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Integrated Nuclear Infrastructure Review (INIR): Ten Years of Lessons Learned



IAEA

International Atomic Energy Agency

INTEGRATED NUCLEAR
INFRASTRUCTURE REVIEW (INIR):
TEN YEARS OF LESSONS LEARNED

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INTERNATIONAL ATOMIC ENERGY AGENCY
VIENNA, 2021

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FOREWORD

Many countries are interested in introducing or expanding nuclear power programmes, as they regard nuclear power as a stable and reliable source of electricity that also makes a significant contribution to climate change mitigation. Several countries operating nuclear power plants are planning to expand their current capacity for electricity generation. About 30 countries are embarking on a nuclear power programme. Of the latter countries, some are conducting the studies needed to make a knowledgeable commitment, some are developing the necessary infrastructure, and others are negotiating or building their first nuclear power plant.

Building a nuclear power programme is a major undertaking and is based on a government commitment to use nuclear power for peaceful purposes, in a safe, secure and sustainable manner. This commitment requires a sustainable infrastructure that includes a legal and regulatory framework, development of the necessary staff with the required managerial and technical capabilities, an industrial strategy and a stakeholder engagement programme. Adherence to international legal instruments and the adoption of internationally accepted standards to ensure high levels of safety, security and safeguards are also essential for establishing a responsible and sustainable nuclear power programme.

The IAEA's Integrated Nuclear Infrastructure Review (INIR) service was designed to evaluate the status of the infrastructure for the introduction of a nuclear power programme. An INIR mission is conducted upon request from Member States. The INIR service enables countries to hold in-depth discussions with a team of IAEA and international experts on experiences and best practices in infrastructure development for nuclear power.

The INIR service covers 19 infrastructure issues outlined in Milestones in the Development of a National Infrastructure for Nuclear Power (IAEA Nuclear Energy Series No. NG-G-3.1 (Rev. 1)), first published in 2007 and revised in 2015. INIR missions are conducted using the conditions set out in the Evaluation of the Status of National Nuclear Infrastructure Development (IAEA Nuclear Energy Series No. NG-T-3.2 (Rev. 1)), first published in 2008 and revised in 2016.

The INIR evaluation process is based on a review of the self-evaluation report and its supporting documents, prepared by the Member State, together with interviews with representatives of the Member State. Recommendations and suggestions are provided in the report to the Member State.

After the INIR mission, the Member State is expected to develop an action plan addressing the recommendations and suggestions identified. This action plan will be the basis of future integrated IAEA support to the Member State.

Since the first INIR mission in 2009, the IAEA has conducted 30 missions to 21 countries. In 2015, the IAEA published IAEA-TECDOC-1779 on the results of the first 14 INIR missions and the experience gained. Since then, a number of what are known as 'newcomer' countries have made progress in introducing nuclear power, with construction of the first units completed in Belarus and the United Arab Emirates and under way in Bangladesh and Turkey.

This publication provides information on the INIR process and summarizes the results of INIR missions. It includes common findings and highlights the most significant areas in which recommendations were made.

This publication is based upon contributions from both IAEA staff and external experts. The IAEA acknowledges the assistance provided by the contributors listed at the end of this publication. The IAEA officer responsible for this publication was M. Ceyhan of the Division of Nuclear Power.

EDITORIAL NOTE

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1. INTRODUCTION

1.1. BACKGROUND

The successful implementation of a nuclear power project requires careful consideration of the infrastructure needed to enable the project to be implemented. The IAEA has developed the Milestones Approach and published Milestones in the Development of a National Infrastructure for Nuclear Power, IAEA Nuclear Energy Series No. NG-G-3.1 (first published in 2007 and revised in 2015) (Milestones Document), [1]. The Milestones Document identifies 19 infrastructure issues important for the initiation and development of a nuclear power programme and considers three progressive phases with a defined milestone at the end of each phase. The required infrastructure includes ‘soft’ elements such as the legal and regulatory framework, the required institutions, policies and strategies, human and financial resources, as well as some ‘hard’ infrastructure elements such as facilities and equipment.

The IAEA Integrated Nuclear Infrastructure Review (INIR) service was designed to evaluate the status of the infrastructure for the introduction of a nuclear power programme. INIR missions are conducted at the request of Member States. The INIR service also enables representatives of the host Member State to have in-depth discussions with a team of IAEA and international experts on experiences and best practices in infrastructure development for nuclear power.

The INIR service covers the 19 infrastructure issues described in the Milestones Document. Missions are conducted using the conditions set out in the publication *Evaluation of the Status of a National Infrastructure for Nuclear Power*, IAEA Nuclear Energy Series No. NG-T-3.2 (Rev.1), first published in 2008 and revised in 2016.

The INIR evaluation process is based on a review of the self-evaluation report and its supporting documents, together with interviews with experts from the related technical areas. Recommendations and suggestions are provided in the report to the Member State.

After the INIR mission, the Member State is expected to develop an action plan addressing the recommendations and suggestions made. This action plan constitutes the basis for future integrated IAEA support to the Member State.

In the last 10 years, significant experience has been accumulated in the IAEA through the conduct of INIR missions. Gaps in the infrastructure were identified in a number of countries. But outstanding practices or arrangements, superior to those generally observed elsewhere, were also identified.

1.2. OBJECTIVES

The primary objective of this publication is to provide information and analysis on the main results of INIR missions in the first 10 years of the service, to share the lessons learned and to help to further improve and adapt the tailor-made support of the IAEA.

1.3. SCOPE

Feedback from INIR missions was first published in the *IAEA TECDOC Integrated Nuclear Infrastructure Review (INIR) Missions: The First Six Years*, IAEA TECDOC No. 1779 in 2015 [3], which shared the results of the first 14 INIR missions. The current publication updates TECDOC No. 1779 to include recent developments in the INIR process and present the results of INIR missions conducted from 2015 to 2020.

This publication also explains the mechanism for supporting Member States after an INIR mission is conducted, identifies areas of infrastructure development where further attention is frequently required, and shares good practices that have been observed.

It is intended principally for decision makers and staff from key organizations (Government/Nuclear Energy Programme Implementing Organization - NEPIO, Regulatory Body, Owner/Operator, TSOs, etc.) with responsibilities for establishing the infrastructure for a nuclear power programme in an embarking country.

1.4. STRUCTURE

This publication consists of two parts:

- Section 2 describes the INIR process, considerations in preparing and conducting an effective INIR mission and the IAEA mechanism to support embarking countries after an INIR mission.
- (Sections 3 and 4 present the main findings of INIR missions and an analysis of recurring issues observed.

2. INIR SERVICE

2.1. THE INIR PROCESS

The Integrated Nuclear Infrastructure Review (INIR) service was developed by the IAEA to evaluate the status of the infrastructure development for nuclear power in a country introducing nuclear power for the first time or expanding its existing nuclear power programme. The IAEA also developed guidelines on how to prepare and conduct INIR missions. These guidelines are described in *Guidelines for Preparing and Conducting an Integrated Nuclear Infrastructure Review (INIR)* (INIR Guidelines document) published in 2017 [4].

The INIR is a holistic review conducted by a team of IAEA staff and international experts who have extensive experience in the development of the infrastructure required for a nuclear power programme. While an INIR mission can be requested at any time during the development of the nuclear power programme, it is expected to be arranged in the following sequence:

- Phase 1 mission (close to Milestone 1);
- Follow-up (18 months to 2 years after the Phase 1 mission);
- Phase 2 mission (close to Milestone 2);
- Follow-up (18 months to 2 years after the Phase 2 mission);
- Phase 3 mission (before fuel loading of the first unit).

The results and analysis presented in Sections 3 and 4 reflect the IAEA experience with Phase 1 and Phase 2 missions.

The main steps in the INIR process are shown in Figure 1 and more details are provided in the INIR Guidelines [4].



FIG. 1. Main steps in INIR process.

Step 1 in the INIR process begins with the Member State request. A letter is sent to the IAEA, identifying a host counterpart and proposing a tentative date for the main mission. This letter should also indicate whether the requested mission will be a Phase 1, Phase 2 or Phase 3

mission. The IAEA will respond, nominating a liaison person from the Nuclear Infrastructure Development Section (NIDS) for further contacts.

Eight to twelve months prior to the main INIR mission, the host Member State should prepare its Self-Evaluation Report (SER) covering all the 19 nuclear infrastructure issues based on *Evaluation of the Status of National Infrastructure Development, Rev. 1* [2], which identifies the conditions for reaching Milestones 1 and 2. Based on the self-evaluation, the country is encouraged to identify, for each issue, if significant, minor or no actions are needed to reach the respective milestone and develop an action plan accordingly. The SER should also include a short description of how the evaluation was conducted and who was involved in the preparation of the SER.

The IAEA will review the SER to assess whether the information provided includes inputs from relevant stakeholders and is sufficient to provide an understanding of the status of the nuclear infrastructure in the country. It will consider whether the statements in the SER are validated by appropriate supporting documents. An SER support mission will be organized if considerable improvements in the SER are needed to facilitate a more effective and efficient main INIR mission and to agree on the time frame needed by the Member State to prepare a final SER version.

