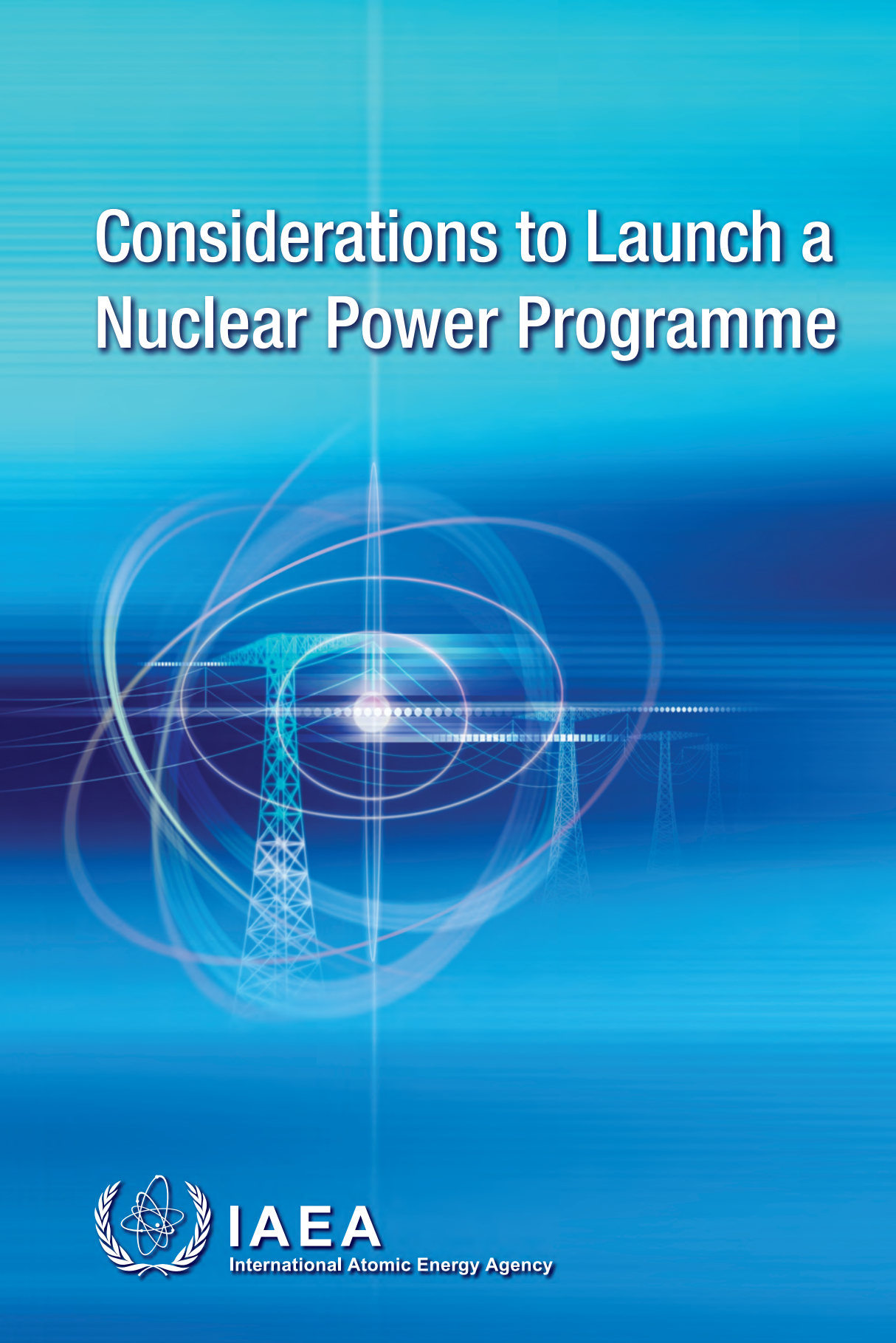
Considerations to Launch a Nuclear Power Programme



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CONSIDERATIONS TO LAUNCH A NUCLEAR POWER PROGRAMME

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

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CONTENTS

A. BACKGROUND

1. Two of the major concerns facing humanity are the pressing need for development in many parts of the world and the importance of ensuring an effective system of international security. These two concerns — development and security — are interlinked.

