency power, heat generation and transportation). Guidance for the modelling of normal and abnormal operation radioactive release and its impact on people and the environment is provided in Refs [12–15].
(b) Aquatic flora, fauna and ecological values: This provides a description of the impact of the new nuclear power plant and infrastructure on the aquatic flora, fauna and ecological values of the area, including:
  (i) Conventional contaminant levels;
  (ii) Aquatic biota populations and structure;
  (iii) Ecological state;
  (iv) Impact of discharge channels on habitat;
  (v) Impact of cooling water on water temperatures (cooling water modelling) and local ecology.
(c) Terrestrial flora, fauna and ecological values: This provides a description of the impact analysis of the new nuclear power plant and infrastructure on the terrestrial flora, fauna and ecological values of the area, including:
  (i) Conventional contaminant levels;
  (ii) Terrestrial biota populations and structure;
  (iii) Ecological state.
(d) Landscape and cultural environment: This provides an analysis of the impacts of the new nuclear power plant and required infrastructure on the landscape (photo montages) and possible cultural values.
(e) Traffic: This describes the impact of the project on traffic amount, type and safety, including construction traffic and workforce traffic during operation and maintenance events.
(f) Noise level: This evaluates the impacts of the nuclear power plant operation and maintenance activities on noise levels around the site area.
(g) People and socioeconomic factors: This provides a description of the impacts of the new nuclear power plant and infrastructure on people and socioeconomic factors, including:
  (i) Fishing and hunting activities, both private and industrial;
  (ii) Regional structure;
  (iii) Economy and employment;
  (iv) Changes in living conditions due to influx of temporary or permanent workers;
  (v) Requirement for additional infrastructure;
  (vi) Additional taxes to be paid to the area.
  (vii) Potential health impacts (ionizing radiation and conventional contaminant related).
(h) Waste management: This describes the amount of radiological and non-radiological waste and impacts of the waste management programmes. For the radiological waste management programme, actions should be presented in accordance with the radioactive waste classification and waste minimization principles. A suitable IAEA publication on waste classification is IAEA Safety Standards Series No. GSG-1, Classification of Radioactive Waste [16], with further discussion on typical disposal approaches in IAEA Nuclear Energy Series No. NW-T-1.20, Disposal Approaches for Long Lived Low and Intermediate Level Radioactive Waste [17].
(i) Spent fuel management: Although this is an issue that needs to be fully addressed much later after the start of the nuclear power plant operation, the description of the general concept considered for the spent fuel management would be the minimum to be included in the EIA, together with a timeline to be followed in solving the issue.

4.4.2.9. Cumulative impact

This section includes a description of other projects in the area and the combined impacts resulting from the addition of the nuclear power project. In addition, the cumulative impact over time on environmental resources that continue to be affected is described (e.g. water and air).

4.4.2.10. Impact of irregular operation and accidents at the nuclear power plant

This section should provide a description of impacts on people and the environment due to design base accidents, beyond design base accidents and severe accidents at the nuclear power plant. The area of impact and measures to address these impacts in case of accidents also need to be included.

4.4.2.11. Transboundary impacts (depending on States)

This section describes possible transboundary impacts (e.g. impacts of accident situations, socioeconomic impacts such as employment, and impacts on a shared watercourse).

4.4.2.12. Nuclear fuel production chain

Generally, the production chain is only described and not assessed. It requires a separate EIA report, often in other States, as these activities do not necessarily take place in the project State. A description of a generic nuclear energy chain and methodological approach for estimating health and environmental impacts can be found in IAEA Technical Reports Series No. 394, Health and Environmental Impacts of Electricity Generation Systems: Procedures for Comparative Assessment [18].

4.4.2.13. Other

Other sections can be dedicated to any topic the EIA developer has to address because of specific requirements in a State.

4.4.2.14. Prevention and mitigation of adverse impacts

In this section, the EIA developer should describe the measures to prevent and to diminish significant adverse impacts of the project. The hierarchy of possible approaches for the mitigation of environmental impacts should be presented. Examples typically include:

— Engineering and planning alterations;
— Practice alterations for construction and operation;
— Habitat restoration;
— Financial compensation;
— Communication of information or other measures found fit by the State.

The selection criteria for the proposed mitigation measures, for example, cost, technical feasibility, legal possibility or social acceptability, should be clarified in this section.

4.4.2.15. Environmental monitoring programme

Based on the EIA results, in this section of the report, a description of the environmental monitoring programme for the construction and operation periods should be provided. Monitoring is generally established for the environment that may be affected, such as groundwater, surface water, soil or biota.

4.4.3. Impact evaluation methodology

A clear description of the EIA report scope is required to provide a background for the selection of the assessment methodology, its application and the identification of uncertainties. For the spatial boundaries, the customary approach is to assess at a local level (on-site and immediately off-site) and at a regional level (as far out as impacts are likely to be observed, which varies depending on different environmental aspects). The temporal boundaries take into account the long operational life and possible life extension of the nuclear power plant, as well as the duration of radioactivity beyond plant operation. Details of this scope and methodological approach should

be identified in the ESR and agreed with the competent authority prior to proceeding further with the development of the EIA report.

4.4.3.1. Criteria for identifying significant impacts

The definition of what constitutes a significant impact that must be avoided or minimized should be identified in the ESR and is an important early step for the competent authority. The methodology to evaluate the significance of an environmental impact could be based on qualitative, quantitative and perhaps intangible parameters of the impact. Some possible examples include:

— Probability;
— Reversibility;
— Extent: geographical and in population;
— Intensity;
— Duration;
— Uncertainty;
— Cumulative impact with time, together with the impact from sources other than the project in question.

Additional criteria may be used by a State, some of which are defined by expert opinion, and others may be found in the State's regulations. Approaches to considering the beneficial and adverse impacts may vary across States. Some approaches to evaluate the list of potential impacts make use of a checklist and matrices, scale and weight, or an expert opinion. Impacts that are found to be significant and adverse would undergo planning for avoidance or mitigation, and should be addressed in the monitoring plan, although some impacts need not be actively monitored. Beneficial impacts should be identified as well thus providing a holistic evaluation of the project. An overall cost–benefit analysis may be performed to evaluate the economic value of the entire project.

4.4.3.2. Use of models in the environmental impact assessment report

EIA reports entail a great number of models. For some issues, expert judgement must be used as the only available means of assessment. However, for complex projects such as nuclear power projects, expert judgement should be used as a sufficient argument only in specific topic areas where modelling is not possible or not yet developed. Various calculation methods and modelling approaches have been implemented in large industrial projects, have shown good results in impact prediction and can be used to identify the effect of the impacts on the environment. Table 2 provides some examples of impact model approaches used in nuclear EIA reports. As can be seen, many are shared with impact modelling approaches for large conventional industry projects.

The competent authority may recommend a particular model for use in the EIA report. However, it is the responsibility of the EIA team to choose the model and calculation approach, provided that the team has satisfied the competent authority as to the model's suitability and accuracy.