Step 2 is the pre-INIR mission to be conducted in the Member State five to eight months before the main INIR mission. The purpose is to present the INIR review process to counterparts in the host Member State and to agree on the Terms of Reference for the main INIR mission, including the agenda, team composition, logistical and interpretation requirements and arrangements for interaction with the media, if desired by the host country.

Step 3 includes preparatory work, conduct of the main INIR mission itself, development of the draft INIR mission report and the finalization of the mission report. In addition to the preparatory work on the Member State side, the INIR team will hold a preparatory meeting before the main mission. The purpose of the INIR team preparatory meeting is to develop an understanding of the status of the infrastructure in the host Member State based on the SER and supporting documents. Key questions may be formulated on topics not addressed, or not totally covered, by the documents submitted by the Member State. These questions will be sent in advance to the Member State to facilitate the interview process.

The main INIR mission is intended to understand the status of infrastructure development in the host Member State, and to formulate conclusions for the preparation of the INIR mission report. During the main INIR mission, interviews with the counterparts are conducted in plenary sessions to seek clarification or gather information not clearly described in the SER and supporting documents. Conclusions are discussed and agreed within the INIR team before being communicated to the counterparts. A draft INIR mission report containing all technical evaluation and factual information, including recommendations and suggestions, is prepared during the main mission and provided to the Member State.

Following the main mission, the INIR mission report is edited and finalized at the IAEA and delivered to the Member State in the presence of senior officials of the Member State and of the IAEA.

Step 4 is the follow-up mission that takes place 18–30 months after the main INIR mission to review progress on the implementation of the recommendations and suggestions provided.

The follow-up INIR mission is conducted based on the action plan progress report prepared by the Member State and other supporting documents. The exact timing of the follow-up mission is agreed between the IAEA and the designated Member State host counterpart.

A request from a Member State for the INIR services signifies a commitment to all four steps described above.

2.2. CHARACTERISTICS AND BENEFITS OF INIR

The INIR service has unique characteristics. The INIR service:

- is an inter-departmental service requiring a team with a variety of competencies as it covers all the soft and hard infrastructure necessary for the implementation of a nuclear power programme. The team may include legal specialists, safety, security and safeguards specialists, regulators, operators, training experts, project management engineers etc;
- addresses all organizations and entities involved in a nuclear power programme, including Government Ministries, the owner/operator, the nuclear regulatory body, environmental agencies, radioactive waste management organization, academia, research and development institutes, technical support organizations and industry;
- evaluates not only the activities, policies, programmes and arrangements required for a certain phase of the nuclear power programme, but also the plans for the next phase. For Phase 2 missions, this evaluation includes a consistency analysis between the activities and plans for the project definition (normally under the responsibility of the owner/operator) and other infrastructure elements (normally under the responsibility of the NEPIO, regulatory body etc.); and
- is a starting point of a long and strategic partnership between the Member State and the IAEA through tailor-made integrated plans based on the findings of the INIR mission and other IAEA review and advisory services. These are called Integrated Work Plans and are further explained in Section 2.6 of this document.
- provides Member States with an opportunity to evaluate their nuclear power programme and the required infrastructure based on the Milestones document;
- draws attention to areas requiring additional work;
- provides a forum for peer discussions and exchange of experiences on infrastructure development;
- helps to harmonize understanding of the infrastructure needed and its status among the relevant organizations;
- helps to improve stakeholder involvement by enhancing coordination and engagement by all relevant organizations in the country; and
- promotes transparency and public awareness.

2.3. INIR TEAM COMPOSITION

INIR missions are conducted by a team of international experts and IAEA staff from different technical competence units. The team is led by a senior IAEA professional staff member with a thorough understanding of the evaluation methodology and experience in INIR missions. A mission coordinator from the IAEA supports the team leader and ensures the logistical arrangements and communication with the counterparts as well as the consolidation of the INIR report.

The INIR team members are expected to have received training on the INIR process and the evaluation methodology. Such training is organized regularly by the IAEA. Team members

should have at least 15 years of experience in one or more of the nuclear infrastructure issues and have held senior positions in relevant organizations. Most team members should have experience in previous INIR missions and together the team should have the experience to cover all 19 nuclear infrastructure issues.

Typically, the size of the INIR team varies between 8 to 11 experts. The team may also include one or two observers who wish to gain insight into the INIR review process.

2.4. KEY CONSIDERATIONS FOR AN EFFECTIVE INIR

2.4.1. Comprehensive Self-Evaluation Report

The development of the SER is based on the Evaluation Methodology [2] which includes tables, to be completed by the Member State, covering each infrastructure issue in Phases 1 and 2. Each table contains the conditions that apply to that issue in that phase and an explanation of what is expected for each condition. It lists examples of the detailed information that may provide evidence that the summary of the condition has been fulfilled. It also provides references to the IAEA safety standards, security recommendations and guidance covering different infrastructure issues relevant to the condition.

The development of a comprehensive SER is fundamental for an effective INIR mission as the time dedicated to each infrastructure issue, during the main mission, is limited. The INIR team needs to have a reasonable understanding of the status of the infrastructure in the country through the SER. The interviews and discussions during the main INIR mission should be dedicated to elements requiring clarification and to address recent developments not reflected in the SER.

The SER preparation requires the participation of all key organizations involved in the nuclear power programme. In most Member States, this activity is coordinated by the NEPIO or similar organization. Analysis of SERs received by the IAEA prior to INIR missions indicated some common gaps where further help may be provided to host Member States:

- *Not all elements of the conditions are always fully addressed in the SER:* It is important that, when preparing the SER, the ‘summary of condition’ as defined in the evaluation methodology is fully understood and all elements of the condition are addressed.
- *Unbalanced level of information for different issues:* As the SER is written by different organizations, it was observed that, in some cases, there is an unbalanced level of information for different issues. Finding the right balance between too much detail and not enough can be challenging. The expectation is that the reader of the SER will have sufficient information to understand the status of that particular infrastructure issue without needing to consult reference documents.
- *Statements without accompanying factual evidence:* In some cases, statements in the SER are not supported by documents or by examples of activities conducted by the Member State. This makes it impossible for the reviewer to make any assessment on the fulfilment of the condition. For example, a Phase 1 condition requests that the main stakeholders understand the key requirements of the IAEA Safety Standards. A statement affirming that those requirements are understood should be accompanied by a description of activities conducted by the Member State to gain awareness of such requirements.
- *Not all the relevant organizations were involved in the preparation of the SER:* This situation can lead to a biased perspective, or to incomplete or incorrect information being included in the SER. This was more frequently observed in Phase 1 countries

where relevant stakeholders such as the Ministry of Environment, Ministry of Finance, Ministry of Health, national intelligence services, grid operator, research institutes, and others are not always part of the team supporting the development of the SER

- *References to laws and decrees are included throughout the SER as evidence that conditions are fulfilled:* Laws and decrees are expected to be referred to for conditions under the *Legal Framework* infrastructure issue. Other infrastructure issues address actions taken to implement the provisions of these laws and decrees. For example, the nuclear law may define the roles and responsibilities of the nuclear regulatory body. However, the law itself cannot ensure that the regulatory body is prepared to oversee the implementation of the nuclear power programme. The practical actions to develop the regulatory body should be presented (developing a recruitment and training programme, establishing a management system, issuing regulations and guides etc.) under the *Regulatory Framework* infrastructure issue.
- *The existing infrastructure is reflected in the SER, but the Report does not include the need to expand it to meet additional demands of the nuclear power programme:* Most countries considering the introduction of nuclear power already have infrastructure in place to address the existing facilities and the uses of radiation for medical and industrial applications. It should be noted that the self-evaluation report does not address the adequacy of the current infrastructure or even plans for its enhancement for the use of medical and industrial applications, but the additional needs that will arise from the nuclear power programme. There is a tendency to include too much detail on existing arrangements and not enough on plans to expand them in order to establish a nuclear power programme.

2.4.2. Requesting the INIR mission at the right time

The conditions defined in the Evaluation Methodology for a phase of the nuclear power programme are written in the form of statements that should be achieved by the end of that phase. One of the purposes of the INIR missions is to evaluate if all actions needed to move to the next phase of the programme were taken. For this reason, the conditions focus not only on whether activities have been completed, but also on whether there is a clear action plan for the next phase of the programme.

A Member State may conduct a self-evaluation for a certain phase and identify gaps that need to be addressed in order to achieve the corresponding Milestone. Based on those identified gaps, the Member State may request an INIR mission, knowing in advance that all conditions are not fulfilled, or choose to wait until all the activities to address those gaps are implemented before requesting the INIR mission. Both cases were observed during the 10 years of INIR missions.

In the case of early requests, the motivation of the Member State is to use the findings of the INIR mission to support the development of a roadmap to achieve the corresponding Milestone. This will lead to the establishment of an action plan and a monitoring system to address the recommendations and suggestions provided in the INIR report.

In the second case, the findings of the INIR mission are used to confirm that all, or most, actions for a certain phase have been taken and to show that the country is ready for the next phase of the nuclear power programme.