2. Energy is essential for development. Nearly every aspect of development — from reducing poverty and raising living standards to improving health care, and industrial and agricultural productivity — requires reliable access to modern energy sources. In this context, it is important to consider the global energy imbalance: today, 1.6 billion people are without access to electricity, and 2.4 billion rely on traditional biomass for cooking and heating because they have no access to modern fuels. Current forecasts suggest the world will see an increase in global energy consumption of over 50% by 2030, with 70% of this growth in demand expected to come from developing countries. Nuclear energy can play a role in providing increased access to affordable energy in many parts of the world.

3. States may have different reasons for considering nuclear power to achieve their national energy needs, such as: a lack of available indigenous energy resources, the desire to reduce dependence upon imported energy, the need to increase the diversity of energy resources and/or the mitigation of carbon emission increases.

4. By its nature a nuclear power programme involves issues associated with nuclear material, ionizing radiation and the related challenges. This is a major undertaking requiring careful planning, preparation and investment in a sustainable infrastructure that provides legal, regulatory, technological, human and industrial support to ensure that the nuclear material is used exclusively for peaceful purposes and in a safe and secure manner.

B. TOWARDS THE IMPLEMENTATION OF A NUCLEAR POWER PROGRAMME

5. The start of a nuclear power programme involves several complex and interrelated activities with long duration. Experience shows that the time between an initial policy decision by a State to consider nuclear power up to the start of operation of its first nuclear power plant (NPP) will be at least 10–15 years. This period consists of three major phases:

1. Considerations before a decision to launch a nuclear power programme is taken;

2. Preparatory work for the construction of an NPP after a policy decision has been taken; and

3. Activities to implement a first NPP.

6. At the end of each phase there are specific factors that would influence decisions to proceed to the next phase.

B.1. CONSIDERATIONS BEFORE A DECISION TO LAUNCH A NUCLEAR POWER PROGRAMME IS TAKEN

7. If a State is considering the introduction of nuclear power, then it is essential that it develops a comprehensive strategy to assess energy needs, and understand the potential role, appropriateness, viability and commitments associated with nuclear energy in the context of plans for national and socio-economic development. An essential task is to assess the implications of installing an NPP in the national grid network, recognizing that normally no single nuclear unit should account for more than 10% of the installed capacity of the entire network. In addition, possibilities for regional and international cooperation should also be assessed.

8. The key activities of this first phase include recognition of the obligations and commitments associated with a nuclear power programme, both at the national and international level. This includes the need to:

- Develop a comprehensive nuclear legal framework covering all aspects of the peaceful uses of nuclear energy, i.e. safety, security, safeguards, and liability, in addition to the commercial aspects related to the use of nuclear material;

- Establish and maintain an effective regulatory system;

- Develop the human resources for the State organizations and also for the operating organizations required to effectively supervise and implement the nuclear programme;

- Ensure adequate financial resources for the construction, sustained safe operation and decommissioning of the NPP, as well as radioactive waste management;

- Develop a programme for all aspects of operation, decommissioning and radioactive waste management;

- Manage nuclear materials for the long term;

- Communicate in an open and transparent manner with the public and the neighbouring States about the considerations behind the introduction of nuclear power.

B.2. PREPARATORY WORK FOR THE CONSTRUCTION OF AN NPP AFTER A POLICY DECISION HAS BEEN TAKEN

9. Following a policy decision, the substantive work begins for ensuring that the necessary level of technical and institutional competence is achieved by the State and commercial (e.g. utility and operating) organizations. This phase requires a significant and continuing commitment from both the State and the commercial organizations.