In addition to the models and approaches used in nuclear EIA (which are also applicable to large conventional industrial projects), specific modelling approaches are required when considering the radiological impacts. A common model approach to estimate the release of radionuclides to the environment is using atmospheric dispersion and dose modelling [13, 15]. The approach requires data on source terms from the technology vendor, as well as knowledge of the pathways and receptors of the radionuclides transmitted via aerodynamic dispersion. The output of this approach is calculation of the dispersion of various radionuclides released in the atmosphere and the estimation of doses received by people and the environment.

The primary sources of radionuclides during normal operation include:

— Radioactive gaseous discharge from the building ventilation exhaust, including the reactor building, reactor auxiliary building and fuel handling building;
— Discharge from the gaseous waste management system;
— Discharge associated with the exhaust of non-condensable gases at the main condenser.

TABLE 2. SOME IMPACT MODEL APPROACHES USED IN NUCLEAR ENVIRONMENTAL IMPACT ASSESSMENT REPORTS

Impact	Model approach	Disciplines involved	Input	Output	Model specifics
Radiation dispersion	Dispersion and dose modelling[a]	Defining source terms Dispersion modelling Radioactive decay products Radioecology Dose calculations	Source term Pathways[b] Impact receivers	Radioactive releases and nuclide types Dispersion Concentrations and doses caused	Due to its importance, approval of the model should be granted by the competent authority and may require more time
Thermal impacts (once-through cooling systems)	Mathematical dispersion modelling	Dispersion modelling	Discharge temperature and quantity, location and technology	Assessment of impacts on water temperatures and thermal stratification	Model calibration may require time consuming measurements
Aquatic biota (impingement, entrainment, changes in the ecosystem)	Demographic approaches	Hydrobiology Oceanography Fisheries, hydrodynamic and water quality modelling	Aquatic field studies Species population data Ecosystem structure	Impacts on aquatic species Biodiversity changes	Aquatic field studies through the seasonal variations may be very laborious
Terrestrial, marine and freshwater biota (radiological risk)	Integrated exposure/dose/effect assessment with risk characterization	Radioecology	Environmental concentrations Dose conversion coefficients Concentration ratios Distribution coefficients	Dose rates Risk quotients	Tiered approach Selected animals and plants
Regional economy (employment, revenues, economy of the region)	Economic modelling	Economic modelling, analysis and projections	Regional economy data Development plans Project financial parameters	Prediction of the economic impacts on the region	Financial risks may influence the model output
People and society (migration, quality of life, culture, environmental justice)	Expert opinion Social trend projections Computer modelling	Socioeconomic impact assessment Communications Resident surveys Media analysis	Socioeconomic characteristics of the population Personal perceptions, opinions and fears	Social impacts from migration and revenue change Environmental justice and cultural heritage considerations Increased communication	Needs to be carefully coordinated with stakeholder Involvement processes

[a] For more information on the types of model, see Refs [13, 14].

[b] Data from baseline meteorology, oceanography, hydrology and groundwater surveys in the investigated area.

Planned releases of radionuclides below prescribed limits from nuclear power plants do occur during normal operation. Although plants are designed to prevent accidental releases, the EIA should consider that such releases could occur and impact humans and the environment. This is primarily handled in the development of the EMP, since, by definition, an accident that can be foreseen must be addressed in the design in order to prevent occurrence. Figure 6 shows the potential exposure pathways of radionuclide release to the public and environment [4]. Descriptions of nuclear accidents are addressed in the SAR, and should not be separately identified in the EIA report.

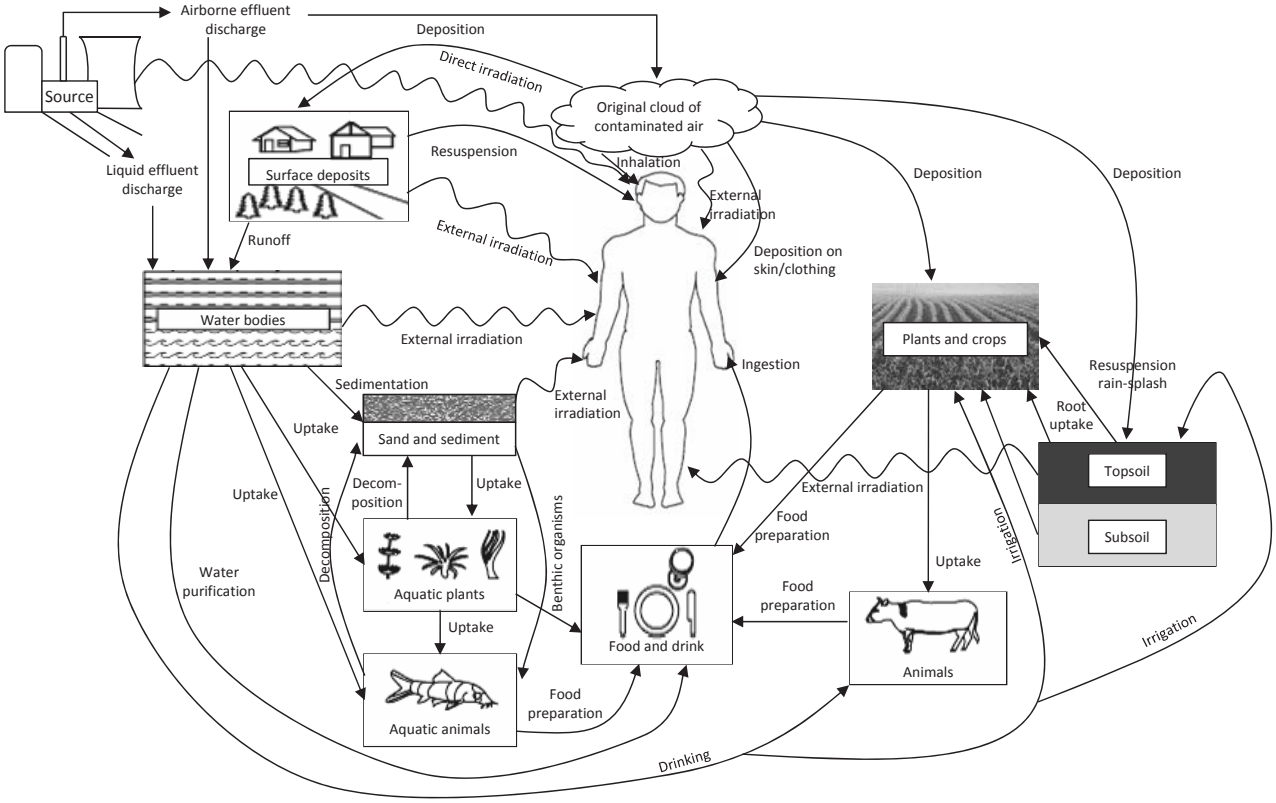

FIG. 6. Potential exposure pathways for use in dose models.

4.4.4. Stakeholder involvement in environmental impact assessment report development

As described in Section 2.3, stakeholders are involved in the review of the final EIA report, coordinated by the competent authority. It is also recommended that stakeholders, particularly the statutory stakeholders, be involved throughout the process of preparing the draft report. Such an approach reduces the risk of major conflicts with the stakeholders' viewpoints in the final stages of public participation. Annex III contains a case study of how stakeholders were involved in a recent EIA process.