2.5. FUTURE INIR CHALLENGES

The Milestones approach and the INIR process developed not only for countries embarking on a nuclear power programme for the first time, but also for countries with small programmes that built their last units some years ago and now plan to build new nuclear power plants.

However, expanding countries are not fully benefiting from INIR and only one such country has requested an INIR mission. Consideration might be given to making more effort to promote, and if necessary adapt, the service. This is especially important given the significant changes in safety standards and international approaches to use of nuclear power over time.

All countries that have requested INIR missions were interested in large nuclear power plants that have been licensed by a mature regulatory body. There is increased interest among embarking countries in the new technology of Small Modular Reactors, in particular among countries with small grids which would have difficulty in financing a large nuclear power plant. In many ways, the infrastructure required for an SMR is similar to that of a large nuclear power plant. However, some specific considerations need to be taken into account, in particular in the conditions of the evaluation methodology.

2.5.1. The use of INIR in expanding countries

In some cases, expanding countries face challenges similar to those of embarking countries. In most expanding countries, the political and industrial environment has changed significantly since the first units were constructed. Governments are reluctant to launch a new nuclear power programme due to limited public acceptance and there are difficulties in financing these projects. Also, in several expanding countries, the legal and regulatory frameworks are outdated considering recent requirements in the areas of safety and security, and human resources are limited due to the lack of interest in the nuclear field among young professionals.

South Africa, which aims to re-start its nuclear power programme, hosted a Phase 2 INIR mission in 2013 and concluded that the mission was beneficial in helping it to prepare for the next phase of the programme. An evaluation made by the IAEA together with South African experts concluded that the Evaluation Methodology and all its conditions apply to the infrastructure development for nuclear power in South Africa, even though the country has been operating two reactor units since 1985 and has an experienced owner/operator and regulatory body. Infrastructure areas identified by the INIR mission where improvements are needed include amending the legislation, in particular the nuclear law, enhancing the country's regulatory framework, finalising its contracting approach and building an integrated approach to human resource development.

In 2019, the IAEA organized a meeting to discuss the preliminary self-evaluation prepared by Bulgaria for the Belene project that was re-launched in 2018.

Belene is a new project to be operated by a new owner/operator. Bulgaria originally decided to start the Belene NPP project in 2004. However the project was suspended by the Government in March 2012.

The Belene project was restarted by the decision of the Government in May 2018. The new project has been designed in a new ownership model. A competition was organised to select a strategic investor for construction of the plant.

The self-evaluation was conducted by a group of experts from different organizations in Bulgaria taking into account the current status of the restarted project. The Self-Evaluation Report (SER) was prepared by this group and sent to IAEA before the meeting. IAEA staff and an external expert reviewed the SER and prepared comments highlighting additional information that was required to complete the SER.

The assessment of the self-evaluation report prepared by Bulgaria showed that the conditions for the INIR Phase 2 evaluation methodology are applicable and helpful. The meeting participants considered that the methodology would be useful to any embarking or expanding country that has not developed a new nuclear project for some time. The participants also

suggested slight modifications in the title or summary text of some of the conditions to better address the situation of both embarking and expanding countries.

Despite the examples presented above, the number of countries that showed interest in requesting an INIR mission or performing a self-evaluation based on the Evaluation Methodology remains limited. It is important that the IAEA further promotes the relevance of INIR to expanding countries.

2.5.2. Adapt INIR for countries interested in SMRs

Several embarking countries requested IAEA support in the field of nuclear infrastructure for SMRs. While the IAEA has a good understanding of the different designs under development and time schedules for construction, more information needs to be gathered on the deployment models proposed by SMR vendors to embarking countries.

In 2017, a first consultancy was conducted by the IAEA to analyse the applicability of the Milestones Approach and the INIR Evaluation Methodology for a country interested in SMRs rather than in a large nuclear power plant. The result of this assessment, for a subset of SMRs (near term deployment types – integral Pressurized Water Reactor and High Temperature Gas Cooled Reactor), was that both the Milestones Approach and the INIR service can also be applied to SMRs as the infrastructure is, to a large extent, similar. However, some conditions of the evaluation methodology need to be analysed, and eventually adjusted, to take into account:

- Potential differences in the legal and regulatory framework which is under review by SMR Regulators Forum established by the IAEA;
- Potential grading of the requirements for siting and emergency preparedness and response;
- Differences in contractual approaches and deployment models;
- Levels of support from technology vendors for human resource development;
- Arrangements for provision of long-term support for operation and maintenance;
- Technology vendor support for fuel supply and radioactive waste management services; etc.

2.5.3 Consolidation of INIR Phase 3

Phase 3 INIR missions are conducted to evaluate the status of infrastructure against the readiness for commissioning and operation of the first NPP. Due to the nature of this milestone, Phase 3 INIR missions have some specificities. Two of the specificities are: the timing of the mission and the development of the SER.

Phase 3 INIR missions need to be conducted just before the fuel loading for the first NPP in order to increase the effectiveness of the mission.

The process of development of the SER is slightly different for Phase 3 missions. During Phase 3, it is likely that a number of other specific IAEA review missions will have taken place to evaluate the country's capability to regulate nuclear safety, security and safeguards, plan for and implement emergency response, and operate the nuclear power plant safely. These missions also include self-evaluation/advanced information reports and will provide the information required to evaluate some of the infrastructure conditions for Phase 3. For this reason, the first step in developing a Phase 3 SER is for the IAEA to provide a template which already includes information known to the IAEA from other missions.

An Evaluation Methodology for Phase 3 INIR missions was developed as working material. It was used in two pilot Phase 3 missions (United Arab Emirates in 2018 and Belarus in 2020). Feedback from those missions will be used to finalize the Evaluation Methodology for Phase 3 before its publication.

The pilot missions showed that the evaluation methodology made effective use of the results of other IAEA review and advisory services and avoided overlap with these missions. The conditions of the evaluation methodology were clear and appropriate. Some minor changes were noted to be considered in finalizing the evaluation methodology.

2.6. INTEGRATED IAEA SUPPORT FOLLOWING INIR SERVICE

It is the sovereign decision of a country to embark on a nuclear power programme. When a country decides to include nuclear power in its energy supply mix, the IAEA can provide coordinated and integrated support to develop the necessary infrastructure and to implement a safe, secure and sustainable nuclear power programme. This support is provided through the Integrated Work Plan process which was established after the conduct of first INIR missions.

The IWP is a formal document belonging to a Member State containing information about its existing or planned activities in relation to developing the infrastructure for a nuclear power programme. The IWP users are primarily Member State counterparts and IAEA management and staff directly involved in activities and projects covered by the IWP.

The IWP's main objectives are:

- To ensure that IAEA assistance is in line with the country's programme and project timeline and is targeting areas of critical need as identified by the Member State based on the report of the latest INIR mission conducted in the country (and any other peer reviews, if available);
- To serve as a unified and integrated plan for an agreed period (normally 2-3 years or more) to facilitate the delivery of IAEA assistance through existing mechanisms where availability of funds has already been guaranteed;
- To enable IAEA Divisions/Offices/Sections involved in infrastructure development projects to integrate their inputs into an appropriate package of services and assistance commensurate with available resources, and the Member State's capacity and (IAEA related) needs;
- To enable the Member State to plan the utilization of complementary assistance from other bilateral and national sources within the scope of its National Action Plan;
- To ensure the IAEA Core Team and experts involved in related IAEA support activities utilize one single integrated work plan for each country being assisted.

The lifespan of the IWP is limited to the period from the receipt of an embarking Member State's SER to the start of NPP operation.

In the preparatory phase for an INIR mission, the Member State prepares an SER which includes an action plan to address the gaps identified during the self-evaluation process, as explained in detail in Section 2.1. This action plan includes all remaining activities required to achieve the corresponding Milestone, identifies organizations responsible for their implementation and a time frame for their completion.

During the main INIR mission, the gaps identified by the Member State in the SER are analysed and, in many cases, new gaps are identified by the INIR team.

After the main INIR mission, the Member State updates its action plan to include activities to address the recommendations and suggestions of the INIR mission to develop a National Action Plan. The National Action Plan will be the basis for the development of the IWP which is reviewed and updated on a regular basis. The scheme for integrated IAEA support to embarking countries including the process for developing and updating the IWP is shown in Figure 2.

Member States and the IAEA have been applying the IWP process for several years based on the guidance provided by IAEA senior management. The Terms of Reference for the IWP process were developed and approved by all relevant IAEA Departments and are revised on a regular basis.



FIG. 2. Scheme of the integrated IAEA support to embarking countries.

In order to support the implementation of IWPs, the IAEA established different core teams for every Member State requesting such support with staff coming from different departments. A typical core team is composed of between 15 to 20 IAEA staff and its members are constituted of qualified experts providing advice and supporting the implementation of the activities identified in the IWP.

Meetings to develop and/or update IWPs are organized annually, or as needed, with the participation of the IAEA core team and the representatives from all key organizations responsible for the development of different infrastructure elements for the nuclear power programme in the Member State (Government/NEPIO, owner/operator, regulatory body, radioactive waste management organization, academia, etc.).