10. During this phase it is expected that the State would:

- Enact all the elements of the comprehensive legal framework mentioned above;

- Establish and ensure the competence of the regulatory body to develop a licensing system and to monitor and supervise compliance with safety standards and security guidelines consistent with IAEA standards;

- Decide upon the financial and operational modalities for the ownership and implementation of an NPP (government, private sector and/or foreign ownership);

- Establish the long term financial arrangements for decommissioning and radioactive waste management as well as the associated liabilities;

- Ensure involvement and support for a nuclear programme of all relevant stakeholders;

- Define the degree of national technical and industrial participation in the development of the future programme;

- Assess where national technical capability needs to be enhanced and develop a policy for national participation; and

- Identify requirements and make arrangements for emergency preparedness, security measures and environmental protection.

11. In addition, it is expected that the State or the owner/operator would:

- Perform a feasibility study in order to confirm the viability of the nuclear power programme;

- Identify and justify a site for the NPP;

- Establish a long term policy for fuel procurement and spent fuel and nuclear waste management;

- Identify how the human resources for the NPP would be developed and trained; and

- Establish an organization with the potential to act as a competent purchaser with the ability to assess design options, establish user requirements, and prepare and evaluate bid documents.

12. Such preparatory work would help to provide confidence nationally and internationally (including to suppliers of nuclear technology) that the State concerned is ready to proceed with the implementation of the NPP project.

B.3. ACTIVITIES TO IMPLEMENT A FIRST NPP

13. To complete and prepare for the operation of a specific NPP, the main focus is to ensure that the project is implemented by the owner/operator in

accordance with the agreed engineering and quality requirements, safety standards and security guides. The owner/operator must achieve the competence necessary to operate, maintain and establish full responsibility for the NPP. This is the phase where the required commitment of financial and human resources is greatest, and where the owner/operator needs to demonstrate the acceptance of the responsibility for the long term management of all of the issues associated with the NPP.

14. During this phase the continued supervision by the regulatory body will provide a framework within which the owner/operator can demonstrate, in an open and transparent manner, that they possess the necessary safety culture to comply with the established safety standards and security guidelines.

15. It is also important to realize that engaging in an NPP project requires continuing international commitments and partnerships with other States. This would include gaining and maintaining the confidence and trust of neighbouring States in the peaceful, safe and secure operation of the NPP project.

C. FACTORS FOR CONSIDERATION

C.1. TIMESCALES

16. A decision to implement a nuclear power programme requires long term commitments throughout the period of planning, operation, decommissioning and waste management. For a State with little developed technical base the implementation of the first NPP would, on average, take about 15 years. For a State with a strong technical base this could be reduced to 10 years if the State initiates a significant and concerted effort to achieve implementation in a rapid manner. Even for States with existing nuclear power programmes it may take about 10 years to approve and construct a new NPP.

C.2. HUMAN RESOURCES AND TRAINING

17. Typically, the operating organization responsible for an NPP has a staff of 200–1000 persons, who collectively have a variety of scientific, engineering and other technical backgrounds in fields needed to effectively and safely operate and maintain the plant. These include: nuclear engineering, instrumentation and control, electrical engineering, mechanical engineering, radiation protection, chemistry, emergency preparedness, and safety analysis and assessment. There is a need to have access to national or international expertise to support the NPP operating organization and regulatory body in scientific areas such as neutronics, physics and thermohydraudraulics and technical areas such as radiation protection, radioactive waste management, quality management, maintenance and spare parts management.

18. In addition to the required scientific, engineering and other technical education, normally the relevant staff need three or more years of specialized training and experience prior to the initial fuel loading of an NPP. For implementation of a first NPP project, much of this specialized training and experience can be included as part of the contract with the supplier of the NPP technology. It is necessary for the operating organization to establish the rigor, culture, ethics and discipline needed to effectively manage nuclear power technology with due regard to the associated safety, security and non-proliferation considerations.

19. Assistance to the nuclear safety regulator in developing the human resources capable of regulating and overseeing the safety of the plant and achieving an effective, competent and independent nuclear safety regulatory organization may be provided by the regulatory body in the country of origin of

the supplier or other regulatory bodies, and complemented by the IAEA and other international organizations.

20. For a first NPP project, many of these nuclear-specific needs are initially satisfied by external suppliers. However, it could be preferable to establish a plan to gradually develop local suppliers and expertise, for example through a technology transfer agreement as part of the contract with the NPP supplier.