5. USE OF THE ENVIRONMENTAL IMPACT ASSESSMENT REPORT

The EIA report is used for:

(a) Preparation of the bid invitation specification or contract;
(b) Basis for subsequent licences and permits;
(c) Creation of the environmental monitoring programme and the EMP.

Figure 7 shows the steps typically taken in order to start construction of the first nuclear power plant.

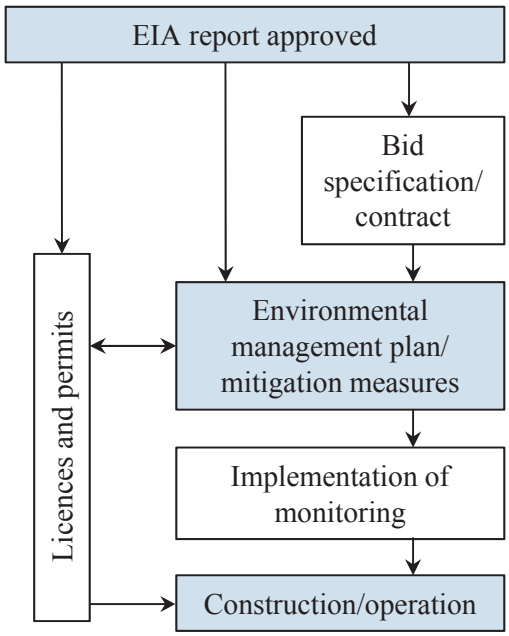

FIG. 7. Use of the EIA report.

5.1. LICENCES AND PERMITS

The licence and permit processes for nuclear facilities, including the purpose of the EIA report, should be precisely described in the legislative framework. The various licences and permits will define conditions pursuant to the conclusions of the report, including the mitigation measures and the environmental monitoring programme described in it.

Examples of licences requiring an EIA report as part of their application process may include those issued by the nuclear regulatory authority pursuant to the State's law on nuclear power for siting, construction and operation. An example of the licensing steps and the use of the EIA can be found in IAEA Safety Standards Series No. SSG-12, Licensing Process for Nuclear Installations [19].

The main milestones of the process are:

(a) The decision to build a nuclear power plant, which will allow the start of implementing activities, including environmental studies;
(b) An early site permit, clearing the way for further assessment of sites approved for nuclear power plant construction;
(c) The construction licence, allowing the start of nuclear power plant construction and also marking the start of the environmental monitoring programme for construction impacts;
(d) The operating licence, marking the beginning of electricity production from the nuclear power plant and the start of the environmental monitoring programme related to nuclear power plant operation.

Permits are usually issued by various authorities (including regional or local) that have regulatory responsibilities other than those that are radiological in nature. These permits are similar or identical to the ones issued for other industrial projects.

Conditions of operation as outlined in the permits may vary depending on the State's legislative framework, but it is of great importance to formulate the permit conditions precisely and unambiguously. Measurable parameters and respective quantifications should be used as much as possible to define whether the owner, or operator, actions comply with the permit. Conditions can be based on discharge limits, but they can also be outcome based. Clear

permit conditions help avoid disputes, problems and unforeseen costs at later stages of the nuclear power plant project.

Attention should also be paid to issues related to the validity of licences and permits, confirmation of compliance and corrective measures, such as:

— Renewal periods of licences and permits;
— Monitoring;
— Review of findings and recording;
— Reporting instances and frequency;
— Appropriate actions when conditions are breached;
— Inspection authority, frequency and costs;
— Enforcement mechanisms.

Depending on how developed a site is, many additional permits may be required for construction of related infrastructure projects, such as roads, transmission lines or waterways. Many of the licences and permits may be interconnected (e.g. approval of one permit is given provided that another is already in force), so a delay in one permit may result in serious delays in the nuclear power plant time schedule (up to a few years). Additionally, approval of the EIA report and the entire EIA process by the competent authority may well be necessary before the nuclear licence is awarded. Therefore, sufficient resources for the regulatory process for licences and permits should be allocated, and proper organizational decisions should be made.

5.2. ENVIRONMENTAL IMPACT ASSESSMENT IN A BID INVITATION SPECIFICATION OR CONTRACT

Before preparing a bid invitation specification, the owner should have selected a qualified site for the plant, and the EIA report should also be finished or in a very advanced stage. This ensures that a major part of the site data, including the wide range of detailed studies required to identify the sensitive environmental issues needed for bid preparation, is available.

Site conditions have a great influence on the layout, design, construction and costs of the nuclear power plant. Comprehensive specification of environmental site conditions, factors, characteristics and data, including those that may seem not to be directly related to the project, should be provided in the bid invitation specification in as much detail as possible. This will mark the end of phase 2 of the environmental component in the nuclear power programme development.

The owner should offer bidders free access to all detailed site studies, including EIA documents and collected site data. The owner should also establish a procedure for the resolution of vendors' questions regarding the interpretation of the site data and the matters mentioned above. In the event that the EIA report is completed before the bid invitation specification is issued, the owner should include in the bid all commitments, limitations and conditions resulting from the EIA report approval. However, if the report is not finished, the owner should ensure that these commitments, limitations and conditions are handed over to a vendor at least at the contract negotiation stage and incorporated in a contract. Otherwise, the owner can face unforeseen expenses during the course of project implementation. Furthermore, the contract should have mechanisms in place on how to resolve future possible licence and permit issues and conditions to enable continuous project implementation.

The competing bids are judged, among other factors, on the basis of environmental impacts from the proposed nuclear power plant. This means that bids should be evaluated, at a minimum, as to whether they are in conflict with EIA report results.

Further information on the subject of EIAs and their role with the bid invitation specifications or contracts can be found in IAEA Nuclear Energy Series No. NG-T-3.9, Invitation and Evaluation of Bids for Nuclear Power Plants [20].

5.3. DEVELOPMENT OF AN ENVIRONMENTAL MONITORING PROGRAMME

The objective of the environmental monitoring programme is to ensure that the environmental impact during construction and operation stays within assessed and accepted limits and, in case it does not, to initiate a process to address the activity causing the observed exceedance values.

It is recommended to include in the EIA report a description of the proposed draft environmental monitoring programme. Based on the findings made in the report and regulatory requirements, this programme is finalized in the permit phase, and approved by the relevant authorities, either separately or as part of permits. Annex IV presents an example of an environmental monitoring programme.

Typically, the environmental monitoring programme is based on:

— Baseline information collected for the EIA report preparation;
— Considerations related to the selected technology (as sources of impacts);
— EIA report results;
— Conditions in various permits and licences.

The environmental monitoring programme should ensure that the significant environmental impacts are monitored to provide timely assurance that they are within the permit limits. The environmental monitoring programme need not monitor every environmental component, as long as a methodology is in place to identify potential release points early enough to activate a more detailed assessment of a release. Thus, soil may not need routine monitoring if air, groundwater and surface water are monitored. Typical examples of monitoring activities include:

— Measurements of concentration in air emissions;
— Groundwater well collection;
— Surface water sampling;
— Temperature measurements for the affected water bodies;
— Bioindicator sampling.