Member States may see a benefit in including in the IWP the support received from other Member States under bilateral agreements or through other international organizations. This “soft coordination” through the IWP allows the Member State and the IAEA to optimize IAEA assistance avoiding duplication.

3. THEMATIC ANALYSIS FROM THE INIR REPORTS

In the last 10 years, significant experience has been accumulated in the IAEA through the conduct of INIR missions. The results of those INIR missions have been submitted to host Member States in the form of INIR reports [5].

Several key issues were identified as common challenges faced by embarking countries. This section provides an analysis of some of them.

3.1. SUSTAINING NATIONAL POSITION AND PROGRESS

The INIR missions identified a number of factors that can inhibit progress:

- **Political considerations:** Experience has shown that a project can be stopped or suspended because of political considerations (for example lack of high level political support, or change of the political party in power) or because of the lack of support from one or more major national stakeholders such as a key government ministry. This highlights the critical importance of obtaining broad national support a nuclear power programme, involving political leaders and major national authorities that might have an influence on making and sustaining a decision. An effective NEPIO with a broad and representative composition and established reporting and communication lines with policy and decision-making authorities will help to mitigate this risk.
- **Energy planning:** In some cases, the nature and timing of the NPP project are re-evaluated because of changing energy demand scenarios. This underscores the importance of conducting realistic and sound energy planning to support nuclear power as a viable and long-term option.
- **Financial considerations:** In some cases, the NPP project cannot progress because the Member State is not able to develop a realistic financial strategy that creates confidence to potential lenders.
- **Public opinion:** Public acceptance is among the challenges that need to be addressed by a country in building and sustaining a decision. Public acceptance will be facilitated by an appropriate strategy for engaging all relevant stakeholders and by effective communication with the public that highlights the benefits of nuclear power and openly addresses safety concerns.
- **Technical considerations:** In some cases, the main constraint to advancing in the nuclear power programme is technical. Often, it involves limitations in the electrical grid capacity. This constraint may be overcome by developing a regional grid with a larger capacity, for example with the involvement of neighbouring countries, or by deploying SMRs when these are available.

INIR missions highlighted the importance of regularly updating the national energy policy and completing studies to support the decision-making process regarding the nuclear power programme, involving all relevant organizations.

3.2. NUCLEAR ENERGY PROGRAMME IMPLEMENTING ORGANIZATION

When the Milestones approach was first developed, the expectation was that a country would set up an organization with its own budget and staff to carry out the Phase 1 investigations and oversee the implementation of the nuclear power programme. This body was then named the Nuclear Energy Programme Implementation Organization (NEPIO). Experience has shown that few countries have followed this exact model. A more common approach is to set up a steering committee with members from the relevant organizations. Some of the staff involved

in NEPIO activities may be full time, while others work part-time. In general, NEPIO members tend to remain engaged in their existing organization while assigned to work on development of the nuclear power programme.

As the nuclear power programme progresses, at least two key organizations evolve: the owner/operator and the regulatory body. The NEPIO function continues through all three phases to perform wide-ranging activities and co-ordinate the work of the programme.

For countries in Phase 1, progress to Phase 2 is more likely to occur if the NEPIO function involves all key stakeholders with relevant influence on the national decision regarding the nuclear power programme. Observed important aspects include:

- The formal designation of the NEPIO with terms of reference that cover all the work required during Phase 1 and the requirement to make a recommendation to the government;
- Having a clear allocation of responsibilities, resources and timescales for the work required;
- Involving all relevant stakeholders, including those responsible for radiation protection, environmental protection, grid, national emergency preparedness and nuclear security that can bring knowledge and experience from previous work or other relevant work areas (radiological, industrial, electricity etc). This aspect will also help with spreading the ownership of government decisions to the relevant stakeholders.

In Phase 2, it was noted that:

- While the responsibility for implementing much of the programme lies with the regulatory body and the owner/operator, the NEPIO needs to ensure that the organizations are being properly staffed as required and complete their required actions inline with the implementation of the nuclear power programme;
- The NEPIO may continue to play a significant role in developing some infrastructure areas, e.g. development of educational programmes, stakeholder involvement, industrial involvement and funding mechanisms for radioactive waste management and decommissioning.

3.3. CONTRACTING OPTIONS: OPEN BIDDING, PARTNERING, IGA

The INIR missions have noted that countries are adopting a broad range of different approaches to establishing their nuclear power programme and contracting for the nuclear power plant project. These options range from establishing a national owner organization and conducting a bidding process to construct an NPP, to establishing a company that will operate an NPP for an agreed price and volume of electricity.

In some cases, countries used a classical bidding process to negotiate and contract for the implementation of the nuclear power plant project. While in other cases, the initial agreement has been at the level of an Inter-Governmental Agreement (IGA) with a preferred government experienced in nuclear power. The main elements that have been considered in country-to-country agreements, include:

- Support of financing, either by loans or investment (debt or equity);
- Support for staffing the owner/operator with experienced staff and large training batch;
- Regulatory support, including services from TSOs and international cooperation;
- Arrangements for fuel supply and spent fuel/radioactive waste management;
- Power purchase agreements.

The scope and level of specific detail in these IGAs varies but the key feature is an early selection of the country to partner with based on preliminary discussions with potential technology vendor countries. The IGA, however, needs to be complemented by an Engineering Procurement and Construction (EPC) contract with detailed technical and commercial terms. The specifics of each country will be different and there is no one single approach that can be recommended. However, the experience from INIR missions suggests that countries need to consider a wide range of potential approaches early in their decision-making process to identify those that need to be pursued in more detail.

3.4. ESTABLISHMENT OF THE OWNER/OPERATOR

While there is no expectation that the owner/operator should be established in Phase 1, INIR missions in Phase 1 have identified the need for leadership programmes to be developed in order to ensure that future key organizations have leaders with appropriate knowledge and experience.

Phase 1 INIR missions have also identified that the comprehensive report needs to give some consideration to how the owner/operator organization will be set up including its ownership structure and staffing levels. These aspects may be closely linked to the contracting arrangements or the financing of the NPP project, which might not have already been established in Phase 1. For example, the potential vendor country could be a significant or even the major shareholder in the planned owner/operator organization. Nevertheless, INIR missions have noted that the country needs a clear plan on how it will move forward with the initial establishment of the owner/operator organization since it will have key responsibilities in Phase 2.

The INIR missions in Phase 2 have identified that the establishment of the owner/operator sometimes lags behind other aspects of the programme development. In several cases, another organization, such as the Atomic Energy Commission/Agency, is conducting work on behalf of the future owner/operator. In this regard, it is important for the future licensee to be established as soon as possible to take ownership of the project.

Three different approaches have been observed for taking forward the responsibilities of an eventual owner/operator: i) A unit is set up within an existing electricity utility, ii) a group is established within the country's atomic energy commission, or iii) a completely new entity is established. In all three cases it is important to create a multi-disciplinary team combining the experience from both electricity supply and nuclear energy.

The INIR missions have observed that when a functional unit is set up within the country's Atomic Energy Commission (AEC), it needs to have a strong project management function and the ability and influence to secure the provision of all resources required. If a functional unit is established within the existing utility, it needs to be provided with significantly more competences related to NPPs than to be required for other electricity projects.

In all cases, it is important to develop a functional unit that can take the project forward to the point where the experience of the vendor country (or another experienced country) can be included. This process will depend on the contracting approach.

The INIR missions have also observed difficulties in establishing a good interface between owner/operator and the regulatory body. Sometimes the drive to be an independent regulatory body has resulted in a lack of communication between the two organizations. Attention needs to be given to establishing independent organizations that can effectively communicate and work in a co-ordinated nuclear power programme.

As the intended contracting approach becomes clearer, the owner/operator needs to expand its competences and start planning of Phase 3 activities. The role of the vendor country to support the establishment and development of necessary competencies of the owner/operator should be defined and agreed in the contractual arrangements.

3.5. DEVELOPING NATIONAL APPROACHES

The INIR missions have identified the challenges in developing national guidance documents such as policies and strategies, high level plans or white papers, to support the development of the nuclear power programme with short and long-term goals and objectives in different areas. These high-level guidance documents are intended to inform the relevant stakeholders on the opportunities and the required human and financial resources to reach the defined goals and objectives of the programme. They need to be consistent with the potential options for the number and ownership of the planned NPPs and take into consideration the international experience and the lessons learned in developing and implementing a nuclear power programme.

The national policies and strategies for safety and security are intended to highlight the country's commitments to safety and security and the necessary mechanisms to implement those commitments. These commitments include building an effectively independent and competent regulatory body, establishing a competent and capable owner/operator, promoting leadership and management for safety and security including safety culture and security culture, promoting the transparency, and fostering international cooperation. The INIR missions observed that several countries had not developed a formal safety and security policy, but the elements of nuclear safety and security policy were well understood and generally reflected in the nuclear law.