21. The development of a national academic programme for the education of the necessary scientists, engineers and other technicians to support technical research would also be expected to be in place as part of the commitment to the development of the required national capabilities.

C.3. REGULATORY ASPECTS

22. The establishment of an effective, competent and independent regulatory body should take into consideration the country's existing situation with respect to regulatory control. For example, most States already have arrangements for exercising the regulatory oversight of nuclear facilities and activities; in this case, the need for additional staff and their specific competencies should be determined. In States where the regulatory body consists of more than one authority (e.g. radiation protection, nuclear safety, environmental protection, conventional health and safety), effective arrangements should be made to ensure that regulatory functions and responsibilities related to the nuclear power programme are properly identified, discharged and coordinated. The authorization process and the basis for granting an authorization for siting, design, commissioning, operation and for discharges to the environment should be defined. The regulatory body needs to develop the capabilities to plan and implement the review and safety assessment activities of the proposed facility throughout its life.

23. While it is difficult to prescribe an organizational model and number of staff for a regulatory body, analysis of existing structures indicates that 30–50 staff members would be necessary for starting the implementation of a nuclear power plant programme. As a minimum, the structure and size of the regulatory body should be sufficient for independently performing the main regulatory functions, such as authorization, review and assessment, inspection and enforcement, and development of national regulations and guides. In addition, it is necessary to provide resources and competencies to implement some shared functions (e.g. emergency preparedness and response, national and international cooperation, dissemination of technical and scientific

information, environmental assessment, and communication with the public and other stakeholders). In some States the regulatory body's capabilities can be augmented with assistance and advice from other organizations (e.g. independent consultants, support organizations, research and educational institutions, other States or international organizations).

C.4. AVAILABLE TECHNOLOGY

24. Most of the reactors available for purchase and construction are water cooled reactors, for which significant operational experience exists worldwide. These are mainly pressurized light water reactors (PWRs), boiling water reactors (BWRs), and heavy water reactors (HWRs). They are generally available in sizes of about 1000 MW or greater electrical output. Slightly smaller reactors of 600–700 MW output are also available using water reactor technology.

25. If a smaller unit is required due to the capacity of the national grid network, then the available technology is limited, although reactors of 200–400 MW output are being operated and developed in some countries. Several designs are being developed for future applications although a major challenge is to achieve an economic design at a smaller size. High temperature gas cooled reactors (160–270 MW) and several small water cooled reactors are being developed which may reach design approval over the next ten years. In addition a barge mounted moveable 70 MW output plant is currently under construction.

C.5. COSTS

26. The construction cost of new plants can vary widely. A value of $1.5–2 million per MW of electrical capacity is indicative of current costs for an NPP (i.e. $1.5–2 billion for a 1 GW output NPP) and even higher in some countries. Efforts are being made to reduce these capital costs and some forecasts of values between $1–1.5 million per MW have been made for future designs. It should also be noted that plants with larger electrical output are generally considered to have lower capital cost per unit of output.

27. To prepare for a nuclear power programme some initial investment is required. This investment is initially quite small, during the first phase of developing an understanding of the needs for a nuclear power programme, but will increase as the need for providing technical and regulatory supervision, and the associated training of staff, arises. The total cost of providing the

necessary infrastructure would not be a large fraction of the cost of the first NPP, but would need to be invested before any return from the power produced by the NPP is obtained. Experience shows that the investment in human resources and infrastructure necessary for a nuclear power programme can also have benefits for society in many unrelated fields.

C.6. FUNDING AND ECONOMICS

28. The capital investment in an NPP may be provided by the government, private utilities or a public and private partnership. The initial high capital cost is normally offset by low operating and fuel costs, so that over a long period the cost of generated electricity from an NPP is expected to be competitive with other sources at current fuel prices. The sensitivity of the electricity generation cost to the price of fuel is much lower for nuclear plants than for fossil fuelled power plants.