The environmental monitoring programme should include a definition of required data reliability, the frequency of data collection, monitoring and sampling locations (along the exposure pathways) and the density of these locations. Monitoring points will be on-site as well as off-site. Additionally, the monitoring programme may expand and include different activities during the life cycle of the nuclear power plant.

It is commonly accepted that the requirement lies with the plant owner, or operator, for fulfilment of all environmental protection legislative framework requirements, including implementation of the environmental monitoring programme.

Environmental agencies (perhaps local) perform surveillance, auditing, independent monitoring and other defined activities according to an environmental protection legislative framework to ensure that the owner follows all prescribed duties. Environmental auditing is generally also performed by the competent authority at appropriate time intervals.

A nuclear power project specifically requires an operational radiological environmental monitoring programme (REMP). The baseline environmental data collection programme to support the REMP must include the same elements and sampling points, but it may start after the EIA report has been completed and prior to commencement of operations. Therefore, the baseline radiological sampling programme may not be as extensive as that required to support the REMP.

Guidance on radiological monitoring programmes and activities, including techniques, procedures, and data interpretation and evaluation, can be found in Refs [4, 21]. An example of an REMP is included in Annex IV.

The environmental monitoring programme, especially its radiological component, is usually designed for normal operations. Following abnormal occurrences, specific monitoring would be developed and modified to adapt to the status of the event (ongoing, ended, pre-remediation and post-remediation). The specific objectives of the ongoing event, or the emergency radiation monitoring in the environment, are:

(a) To provide accurate and timely data on the level and degree of hazards resulting from a radiation emergency, in particular, on the levels of radiation and environmental contamination with radionuclides;
(b) To assist decision makers on the need to make interventions and take protective actions;
(c) To provide information for the protection of emergency workers;
(d) To provide information to the public on the degree of hazard;
(e) To provide information required to identify any people for whom long term medical screening is warranted.

5.4. ENVIRONMENTAL MANAGEMENT PLAN

After the EIA report has been approved by the competent authority, it may come to light that project impacts have been underestimated or overestimated. If this is the case, and changes therefore become necessary, the mitigation measures are then included in the EMP.

One of the objectives of this plan is to ensure adaptive management as a key feature to address uncertainty in the EIA. An established process to review the unexpected impacts and to develop a suitable response is a good framework for adaptive management. If an unexpected change is found by monitoring, then a case specific remediation plan and post-remediation monitoring is to be developed and implemented. Entities involved in resolving deviations beyond permit conditions need to have a clear role in such situations, with obligations and means to meet these obligations. Communication lines, coordinating mechanisms and time schedules for action need to be in place before the nuclear power plant commences operation.

This plan may not be limited to adaptive management protocols. It may well contain the mitigation measures examined in the EIA report, action protocols that are part of permit conditions, and agreed processes and schedules for reviewing EMP adequacy. The plan allows for the actual impact assessment and mitigation measures to be revisited for suitability, not only after operational experience, but also after selecting the nuclear power plant technology.

In case of changes that have been foreseen as possible, and after the monitoring results indicate an absence of compliance with the permit conditions, the responsible entities (institutions, operators and regulators) will take an appropriate action as specified in the permit and included in the EMP.

In order to facilitate an appropriate mitigation action, a characterization and potential response for out of the ordinary situations need to be developed per impact factor including, for example:

— Higher water outlet temperatures;
— Increased alpha or beta activity;
— Reduced visibility by fogging;
— Biodiversity loss or a significant decrease in the local species population.

The response may be defined by the competent authority that issued the permit, but it may also suffice to require that the operator defines suitable response actions in the EMP as a precondition for issuing a permit.

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Annex I

INTERNATIONAL LEGAL INSTRUMENTS

I–1. MAIN PRINCIPLES AND DECISION MAKING IN INTERNATIONAL LEGAL INSTRUMENTS

With few exceptions, international environmental law instruments started developing after 1972, when the Declaration of the United Nations Conference on the Human Environment (Stockholm Declaration, 1972) defined most of the basic common principles to protect the environment. Since then, the number of international agreements has grown, and the main concern nowadays is how to develop a means to coordinate the implementation of related legal instruments. It is estimated that more than 900 international legal instruments either focus on the environment or contain important provisions in this field.

Several international legal instruments have been produced which form a compound of ethics that can be used as a reference in the field of environmental protection. Fundamental principles of environmental law were mainly defined during the United Nations Conference on the Human Environment, in Stockholm (1972), and the United Nations Conference on Environment and Development, in Rio de Janeiro (1992). The latter resulted in the Rio Declaration on Environment and Development, setting the ground for the main methodological principles of environment protection by specifying implementation means for environmental protection. The Rio Declaration defines public participation as a way to better handle environmental issues, and develops the idea that environmental damages should be compensated, as well as the precautionary principle that the "lack of full scientific certainty shall not be used as a reason for postponing cost effective measures to prevent environmental degradation."

The Rio Declaration also stresses that environmental impact assessments (EIAs) are necessary before activities likely to have a significant adverse impact on the environment are undertaken.

Other examples of international legal instruments specifying public participation in EIAs include:

— Convention on Access to Information, Public Participation in Decision-Making and Access to Justice in Environmental Matters (Aarhus Convention, 1998);
— Convention on Environmental Impact Assessment in a Transboundary Context (Espoo Convention, 1991).

I–2. INTERNATIONAL LEGAL INSTRUMENTS FOR THE PREVENTION OF POLLUTION AND THE PRESERVATION OF NATURE AND THE ECOSYSTEM

Beyond giving general methodological guidelines, a number of international legal instruments were produced to protect particular areas or components of the environment or to prevent certain activities or behaviour which may damage the environment. These legal instruments encompass two different goals: the prevention of environmentally harmful practices, including pollution limitation and remediation, and the preservation of resources. The following are some examples of international legal instruments for the prevention of pollution and the preservation of nature and the ecosystem:

— Convention on Wetlands of International Importance especially as Waterfowl Habitat (Ramsar Convention, 1971);
— Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (London Convention, 1972);
— Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal (Basel Convention, 1989);
— Bamako Convention on the Ban of the Import into Africa and the Control of Transboundary Movement and Management of Hazardous Wastes within Africa (Bamako Convention, 1991);
— Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR Convention, 1992);
— Convention for the Protection of the Marine Environment and the Coastal Region of the Mediterranean (Barcelona Convention, 1995).