The national strategy for human resource development (HRD) is intended to guide the development of necessary staff for the nuclear power programme. It needs to include the full range of legal, financial and technical skills required, an analysis of the current capabilities within the country, the need for enhancing the national education system, plans for gaining international experience, recruitment and retention strategies and the utilization of external support. Some INIR phase 1 missions identified an HRD strategy, which was drafted but not finalized in many countries. Countries have undertaken detailed studies on the resources needed in each organization but have not clearly identified the main elements of their national HRD strategy.

The national policy and strategy for stakeholder involvement is intended to ensure engagement from all relevant stakeholders and to build national support for the nuclear power programme. It needs to identify main stakeholders (governmental organizations, NGOs, general public and local communities) and mechanism for interaction among them. The INIR missions identified that in many countries stakeholder involvement strategy was developed in phase 1, but in several countries, there was a reluctance to implement the strategy especially in the area of public communication. Acquiring and maintaining a broad national support from the stakeholders early in the process will enhance public acceptance and further support the development and sustainability of the nuclear power program. The INIR missions also identified in several countries the need to improve the coordination among the key organizations (NEPIO, RB, Owner/Operator).

National policy and strategies for industrial involvement aims to set short and longer term targets for national industry participation levels. The INIR missions have shown that the Government/NEPIO should develop a policy for national and local industrial involvement in order to guide industrial involvement planning and capacity building and provide information

about the programme's the contractual approach. This policy should be based on the selected options for the first NPP ownership and take into consideration current national industrial capabilities, the potential investment requirements and the international experience and lessons learned on industrial involvement for a nuclear power programme. The contractual approach needs to consider the desired extent of local industrial involvement, based on the assessment of the local industries' capability. This process will result in the development and implementation, by relevant stakeholders, of an industrial involvement plan, specifying requirements for industry participation to the project to guide negotiation, contracting and planning activities. Short and long-term programs for increasing national and local participation for the future NPP need to be also developed after approval of the ownership and contractual approach for the first NPP and included in the specifications for contracting.

Management of spent fuel and radioactive waste is certainly a vitally important topic for embarking countries. The results of INIR missions confirmed that the front and back end of the nuclear fuel cycle is a very common issue raised to most embarking countries during INIR missions. They highlighted the need for governments to develop and adopt a national policy and strategy as well as plans for the safe and sustainable management of radioactive waste and spent fuel, taking into consideration the international experience and lessons learned.

While the national policy needs to address national priorities, responsibilities, structures and provision of human and financial resources for the front and back-end of the nuclear fuel cycle, the radioactive waste management strategy needs to address approaches for:

- Inventory management, processing and storage options and capacities for radioactive wastes;
- Disposal options for all types of generated waste;
- Decommissioning of NPPs;
- Time schedules with major milestones (processing facility, storage, repository);
- Responsibilities and funding mechanisms.

The strategy may also consider the establishment of a state entity for the management (including disposal) of Spent Fuel (SF) and Radioactive Waste (RW). The government needs also to develop plans for all aspects of radioactive waste management addressing the construction of facilities for characterisation, processing, storage and disposal of RW, funding and financing.

3.6. PROGRAMME VS PROJECT DEVELOPMENTS

The nuclear power programme is the necessary environment in which one or more nuclear power plant projects and the supporting infrastructure are developed. As the nuclear power programme develops, many specific activities will be undertaken in order to implement the first nuclear power plant project. It is important that the distinction be clear between a nuclear power programme and a nuclear power plant project. The projects are temporary undertakings to develop and construct nuclear power plants in the country. The infrastructure provides the environment, processes and capabilities in order to enable the project activities and the subsequent operation of the nuclear power plant to be implemented in a safe, secure and sustainable manner.

As part of taking the decision to start a nuclear power programme, the country needs to recognize the need of building the necessary infrastructure and allocating necessary financial and human resources to build the infrastructure. The INIR missions observed the difficulties, in some countries, to assess and allocate the necessary resources to address all aspects of a

nuclear power programme. It is important to assess and plan the whole programme in the short, medium and long term addressing all the 19 infrastructure issues at national level.

To ensure a successful nuclear power programme and manage the programme risk, the milestones document identifies a number of activities to be completed in Phase 2. The INIR missions noted in several countries the difficulty of enacting the necessary legislation including the modifications in the existing legislation, establishing the independent regulatory body with sufficient human resources and funds, developing the necessary regulations and guides, and establishing the competent and capable owner/operator, etc. The INIR missions also observed that development of the infrastructure often takes longer than envisaged. The nuclear power plant project could sometimes progress faster than the development of the infrastructure that requires national decisions, implementing laws and regulations, establishing national organizations and allocating resources. In several countries, the INIR missions noted that the nuclear power plant project was advancing without having all the necessary infrastructure in place in a timely manner. This gap leads to additional risks to the project and may result in delays or additional costs.

4. RESULTS OF INIR MISSIONS

4.1. INIR MISSIONS CONDUCTED

The IAEA has conducted 30 INIR mission in 21 countries from the first in 2009 until April 2020 (see Table 1). This TECDOC provides the results of INIR missions conducted after the revision of the Evaluation Methodology.

TABLE 1. INIR MISSIONS CONDUCTED.

No.	Country and Phase	Year	Evaluation Methodology
1	Jordan (Phase 1)	2009	2008
2	Indonesia (Phase 1)	2009	2008
3	Viet Nam (Phase 1)	2009	2008
4	Thailand (Phase 1)	2010	2008
5	United Arab Emirates (Phase 2)	2011	2008
6	Bangladesh (Phase 1&2)	2011	2008
7	Jordan Follow-up (Phase 1)	2012	2008
8	Belarus (Phase 1&2)	2012	2008
9	Viet Nam (Phase 2)	2012	2008
10	South Africa (Phase 2)	2013	2015
11	Poland (Phase 1)	2013	2015
12	Turkey (Phase 2)	2013	2015
13	Jordan (Phase 2)	2014	2015
14	Viet Nam Follow-up (Phase 2)	2014	2015
15	Nigeria (Phase 2)	2015	2015
16	Kenya (Phase 1)	2015	2015
17	Morocco (Phase 1)	2015	2015
18	Bangladesh Follow-up (Phase 1&2)	2016	2015
19	Poland Follow-up (Phase 1)	2016	2015
20	Malaysia (Phase 1)	2016	2015
21	Kazakhstan (Phase 1)	2016	2015
22	Ghana (Phase 1)	2017	2015
23	Niger (Phase 1)	2018	2015
24	United Arab Emirates (Phase 3)	2018	Working Paper
25	Saudi Arabia (Phase 2)	2018	2015
26	Sudan (Phase 1)	2018	2015
27	Philippines (Phase 1)	2018	2015
28	Egypt (Phase 2)	2019	2015
29	Ghana Follow-up (Phase 1)	2019	2015
30	Belarus (Phase 3)	2020	Working Paper

4.2. SUMMARY OF FINDINGS ON 19 INFRASTRUCTURE ISSUES

The findings of the Phase 1 and Phase 2 INIR Missions are summarized below. The data for Phase 3 Missions is still limited and is not included in this document.

4.2.1. National Position

In Phase 1 there are three conditions. The first one requires a clear statement from government of its intend to develop the nuclear power programme and of its commitment to safety, security and non-proliferation. The second condition relates to the establishment of an effective NEPIO, and the third one relates to the content of the report which defines and justifies the national strategy for introducing nuclear power.

In Phase 2 there are also three conditions. The first one relates to the continued effectiveness of the NEPIO function, and the second one to a clear definition of the overall strategic approach for contracting the planned NPP and associated support, and the third one to the effective establishment of the owner/operator and regulatory body.

Phase 1 INIR missions identified that some countries developed a national nuclear policy document early in Phase 1, but some aspects of the policy were not considered as the work develops, and the decision to move forward is delayed. The INIR missions identified the importance of maintaining an up-to-date policy statement with respect to the nuclear power programme and a sustained governmental endorsement of this statement. Having a policy in Phase 1 does not mean the national decision has been made, but it does mean that the option is being considered and some of the guiding principles are defined.

The INIR missions identified different approaches for establishing the NEPIO function and, in general, the appropriate stakeholders were part of the NEPIO. However, in several countries, the need to improve the co-ordination between organizations and the involvement of all relevant stakeholders was identified. In some countries the INIR missions also identified the need to ensure that the NEPIO has adequate resources to complete its work. It should be noted that completing all the studies required for Phase 1 requires significant investment from the country.

The INIR missions also identified that several countries in Phase 1 needed to update/complete the necessary studies for Phase 1 to ensure that all the information required to support a knowledgeable decision was available and up to date. The INIR missions also identified that once the studies are completed, it is important to compile the key messages in a comprehensive report to the Government.

Phase 2 INIR missions identified in several countries that policies and strategies need to be finalized and endorsed by the Government to provide clear direction for the development of the programme.

The INIR missions also identified that responsibilities need to be clearly defined as a country begins the development of three key organizations – the owner/operator, the regulatory body and the government organization responsible for the nuclear power programme (NEPIO). For example, defining the organization responsible for maintaining and updating policies, the process on how the owner/operator responsibilities will be addressed and the proposed structure of the future owner/operator.

Most phase 2 INIR missions also noted the need to ensure that the NEPIO continues to coordinate the programme activities and follow-up the establishment of the key organizations.

In some of the phase 2 INIR missions, the need to define and agree on a contracting strategy was identified.

4.2.2. Nuclear Safety

In Phase 1, there are two conditions: one to ensure that the key requirements for nuclear safety are understood and their implications are recognized and the other to ensure that international cooperation is initiated.

In Phase 2, the first condition relates to recognizing the safety responsibilities of key organizations and the second condition relates to establishing expectation for relationships with suppliers.

Phase 1 INIR missions observed that all countries are doing some work to familiarize NEPIO members with nuclear safety through various mechanisms (seminars, trainings, visits, meetings, newsletters, etc.), including initial training in safety culture and leadership. However, Phase 1 INIR missions also identified in several countries that not all NEPIO members, nor relevant governmental officials, are involved in these activities and no mechanisms are established to ensure that they understand the implications of nuclear safety in a nuclear power program/project.

Few countries have developed a draft national policy and strategy for safety and were encouraged to expand more on nuclear safety principles and knowledge. Some other countries have been asked to plan for the establishing of a national policy and strategy for safety to express their long-term commitments to nuclear safety principles and objectives.

Most of **Phase 2 INIR missions** have identified the necessity to enhance the knowledge and competence of the owner/operator and the regulatory body staff and management to perform the review and assessment process, to prepare / review the license application and to manage and oversee the construction. For this, embarking countries may need to consider:

- developing formal programmes that gather and evaluate operating experience,
- developing and implementing training and qualification programmes,
- ensuring long term vendor support,
- ensuring knowledge transfer from the technical support organizations.

In several countries, the Phase 2 INIR missions identified the need for the owner/operator and the regulatory body to develop and implement safety culture programmes in the early stages of the nuclear power programme that are promoted by senior leadership. These programmes need to empower staff to raise safety concerns, need to be incorporated in the management system and could be extended to other organizations such as TSOs, as the nuclear power project evolves.

Phase 2 INIR mission also identified the need for some countries to establish a formal communication process to ensure the effective management of safety information during the licensing processes between the owner/operator, the regulatory body and as needed the vendor.

4.2.3. Management

In Phase 1 the condition is to ensure commitment to leadership and management systems to ensure the success of the programme. There is also a need to plan for the transfer of knowledge from the NEPIO to the key organizations that will be established in Phase 2.

In Phase 2 there are three conditions. The first relates to defining the requirements in the specifications for the bidding process or negotiations with a sole supplier. The second relates to the competence of the owner/operator to manage the procurement requirements and to ensure that they are met. The third relates to implementing effective management systems in each of the key organizations.

Most **Phase 1 INIR missions** identified the need for NEPIO teams to improve their understanding of the IAEA safety standards in the area of management systems and develop plans and guidance to implement appropriate and phased management systems in the key organizations involved in the nuclear power programme.

Several **Phase 2 INIR missions** identified the need to ensure that a comprehensive set of requirements is developed covering not only technical and financial requirements but also short and long-term requirements for HRD and support from vendor related organizations. This is valid for the situation where the strategy is to embark on a competitive bidding process, and where the country is negotiating with an already chosen vendor country.

Most Phase 2 INIR missions also identified the need to strengthen the capabilities of the owner/operator in the areas of procurement and project management, recognizing that this is required even when the procurement strategy is via a turnkey EPC contract. They also identified the need for more detailed plans for the development of the owner/operator structure.

Most Phase 2 INIR missions observed that the organizations have initiated the development of management systems to cover the activities of Phase 2. However, in most cases they were not completed or not implemented effectively. The need to further develop management systems to cover Phase 3 in each of the key organizations, including the need to continue the development of a safety and security culture, was also identified.

4.2.4. Funding and Financing

In Phase 1 and 2 there are two conditions. In both phases, the first relates to the plans to fund the infrastructure development in the next phase of the programme and the second relates to the planned approach for financing the nuclear power plant itself, with more detail being expected in Phase 2.

Phase 1 INIR missions observed that most countries had not completed an estimation of the costs of developing the nuclear infrastructure based on identification of the main activities. Several had identified the main areas where funding would be required but had not quantified the cost. This made it difficult to plan future budgetary requirements in the relevant ministries and organizations.

Phase 1 INIR missions also identified the need to review approaches for ensuring adequate funding of radioactive waste management and decommissioning in countries with nuclear power and to identify the principles of an approach that best suit the country.

With respect to financing, most Phase 1 INIR missions identified the need to develop a financial model of the proposed programme in order to evaluate the implications of different financing and contracting options. This should then be used to evaluate potential sources of financing and the impact of their costs on the proposed programme.

In several countries, **Phase 2 INIR missions** identified the need to finalize arrangements to ensure adequate funding of the regulatory body for its licensing and inspection activities in Phase 3. Several missions also identified the need to establish plans for the development of appropriate arrangements for establishment and management of a radioactive waste management and decommissioning fund.

With respect to financing, Phase 2 INIR missions identified the need for further work and resources to evaluate financing and contracting models to demonstrate feasibility and to understand the risks to the programme and how they will be addressed in future contracts.

4.2.5. Legal Framework

In Phase 1, there are three conditions to assess the countries plan to adhere to all relevant international legal instruments (condition 1), have a plan for the development of a comprehensive national nuclear law (condition 2), and have plans to enact and/or amend other legislation affecting the nuclear power programme.

In Phase 2 there are three conditions to demonstrate the conditions in Phase 1 were fulfilled (adherence to international instruments, a comprehensive nuclear law enacted, and the other legislation affecting the nuclear power programme enacted and/or amended).

Phase 1 INIR missions identified that most countries have already signed and ratified some of the relevant international legal instruments, but some countries still needed a clear plan for adherence to remaining relevant international legal instruments.

Phase 1 INIR missions identified that most countries had already enacted a nuclear law but needed further development or revision to adequately address all aspects of a comprehensive national nuclear law that are relevant for a nuclear power programme.

Phase I INIR missions also noted that all the countries were in the process of identifying other existing legislation affecting the nuclear power programme, but the majority of the countries don't have plans to enact and/or amend these legislations.

Phase 2 INIR missions identified that most countries had in place a law to address the regulatory responsibilities regarding the use of nuclear energy or radiation sources but not yet enacted a comprehensive nuclear law addressing the needs of a nuclear power programme. Phase 2 INIR missions identified for most of the countries the need to enhance the existing laws regarding the establishment of an independent regulatory body and the delineation of State responsibilities for safety, security and safeguards, which in some Member States entails changes to long-standing institutional structures and practice. They also identified the need to promulgate a law on civil liability for nuclear damage or to include relevant provisions in the comprehensive nuclear law in some countries.

Phase 2 INIR missions identified that all countries have adhered to some of the relevant international legal instruments. Examples of international legal instruments still requiring adherence include: Convention on the Physical Protection of Nuclear Material and Amendment; Convention on Nuclear Safety ; Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management; 1997 Protocol to Amend the Vienna Convention on Civil Liability for Nuclear Damage; Convention on Supplementary Compensation for Nuclear Damage); and Additional Protocol to the Comprehensive Safeguards Agreements.

Phase 2 INIR missions also observed that most of the countries have done a limited review of laws other than the nuclear law to make necessary amendments that may be required to successfully implement the nuclear power programme. The need for the completion of the review and amendment process was identified by the Phase 2 INIR missions.

4.2.6. Safeguards

In Phase 1 There are three conditions. Condition 1 is to ensure that the terms of international safeguards agreement are in place. Condition 2 is to demonstrate the country has a plan to strengthen the SSAC. Condition 3 is to check that the recommendations from any previous reviews or audits have being.

In Phase 2 there are three conditions. The first condition relates to the strengthening of the SSAC. The second condition relates to the owner/operator awareness of the SSAC requirements

for the NPP. The third condition relates to the recognition of the design information requirements for safeguards.

Phase 1 INIR missions observed that all countries have a Comprehensive Safeguards Agreement (CSA) with several countries having Small Quantities Protocol (SQP). They also identified in some countries the need for a plan to rescind the SQP.

Phase 1 INIR missions noted that several countries have a State System on Accounting for and Control of nuclear materials (SSAC). Phase 1 INIR missions identified in several countries the need to develop a plan for enhancing the SSAC and the associated regulations to meet the requirements of the nuclear power programme. Also, in Phase 1, the need to enhance the mechanism to ensure that all organizations are aware of the countries' non-proliferation obligations, including the collection and reporting of safeguards information.

Phase 2 INIR missions observed that most countries met the expectations of the condition. Some specific issues were identified including:

- developing or finalizing the requirements for the implementation of safeguards,
- identifying the necessary staffing, training and technical resources in the owner/operator,
- Strengthening the information management system for collecting, processing and communicating safeguards relevant information.

4.2.7. Regulatory Framework

In Phase 1, there is 1 condition related to planning the development of an adequate regulatory framework.

In Phase 2, there are 2 conditions: the first one is related to establishing a competent, effectively independent nuclear regulatory body and the second one is related to developing the regulatory framework.