Annex II

PREPARING A NUCLEAR POWER PLANT ENVIRONMENTAL IMPACT ASSESSMENT REPORT

TABLE II–1. MAIN TECHNICAL SOURCES OF INFORMATION REQUIRED

Main issues	Specifications
Description and statistics of present operations on-site	None
Fuel sources, processing phases and transportation	None
Location of the plant	None
Layout of the area in construction and operation phases	None
Dimensions of the plant for photomontages and animations	None
Technical information of the nuclear power plant	Number and type of reactors Electric and thermal effects Efficiency Description of operating principles Fuel properties, loading patterns and consumption Process description Annual energy production Nuclear safety principles Emergency power systems
Fuel mining, processing phases and transportation	None
Cooling water arrangements	Location and type of cooling water inlets and outlets Cooling water requirements (m^3/s) and temperature change Thermal load to recipient (PJ/a) Cooling water treatment (inlet and outlet)
Waste (source, amount, quality, management)	Construction phase Operation phase — Conventional waste — Liquid waste — Low and medium active waste Decommissioning — Conventional waste — Low and medium active waste
Spent nuclear fuel	Amount over time and total Intermediate storage Final disposal
Water consumption in construction and operation phases	Consumption for different purposes (m^3/a) Sources and treatments for different purposes
Wastewaters in construction and operation phases	Amounts (m^3/d) and (m^3/a), types and qualities Treatments Loads to recipient
Emissions into air in construction and operation phases	Construction machinery, reserve power sources, radioactive releases

TABLE II–1. MAIN TECHNICAL SOURCES OF INFORMATION REQUIRED (cont.)

Main issues	Specifications
Noise emissions and sources in construction and operation phases	None
Accidents	Accident classification, source term definition
Related projects	Grid connections and reinforcements Land traffic connections and logistics Shipping connections and logistics

Annex III

ROLE OF PUBLIC PARTICIPATION AND COMMUNICATIONS IN A GREENFIELD NUCLEAR POWER PLANT PROJECT IN FINLAND

In January 2008, Fennovoima Oy launched an EIA procedure regarding the construction of a new greenfield nuclear power plant in Finland. The EIA dealt with the construction of a power plant consisting of one or two reactors with an electrical output of 1500–2500 MW to one of the following municipalities: Pyhäjoki, Ruotsinpyhtää or Simo. The EIA procedure was concluded in 2009, when the Ministry of Employment and the Economy (MoEE) gave its final statement. Following the approval of the EIA, the Finnish Government and Parliament gave Fennovoima a Decision in Principle (DiP)[1] in 2010, which granted Fennovoima the right to build a new nuclear power plant.

The following sections briefly introduce the role of public participation in Finnish EIA procedures and illustrate the interaction between the participation and communication procedures and project development. The Fennovoima EIA procedure is used as a case example, but the principles of the role of public participation and communications apply to other large scale EIAs.

III–1. INTRODUCTION TO PUBLIC PARTICIPATION AND COMMUNICATIONS IN ENVIRONMENTAL IMPACT ASSESSMENTS

The EIA procedure is the key tool for communications in the early project development phase. The objective of the procedure is to improve the EIA and to align its consideration in planning and decision making. Another objective is to increase the availability of information to all citizens and the possibilities of public participation in the planning of projects. The Finnish EIA procedure does not require the plant design or layout to be strictly defined, and the EIA report is not a licence but a prerequisite for several licences.

Figure III–1 shows the linkages between procedure, public participation and communications in the Fennovoima EIA. It also illustrates activities required by law, other means of public participation commonly part of the EIA procedure and examples of the supporting communication efforts. The figure shows that interaction between the project developer, the public and the authorities is commonly regular throughout the process and includes both ‘formal’ communication (statements and opinions) and more informal interactions (information events and meetings). The public participation practices in the procedure are well established, and authorities, the public and project developers have all defined roles, which eases the participation significantly. It should also be noted that information and opinions gathered during the procedure feed into the plant design and later decision making procedures. For example, one of the original alternative sites in the Fennovoima case was excluded during the procedure partly due to environmental reasons.

III–2. GENERAL PARTICIPATION CHRONOLOGY

In January 2008, Fennovoima submitted the environmental scoping report (ESR) to the MoEE, which acts as the coordinating authority for nuclear power projects in Finland. The programme was placed on display for public inspection for two months. During this time, the MoEE and Fennovoima organized open public meetin1gs in each alternative location. Project related plans and the associated EIA procedure were presented to the public at the meetings. The public had the possibility to voice their opinions on the EIA work and its sufficiency and to discuss with Fennovoima, the MoEE and the experts who had been involved in composing the EIA programme.

[1] In accordance with the Nuclear Energy Decree, the DiP shall include, among other items, an EIA report. The DiP is only required for nuclear activities, and is not a formal part of the Finnish permit system.