All countries have developed regulations to cover their existing activities. While many countries began drafting plans and sometimes even drafting regulations for nuclear power, **Phase 1 INIR missions** identified the need for most countries to further enhance their plans for the development of the regulatory framework required for the nuclear power programme. These include plans for developing regulations and guides covering nuclear safety, nuclear security and safeguards at the different stages of a nuclear power programme.

Phase 1 INIR missions observed that most countries had plans to establish an effectively independent competent regulatory body.

Several phase 1 INIR missions identified the need to get external technical support required for the future stages of the implementation of the nuclear power programme. In this area, Phase 1 INIR missions observed the following ways of utilization of external support to help in performing the regulatory functions and developing the necessary competences:

- using the support from external consultants, including international TSOs;
- obtaining support from other regulatory bodies of countries with a well-established nuclear power programmes, through Memorandum of Understandings (MOU);
- getting support of the IAEA;
- initiating a cooperation with other international organizations.

Phase 2 INIR missions have identified the need for many countries to ensure that the regulatory body is established and independent and that it has the necessary resources and competence to

perform its regulatory functions for Phase 3. These include the review and assessment of safety documentation required for the licensing process and the inspection during the construction phase including the manufacturing of safety related equipment.

Phase 2 INIR missions also identified the need for regulatory bodies in several countries to complete the development or adoption of the necessary regulations and guides required for Phase 3 of the nuclear power programme.

4.2.8. Radiation Protection

In Phase 1, there is one condition related to planning for enhancements to radiation protection programmes.

In Phase 2, there is one condition related to planning the development of radiation protection programmes and expansion of appropriate infrastructure.

All countries have some radiation protection infrastructure, mainly to deal with the existing activities and facilities and are considering some enhancements. **Phase 1 INIR missions** identified in several countries, the need to assess the existing capabilities against the additional requirements for the nuclear power program and to identify the needed enhancements. Typical enhancements include developing additional capabilities or expanding the scale of the existing infrastructure such as for external and internal dosimetry services, calibration and laboratory facilities.

Phase 2 INIR missions identified in several countries the lack of a plan to enhance the radiation protection infrastructure to meet the requirements for the nuclear power programme. The plan needs to involve the operator, the regulator and the radiation protection services providers.

4.2.9. Electrical Grid

In Phase 1 the condition is to conduct a preliminary study of the reliability of the grid and its capability cope with installation of an NPP.

In Phase 2 there are two conditions. The first relates to detailed studies to determine any enhancements needed and the second to the planning and funding of the identified enhancements.

Some **Phase 1 INIR missions** identified that an assessment of grid reliability and particularly, its ability to withstand the unplanned and sudden loss of output of a large NPP had not been completed.

Some **Phase 2 INIR missions** identified that the more detailed studies on grid impact and identification of upgrades required still needed to be completed. Once identified the funding needed to be agreed and a plan for the implementation of the improvements prepared, consistent with the NPP construction programme. Some phase 2 INIR missions also identified the importance of ensuring the needs of the grid and the needs of the NPP are understood by both the owner/operator and the grid company.

4.2.10. Human Resource Development

In Phase 1 there are two conditions. The first relates to identifying the gap between the current capabilities in the country and those required for the nuclear power programme. It covers education and training programmes and facilities. There is also a need to consider the adequacy of leadership development in the country. The second relates to the need for a strategy to address the gaps identified and to develop plans for more detailed workforce planning.

In Phase 2 there are three conditions. The first relates to development of detailed organization and staffing plans for each organization in Phase 3 and beyond and the second to plans for

development of the resources required. The third relates to co-ordination of the approach and maintaining a national HR strategy to support the organizational plans.

Most countries had undertaken significant work in this area but **Phase 1 INIR missions** identified the need to finalize the studies to identify:

- the HR needed in the different phases of the programme for each key organization;
- the current gaps in national education and training capability;
- an HRD strategy that defines the required enhancements to educational capabilities and vocational trainings.

In particular Phase 1 INIR missions noted the need to take account of:

- the planned timescales for the programme, and the time required for recruitment and training of personnel;
- a realistic review of the availability and competence of people working in other national organizations.

All **Phase 2 INIR missions** identified the need for further work on human resource development in each of the key organizations. Specific issues noted included:

- to continue to review the national strategy and the staffing requirements of each organization to ensure consistency with the current programme size, strategy and timescale;
- to maintain and implement the national strategy with clearly allocated roles and responsibilities including addressing shortfalls in education at secondary, graduate and technician level;
- to accelerate recruitment and training activities in the regulatory body to ensure readiness for licensing activities;
- to develop detailed staffing structures, recruitment and training plans for the owner/operator, in order to be ready for construction supervision and to agree detailed training requirements with the vendor.

4.2.11. Stakeholder Involvement

For Phase 1 the condition is to develop and implement a stakeholder involvement strategy and plan.

For Phase 2 there are two conditions. The first requires each of the key organizations to develop, implement and review stakeholder involvement plans and the second requires NEPIO to co-ordinate the approaches of the organizations.

Several **Phase 1 INIR missions** identified the need for further work on the development and implementation of a stakeholder engagement strategy. Specific areas noted included:

- The need to implement appropriate communication activities even when the decision is under consideration or politically sensitive;
- The need for early surveys and consultation to identify key issues;
- The need for training of spokespersons and senior managers.

All **Phase 2 INIR missions** identified the need for further work in this area. Topics included:

- The need to maintain a co-ordinated national strategy and to ensure each organization is implementing its plan;

- The need to ensure adequate financial and human resource with appropriate competence;
- The need for the regulatory body and the owner/operator organization to develop their own communications strategy and plan, consistent with the national strategy;
- The need to implement plans for public information centres;
- The need to ensure appropriate communications with neighbouring countries.

4.2.12. Site and Supporting Facilities

In Phase 1 the condition is to complete the site survey identify candidate sites.

In Phase 2 there are two conditions. The first relates to completion of the site characterization studies and the second to the planning of the physical infrastructure needed on and around the site (e.g workforce housing, services, transport).

Phase 1 INIR missions observed that most of the countries completed their site survey studies to identify the candidate sites. Phase 1 INIR missions also noted areas for further work such as improved stakeholder engagement, site visits and preparations for the next stage of final site selection.

Phase 2 INIR missions observed that several countries had conducted site characterization studies but the evaluation by the regulatory body was not completed. Most of the countries used consultancy services from foreign technical support organizations in addition to their domestic capabilities in order to conduct the site characterization studies. In this area, Phase 2 INIR missions identified several specific issues including:

- The need for the regulatory body to issue guides in the area of site evaluation to ensure that a firm basis exists for site selection and evaluation. The guides should address safety and security requirements;
- The need to initiate activities for the confirmation of the site selection and site evaluation early in Phase 2, as studies and approvals are likely to take time and will require the involvement of various Ministries and stakeholders;
- The need for competent staff and an appropriate system for effective management and oversight of the site evaluation activities;
- The need to consider timing of activities for the identification of sites for radioactive waste management facilities.

Phase 2 INIR missions also noted that in several countries there is a need to allocate responsibilities for works related to the development of the site infrastructure among the different organizations – e.g. vendor, owner/operator, local government, national government and companies, and ensure adequate funding for those works.

4.2.13. Environmental Protection

In Phase 1, there are two conditions. Condition 1 is to demonstrate that the main environmental requirements related to the siting of an NPP have been considered, while condition 2 relates to the revision of the framework for environmental protection.

In Phase 2 there are three conditions, Condition 1 is to demonstrate that the Environmental Impact Assessment has been performed. Condition 2 relates to the provision of the environmental characteristics, and Condition 3 is to demonstrate that environmental regulations exists and there is a clear understanding with the nuclear regulator.

Phase 1 INIR missions identified in several countries the need to review the environmental protection framework to assure that the required issues for the nuclear power programme are incorporated.

Phase 2 INIR missions observed that EIA's were in different stages of completion in different countries, few have finalized EIA process, but others have not even started. Phase 2 INIR missions identified in several countries that they need to develop regulations or guides to define the content of the environmental impact assessment report for an NPP in order to help to improve the process.

Phase 2 INIR missions also noted that, in several countries, there was a need to develop a Memorandum of Understanding (MoU) between the Environmental Regulator and the Nuclear Regulatory Body to define the respective roles and responsibilities of both organizations for the EIA process.

Phase 2 INIR missions identified, in several countries, the need for the completion of the EIA process and incorporation of the EIA results in the bid invitation specifications or in contractual arrangements.

4.2.14. Emergency Planning

In Phase 1, there are two conditions, the first one is related to the recognition of the requirements of developing an emergency response capability and the second one is related to addressing recommendations from previous reviews or audits.

In Phase 2, there is one condition related to defining responsibilities of each organization and developing approach for emergency planning.

In several countries, **Phase 1 INIR missions** observed the need to assess the enhancements needed to their existing EPR arrangements, additional infrastructure and resources to meet the requirements for the nuclear power programme.