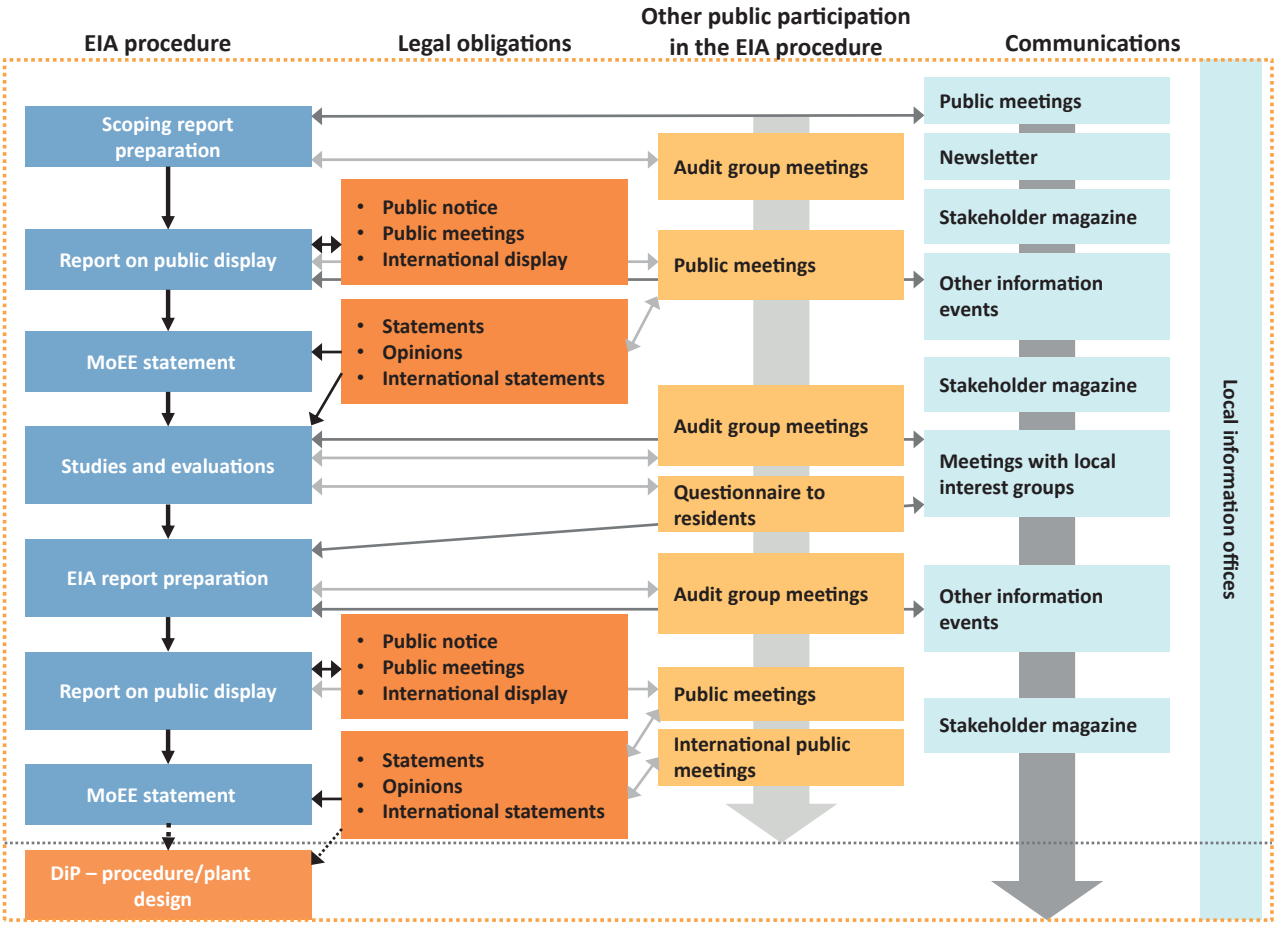

FIG. III–1. Public participation and communications as part of the Fennovoima EIA procedure (courtesy of Pöyry Energy Oy).

Following the MoEE request for statements, 69 communities submitted a statement concerning the ESR. A total of 153 opinions on the programme were submitted. Of these, 35 were from Finnish communities and organizations, four were from foreign communities and organizations, and 113 were from private individuals from various States. The MoEE issued a statement on the programme in May 2008. The statement took into account the comments and opinions received. It defined which issues the EIA report had to cover, and thus provided a way to incorporate the topics seen to be important by the general public into the report. In its statement, the MoEE specifically referred to an opinion from a nature conservation organization and requested the project developer to assess the specific concerns expressed on waste management, among other things.

The report was finalized towards the end of 2008 and submitted to the MoEE and placed on public display for two months. During this phase, open public meetings were also organized in each alternative location, providing a possibility for questions and comments on the report. Following the request by the MoEE, a total of 66 statements and 89 opinions were submitted.

The MoEE final statement concluded the EIA procedure in February 2009. The statements and opinions submitted were considered by the MoEE, which used some of the issues raised in its final statement. Based on the MoEE statement, the developer had to conduct additional studies to be attached to the DiP application, which addressed the concerns raised by authorities and the public.

III–3. INVOLVING AUTHORITIES AND INTEREST GROUPS

Regional ‘audit groups’ were established at each alternative location to follow and to guide the EIA procedure and to advance communication between the project developer, authorities and interest groups. Local authorities also helped to identify the relevant organizations to be invited. The audit groups consisted of members of

stakeholder associations, such as nature conservation groups and local businesses, as well as members of municipal and regional authorities. The aim was to gather as extensive representations as possible, and the outcome showed significant variations in the presented views.

Each audit group met three times during the procedure. The first meetings took place in the scoping phase. At the meetings, the project, procedure and the project's EIA programme draft were presented to the audit group members. The comments received from the audit groups paid attention to, for example, the project's impacts on waters, fish, land use and value of properties, as well as the means of livelihood and opportunities for leisure activities. Matters of particular interest also included the safety of the nuclear power plant.

All comments and specifications received at the meetings and afterwards were comprehensively taken into account when drawing up the EIA programme, as far as they related to the programme. Comments, information and sources of information not related to the programme were taken into account in the implementation of the EIA procedure and in the EIA report and related surveys. Important information was received on, for example, the nature conservation (such as bird sanctuaries) and cultural historical environments in the immediate surroundings of the site locations. The audit groups also provided important additional information for surveys carried out in the assessment and planning.

The audit groups met for the second time in the EIA report composition phase. The statement on the EIA programme by the MoEE and the composition of the report were discussed at the meetings. In addition, the contents of the surveys made for the EIA, their current status and some results available at the time were presented to the audit group members.

At the third meeting of the groups, the draft report was presented. The groups were able to comment on the draft report and to request clarification. Based on the comments received, the report was revised before publication of the final version.

III–4. INVOLVING THE LOCAL PUBLIC

The realization of a nuclear power plant project in Finland requires a statement of recommendation concerning its construction, which is issued by the municipality responsible. This means that general opinion at the municipal level has to be positive towards the planned nuclear power plant for the project to proceed, and, thus, it is essential to place adequate focus on communication activities at the local level. Moreover, local people often possess knowledge of the site and environment that would not be available from other sources. Therefore, involving the public in the planning phase of the project is important.

Public participation and communication in the EIA phase of the Fennovoima project also included activities which were specifically designed to involve local people. For example, Fennovoima opened offices at each alternative EIA location in 2008. The local public and others interested in the project had the possibility to visit the offices to gather information about the project, raise questions and discuss possible concerns. During the EIA procedure, the offices were visited by approximately 1000 people. The offices could also be contacted by telephone. The most common discussion and question topics included the project's financial impact on the municipality and region, the selection criteria for the locations, Fennovoima's ownership and background organizations, the impact on nature and the living environment, technical and safety issues, and waste issues.

The project developer organized information events, seminars and public meetings, at which the project was presented and participants could pose questions to Fennovoima's technical, safety and environmental experts of the project developer. In addition, representatives of the Radiation and Nuclear Safety Authority participated in various meetings.

A newsletter from the project developer was also distributed with local newspapers to the residents of the alternative sites. The newsletter reviewed the EIA procedure, Fennovoima and nuclear power and safety in general, as well as some region specific topics. Moreover, the project developer regularly published a stakeholder magazine, which was distributed to the public.

Local knowledge was utilized, where possible, as part of the EIA. The observations of local bird watchers were used in surveying the avifauna of the site locations and their surroundings. The bird watchers' observations provided the experts who composed the report with long term information in support of their assessment work. The experts who assessed the present situation of fish stocks and impacts on them were in contact with local fishermen

to gather additional information in support of their work. Information from the public was also used in detailed site planning.

III–5. TRANSBOUNDARY ENVIRONMENTAL IMPACT ASSESSMENT PROCEDURE

Nuclear power plants are subject to a transboundary EIA procedure pertaining to the Convention on Environmental Impact Assessment in a Transboundary Context (Espoo Convention), to which Finland is a State Party. The Espoo Convention sets out obligations for States Parties to notify and to consult each other on all major projects under consideration that might have adverse environmental impacts across borders.

The EIA documentation in both the scoping and the report phase was submitted to States wishing to participate in the Espoo procedure. Finland received statements from seven States. Comments on the ESR were taken into account in the preparation of the EIA report, and the developer provided separate written answers to the comments. Information events to present the results of the report were organized for authorities (such as in Austria) and the public (such as in Estonia).

III–6. CONCLUSIONS

Nuclear power projects are, by definition, seen as controversial by the general public. Providing the public with adequate, reliable information of the planned project is of significant importance in creating public trust and acceptance. In a nuclear power plant project, the means of public participation and communication have to be designed to cover the information requirements of the general public at local, national and international levels alike. However, it is especially important to involve local people in the process, as they often play a key role in making the decision about the project and because they also possess important local knowledge to be taken into account in project planning.

The EIA procedure provides a structured, well established process for distributing information about a planned project and for involving the public in project development. The Fennovoima case provides a good example of a project in which the EIA procedure was properly utilized in communications. The process involved extensive public participation arrangements at local, national and international levels. During the process, public opinions were addressed in a more official manner in the EIA report, but probably more significant were the numerous discussions on various participation events where concerns and questions were addressed. Finally, it can be concluded that the successful completion of the procedure, among other factors, paved the way for the positive DiP.

Annex IV

EXAMPLE OF ENVIRONMENTAL MONITORING APPROACHES: CASE OF THE CERNAVODĂ NUCLEAR POWER PLANT

The following example of a monitoring programme and its constituents is taken from the Cernavodă operational monitoring of Canada deuterium–uranium (CANDU) reactor units 1 and 2 (heavy water moderated reactors).

IV–1. ROUTINE ENVIRONMENTAL RADIATION MONITORING PROGRAMME

The purpose of a routine environmental radiation monitoring programme is to provide reliable and accurate data, including statistically valid datasets for significant nuclide and environmental media on an annual basis. The monitoring programme is designed to meet the following objectives under normal nuclear power plant operating conditions:

(a) To measure the radionuclide concentrations in environmental media and to assess the increased radiation levels in specified environmental pathways, which might be modified as a result of the Cernavodă nuclear power plant operation;
(b) To provide an independent assessment of the effectiveness of the source control, effluent control and monitoring based on measurements in the environment;
(c) To validate the models and parameters used to calculate the derived emission limits (DELs);
(d) To demonstrate the negligible environmental impact of the Cernavodă nuclear power plant operation and, hence, to contribute to public reassurance;
(e) To provide data to aid in the development and evaluation of models and methodologies that adequately describe the movement of radionuclides through the environment.[1]

IV–1.1. Basis of the programme

The radiological impact from the operation of the Cernavodă nuclear power plant is measured in terms of dose to people. The derived emission limit (DEL) is the amount of radionuclide that, if emitted consistently for one year, would result in a maximum additional annual whole body dose of 1×10^{-4} Sv to a individual in the most exposed (‘critical’) group. This upper limit is derived from the regulatory dose equivalent limit by analytical models for all radionuclides and all critical pathways.

The basis of the programme is the site specific DEL document for the Cernavodă nuclear power plant. This document identifies the radionuclides that are likely to be released from the station and the likely environmental pathways for them.

Based on DEL results regarding the significant pathways and critical groups taken into account, the environmental monitoring programme specifications have been prepared for nuclides or groups of nuclides in environmental pathways.

IV–1.2. Monitoring programme elements

The major components of the monitoring programme are:

— Monitoring locations;
— Environmental media and specific nuclides to be monitored;
— Monitoring frequency;

[1] See http://www.umweltbundesamt.at/fileadmin/site/umweltthemen/umweltpolitische/ESPOOverfahren/UVP_Cernavoda/UVE/UVEengl/chapter_6/UVECernavoda_6.pdf.

— Analytical frequency;
— Minimum required specific activity;
— Assessment of adequacy of source control.

The applicable requirements and structure for each component are developed and presented below. These elements are specific for the Cernavodă nuclear power plant.

IV–1.3. Locations and specific media

There are four types of monitoring location:

(1) Indicator locations: Outside the plant perimeter, established depending on emission type, critical groups and pathways used for DEL calculation.
(2) Background locations: Monitoring conducted beyond the influence of station emissions.
(3) Control locations: Used together with the indicator location to determine the dilution factor as a function of distance from the nuclear power plant site.
(4) Supplementary locations.

IV–1.4. Specific radionuclides

For each emission category, a group of radionuclides, or a representative radionuclide, is selected to identify the category (see Table IV–1).

IV–1.5. Monitoring frequency

The frequency of monitoring or sampling depends on the mean lifetime of the nuclide in a pathway. Air monitoring frequency was established as a function of plant emissions.

IV–1.6. Minimum required detectable activity

The minimum required detectable radioactivity above background values are used to detect radionuclides present in the environment as a result of the Cernavodă nuclear power plant operation. Consequently, they are used to select sampling equipment, analytical techniques and procedures.

Measuring equipment and methods are selected to allow measurements at substantially lower levels (at least one order of magnitude) than those defined for dose constraints. For each monitored exposure route, a certain fraction of the dose constraint is allocated. Minimum detectable radioactivities are calculated to guarantee detection of all possible contributions to the total dose.

IV–2. NON-RADIOACTIVE LIQUID AND GASEOUS EFFLUENT PHYSICAL–CHEMICAL MONITORING PROGRAMME

The purpose of this part of the environmental management programme is to provide reliable and accurate data regarding the non-radioactive liquid and gaseous effluent quality to demonstrate the compliance with the environmental licence for the Cernavodă nuclear power plant. The basis of the non-radioactive liquid and gaseous effluent physical–chemical monitoring programme is the environmental licence for the Cernavodă nuclear power plant and the agreement with the local environmental protection agency.

Sampling points for air quality in the startup boiler emission impact area are chosen for analysis of CO, NO_2, O_3, SO_2 and suspended powder (in correlation with wind direction and speed). The monitoring and reporting frequency are agreed with the local environmental protection agency. The specific values for the approved discharge limits for non-radioactive liquid effluent are presented in an operating manual.

TABLE IV–1. COMBINATIONS OF RADIONUCLIDE/ENVIRONMENTAL COMPARTMENT RELATED TO CRITICAL RADIONUCLIDES AND POSSIBLE CRITICAL EXPOSURE PATHWAYS SPECIFIC FOR THE CERNAVODĂ NUCLEAR POWER PLANT SITE

Emission type	Critical radionuclide	Critical exposure pathways	Representative radionuclide	Representative environmental compartment
Atmospheric emission	Tritiated water vapour	Inhalation and skin absorption	H-3	Air
		Uptake in plants → Ingestion of vegetables, fruit, dairy products, beef, pork and poultry		Most abundant edible parts of fruit and vegetables grown for consumption, dairy products and meat
	Noble gases	External exposure from immersion in the radioactive cloud	Ar-41 Kr Xe	Air (external gamma dose rate)
	I-131	Deposition on pasture → Dairy product ingestion	I-131	Milk
		Inhalation		Air
	Radioactive particulates	Deposition on vegetables, fruit and pasture → Ingestion of vegetables, fruit, dairy products, beef, pork and poultry	Co-60 Cs-134 Cs-137 Nb-95 Zr-95	Dry and wet deposition
		Inhalation		Air
		External exposure from soil deposition		Soil (external gamma dose rate)
	C-14 (CO_2)	Uptake in plants → Ingestion of vegetables, fruit, dairy products, beef, pork and poultry	C-14	Products with maximum carbon content in edible parts
		Inhalation		Air
		External exposure from immersion in the radioactive cloud		Air (external beta dose rate)

TABLE IV–1. COMBINATIONS OF RADIONUCLIDE/ENVIRONMENTAL COMPARTMENT RELATED TO CRITICAL RADIONUCLIDES AND POSSIBLE CRITICAL EXPOSURE PATHWAYS SPECIFIC FOR THE CERNAVODĂ NUCLEAR POWER PLANT SITE (cont.)