Phase 1 INIR missions noted that some countries have developed a draft national emergency plan for nuclear and radiological emergencies, but these plans will need to further address the requirements for nuclear power programme. Phase 1 INIR missions identified in few countries the need to ensure consistency with the other national emergency plans and with the legislation regarding emergency planning responsibilities.

Some **Phase 2 INIR missions** identified the need to assess and improve arrangements and networks for emergency communication, including with neighbouring countries.

Some Phase 2 INIR missions also identified the need to ensure that the roles of all relevant organizations are clearly defined with regard to nuclear or radiological emergencies.

4.2.15. Nuclear Security

In Phase 1, there are two conditions. Condition 1 is to demonstrate Nuclear security requirements are recognized and the actions of all relevant organizations coordinated, while condition 2 is to assess that recommendations from any previous reviews or audits have being addressed.

In Phase 2 there are four conditions, Condition 1 is to demonstrate that the required physical protection measures have been developed. The other three conditions are to demonstrate that programmes are in place for the management of sensitive information (2), for the trustworthiness of personnel (3), and for the promotion of a nuclear security culture (4).

Phase 1 INIR missions identified in some countries the need for designation of a competent authority to develop the Design Basis Threat (DBT) for the nuclear power plant with the help of national intelligence and law enforcement authorities.

Phase 2 INIR missions identified that many countries had not completed the national threat assessment and the development of the DBT for the nuclear power plant. It was also observed that the physical protection requirements, taking into account the DBT, to be specified in the bid specifications or in the contract had not been clearly defined.

Phase 2 INIR missions also identified the following specific issues regarding nuclear security:

- the need for arrangements in each organization for the classification and management of sensitive information;
- the need for arrangements in each organization for the trustworthiness of personnel in order to address NPP staff trustworthiness checks;
- the need for an enhancement in the area of development and implementation of security culture programme.

4.2.16. Nuclear Fuel Cycle

In Phase 1 there is one condition related to the consideration of all the options for the nuclear fuel cycle (front end and back end).

In Phase 2 there are two conditions to demonstrate that the strategies for the Front end and the Back end of the fuel cycle strategy are defined.

Phase 1 INIR missions identified the need for most countries to expand their studies of fuel cycle options. Issues noted for further consideration included:

- a better understanding of the medium and long term spent fuel storage requirements;
- analysis of a wide range of options to identify which would be feasible in the country;
- the feasibility of repatriation of spent fuel to the vendor country.

Phase 2 INIR missions identified the need for most countries to finalize the development of a national policy and strategy on the nuclear fuel cycle, for the front-end and back-end, including Spent Fuel/High Level Waste management.

4.2.17. Radioactive Waste Management

In Phase 1 there are two conditions. Condition 1 is related to the consideration of the requirements for the management of radioactive waste from NPPs. Condition 2 is related to the understanding of the options for management of all radioactive waste categories.

In Phase 2 there are two conditions. Condition 1 is related to the consideration of handling the burdens of radioactive waste. Condition 2 is to demonstrate that a preliminary decommissioning plan has been requested.

Phase 1 INIR missions identified the need for several countries to develop a greater understanding of the amounts and types of radioactive waste that will be produced by the nuclear power programme and the options and technologies available for their management (characterisation, processing, handling, storing and disposal).

Phase 2 INIR missions identified that most countries had developed a draft strategy for radioactive waste management, but some countries needed to complete and finalize the document.

In some other countries much of the strategy still needed to be developed. Issues needing consideration included the role of a national radioactive waste management organization and the plans for national radioactive waste management facilities.

Phase 2 INIR missions noted that all countries understood the need to request an initial decommissioning plan from the vendor, but some countries needed to define their high level strategy and national requirements for decommissioning or consider specifying preferred options for decommissioning to the vendor.

4.2.18. Industrial Involvement

In Phase 1 the condition is to develop a policy for national involvement in the nuclear power programme.

In Phase 2 the condition is to have identified areas where national suppliers can be developed and to identify expectations of national involvement in the contracts.

Most **Phase 1 INIR missions** identified the need to complete the survey of national industrial capability and develop an industrial policy.

Most **Phase 2 INIR missions** also identified the need for further work to complete the assessment of the capabilities of the local industry. They also identified that countries need to develop specific and realistic expectations in the area of industrial involvement (based on national policy and a good understanding of industry capabilities) and ensure they are discussed and negotiated with the vendor. There is a need to ensure that the potential suppliers are aware of the quality standards and industrial codes used by potential vendors.

4.2.19. Procurement

In Phase 1 the condition is to be aware of the requirements associated with purchasing services to support the development of the programme.

In Phase 2 the condition is to have established the capability of each organization to contract for the required services.

There were no issues identified in **Phase 1 INIR missions** except that in one country there was a need to clarify the responsibilities and associated plans regarding the establishment of necessary capabilities to manage phase 2 procurement activities.

Phase 2 INIR missions identified in some countries the need to enable public organizations involved in the programme to manage the procurement of goods and services in a timely manner, recognizing that nuclear power programs require contracting in an international market and sometimes from sole source suppliers. This may require modifications in the national legislation and regulations governing the procurement.

4.3. RESULTS FROM FOLLOW-UP MISSIONS

Five follow-up missions were conducted since the beginning of the INIR service. The experience with the follow-ups showed that some countries have developed and implemented the action plan to address the recommendations and suggestions and completed the actions to meet the relevant conditions of the evaluation methodology. However, in some countries although they developed the action plan, the implementation of the action plan was not adequately covering all the recommendations and suggestions of the main INIR missions. Most of the cases, the reason was the slow progress in the implementation of the nuclear power programme due to the delay of certain decisions at political level.

4.4. GOOD PRACTICES OBSERVED DURING INIR MISSIONS

One of the functions of the INIR missions are to identify good practices which recognizes an outstanding practice or arrangement, superior to those generally observed elsewhere. Good practices are more than fulfilment of the conditions or expectation and worthy of attention of other countries involved in the development of nuclear infrastructure as a model in the drive for excellence.

INIR missions conducted so far identified a number of good practices in different Member States and in different infrastructure issues. **Phase 1 INIR missions** observed good practices in conducting preliminary feasibility studies to support making the decision to initiate a nuclear power programme, in conducting variety of activities related to informing public about the nuclear power programme mostly by the government, and in consultation and collaboration with the other relevant institutions in the country when conducting site survey and site selection activities.

Phase 2 INIR missions identified good practices in early identification of the HRD and training needs and collaboration with national and international institutions to support HRD activities, in public information with additional efforts by regulatory body and future owner/operator, and in coordination and collaboration among the relevant national organizations in the area of nuclear security.

4.5. DATABASE OF RECOMMENDATIONS, SUGGESTIONS AND GOOD PRACTICES

A database has been developed providing the recommendations, suggestions and good practices from the INIR missions conducted. The database is maintained by adding new data after conducting a new INIR mission on a regular basis. The database is available at IAEA Web site in the format presented in Figure 3. The link can be found in IAEA Infrastructure Bibliography [6].

FINDINGS FROM INIR MISSIONS CONDUCTED FROM 2009

No	Phase	Issue	Finding Type	INIR Finding
1	1	1	Recommendation	The Government should implement the proposed expansion of the current NEPIO in order to enhance nuclear power programme coordination.
2	1	1	Good Practice	The Government prepared a comprehensive prefeasibility study report, with strong national involvement, which considered all 19 infrastructure issues and provided clear recommendations for further action. This will assist the country in making a knowledgeable decision about the introduction of nuclear power.
3	1	1	Suggestion	The Government may consider having the IAEA's assistance in reviewing the draft comprehensive nuclear law.
4	1	1	Recommendation	The Government should clarify the planning and decisions needed for a nuclear power program and identify future Owner/Operator.
5	1	1	Recommendation	The Government should complete the revision of the draft energy plan.
6	1	1	Recommendation	NEPIO should update the comprehensive report to take into account the results of studies that need further development.
7	1	1	Good Practice	Strong support for the work of the NEPIO from the highest level of government and a strong connection between the two committees that form the NEPIO, facilitated by the chair of the Technical Committee providing the secretariat for the Ministerial Committee.
8	1	1	Recommendation	The Government should complete its planned update of the draft Nuclear Power Programme to reflect the latest considerations and proposed national policies, as well as Government's commitment to nuclear safety, security and non-proliferation prior to its submission to the Council of Ministers for approval.
9	1	1	Suggestion	The Government is encouraged to finalize the consultations on the proposed executive order to achieve consensus on the way forward.
10	1	1	Suggestion	The Government should take steps to strengthen coordination, especially between the NEPIO, RB and the future Owner/Operator, with due respect to the RB independence.

FIG. 3. Format of the presentation of INIR findings on www.iaea.org.

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LIST OF ABBREVIATIONS

DBT	Design Basis Threat
EPC	Engineering, Procurement and Construction
HRD	Human Resource Development
INIR	International Nuclear Infrastructure Review
IWP	Integrated Work Plan
NEPIO	Nuclear Energy Programme Implementing Organization
NPP	Nuclear Power Plant
SER	Self-Evaluation Report
SMR	Small Modular Reactors

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