Emission type	Critical radionuclide	Critical exposure pathways	Representative radionuclide	Representative environmental compartment
Liquid emission	Tritiated water	Ingestion of drinking water	H-3	Potable water
		Uptake in fish → Fish ingestion		Water from fish
		Irrigation → Ingestion of agricultural and animal products		Most abundant edible parts of vegetables and fruit grown for consumption, dairy products and meat
	Dissolved radionuclides or suspensions other than tritium	Uptake in fish → Fish ingestion	C-14 Co-60 Cs-134 Cs-137 Nb-95 Zr-95	Edible fish meat
		External exposure from coastal deposits or sediments dredged out		Sand beaches (external gamma dose rate)

IV–3. ROUTINE NON-RADIOACTIVE LIQUID EFFLUENT PHYSICAL–CHEMICAL MONITORING PROGRAMME

The basis of the non-radioactive liquid effluent physical–chemical monitoring programme is provided by the water management licence (listing chemicals, possible pathways and maximum acceptable ranges concentration), as well as an agreement signed with the local water administration (listing physical–chemical parameters that must be analysed, the monitoring frequency and sampling points).

The monitoring programme consists of two parts:

(1) The routine non-radioactive liquid effluent chemical monitoring programme with parameters, analytical methods and sampling points chosen to ensure compliance, encompassing both the liquid influent and the non-radioactive liquid effluent;
(2) The chemical spill part, with actions, increased monitoring frequency, supplementary sampling points and reporting procedures.

GLOSSARY

environmental impact assessment (EIA). A process in which environmental factors are integrated into project planning and decision making, also known as the environmental and social impact assessment. In this publication, EIA refers to the EIA process, unless otherwise stated. The EIA report contains all the relevant aspects of the EIA process, including assessment methodologies and findings and proposed mitigation measures.

environmental management plan (EMP). Procedures to guide ongoing implementation of environmental protection, including monitoring results of mitigation actions or other appropriate steps, designed for construction and normal operation conditions.

environmental monitoring programme. The coordination of all of the environmental measurements for ecological, radiological and socioeconomic parameters on- and off-site during construction and operation of the nuclear power plant, as identified during the EIA process and required through permits or by competent authorities.

environmental scoping report (ESR). A document which defines the scope, processes and timelines of the EIA report, sometimes known as the EIA terms of reference.

initial environmental information. Quantitative and qualitative information on ecological, radiological and socioeconomic parameters, usually obtained from already existing sources.

plant parameter envelope (PPE). A tabular set of data which addresses all technologies under consideration and identifies each aspect leading to a potential environmental impact, along with the value associated with each technology. The PPE includes the important physical and chemical parameters which may affect the environment (such as water requirements, land use and emissions) for the considered plants, and identifies the highest impact value or range of values for each parameter. These bounding parameters are then used for environmental analysis in the EIA process.

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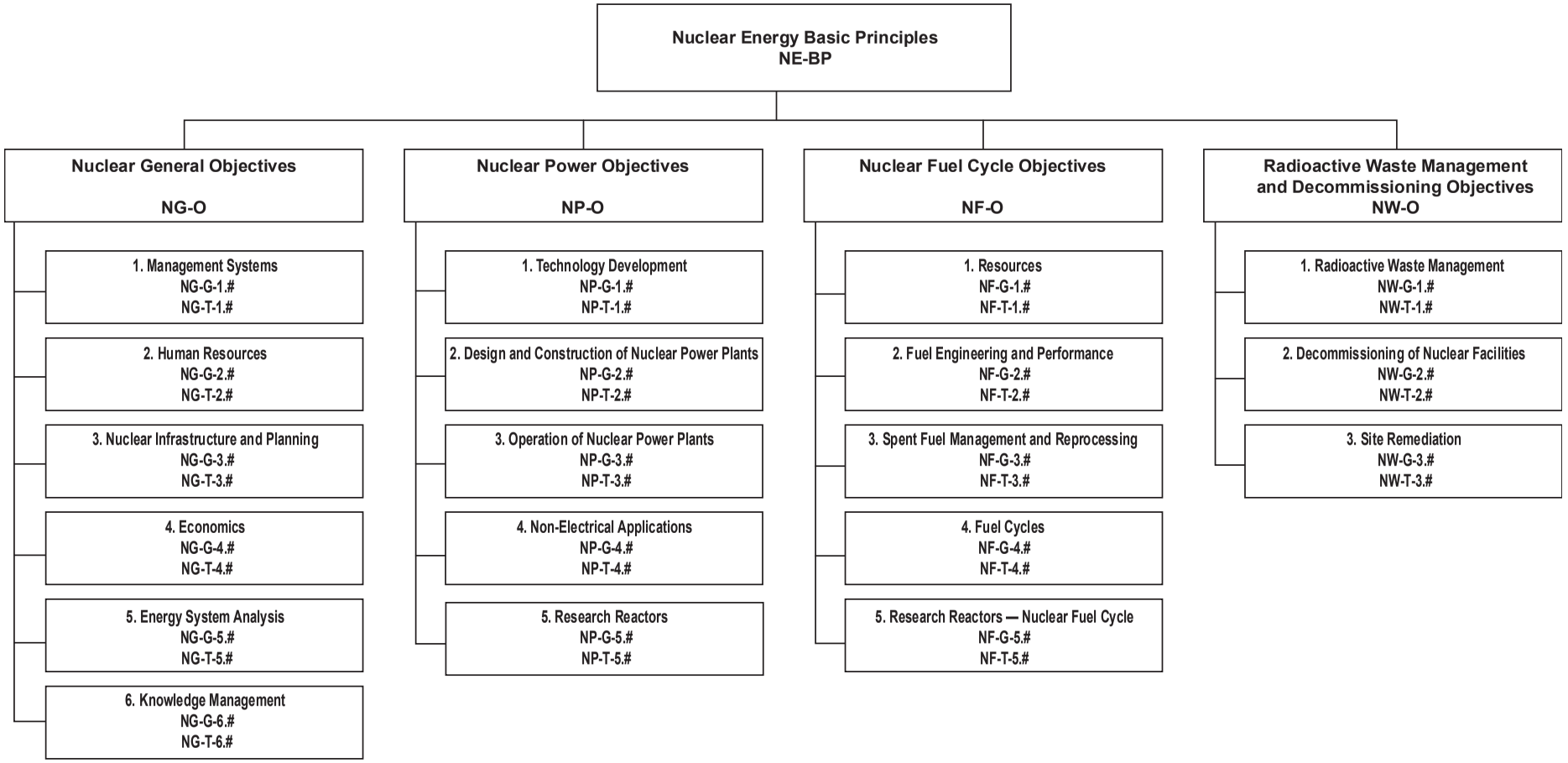

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