29. The costs of developing a national infrastructure are difficult to define. The major costs would normally involve the human resources required, which would include the necessary training and development of a competent group of staff to implement a nuclear power programme including the associated legislation and regulation. In the first phase the costs may not be large, but the costs would increase as the project moves towards concrete implementation. In addition, similar to any power plant investment, the costs of the development and establishment of other facilities such as a grid network would need to be included.

30. The risk associated with an NPP investment can be reduced if the uncertainties associated with the construction and licensing are reduced. In this regard, demonstration by the State concerned that it has fully complied with all international standards might help foster an environment in which financial costs are reduced.

31. In order to finance the long term liabilities of decommissioning, fuel storage and waste management it is expected that financial arrangements for collecting funds during operation to cover such liabilities will be established.

C.7. FUEL SUPPLY SECURITY

32. For many States energy supply sources are mainly imported and this may be considered a source of risk to national fuel supply security.

33. Gas supplies are dependent upon immediate supply conditions and it is difficult to stockpile supplies for a long period. Coal requires large volumes for any prolonged period. In contrast, nuclear fuel for a reactor can be stored to ensure that the supply for up to 10 years will remain available. The electricity supply from an NPP is then not subject to external events for this period. Although most current NPPs do not store fuel for long periods, recognizing that the market supply of fuel provides the necessary confidence in supply security, the option is there to do so. International initiatives to develop acceptable schemes to achieve increased confidence in security of fuel supply are being considered.

C.8. TECHNOLOGY SUPPORT AND ORGANIZATION

34. For most commercially available designs of NPPs there are internationally experienced sources of technical support that could assist either the regulator or the operator. These services are provided worldwide from many countries, either from State owned organizations or private suppliers and consultancies. However, it is expected that in the long term States and operating organizations would wish to develop their own technical capabilities, and to gradually reduce dependence upon foreign support. This can be achieved over a period, with contractual arrangements for the transfer of technology, service and support contracts, and training programmes supported by the suppliers.

C.9. LEGISLATION

35. As indicated above, a wide range of legislation is expected to be in place in a State that has decided to implement a nuclear power programme; the key elements of such legislation being nuclear safety, security, safeguards and liability for nuclear damage. An outline of the legal requirements needed for embarking on a nuclear power programme is contained in the *Handbook on Nuclear Law* from the IAEA. The underlying environmental protection and commercial and industrial framework also need to be considered when developing the corresponding legislation.

C.10. DECOMMISSIONING

36. Preparation for decommissioning of the NPP addressing the technological, regulatory and financing aspects should be included in the preparatory phases of the introduction of nuclear power. An appropriate plan

for the management of the decommissioning would be expected to be prepared.

C.11. USED FUEL AND WASTE MANAGEMENT

37. After use in a reactor, fuel assemblies need to be managed safely and securely. An initial period of storage at, or close to, the NPP is appropriate. After this period many options are available. For example, the fuel can be stored for a long period and currently there are around 90 spent fuel storage facilities operating successfully worldwide. Following this the fuel can be placed in a long term repository, or it can be reprocessed to reduce the amount of radioactive waste and to obtain the reusable nuclear material remaining in the used fuel with the residual high level waste stored in a repository. Although some sites have been identified and work is underway, no repository is yet in operation. An appropriate plan for the management of the used fuel and waste would be expected to be prepared.

38. Low and intermediate level waste would be expected to be handled in accordance with the procedures that have been established for the management of existing radioactive materials, such as radioactive sources and radioactive waste generated by medical use of radioactive substances.

C.12. PUBLIC INFORMATION

39. For the successful introduction of a nuclear power programme it is important that the public is fully informed about the underlying rationale behind the introduction of nuclear power, the planned siting of the NPP, and the arrangements being made to ensure compliance with national and international standards and conventions. Before final decisions are made it is suggested that programmes of public consultation are developed, involving local communities, leaders, politicians, non-governmental organizations and other civil society stakeholders.

D. IAEA ASSISTANCE

40. Under its Statute, the IAEA is authorized to assist any Member State that is considering or has decided to introduce nuclear power to meet energy needs and it has considerable experience in doing this through its assistance programmes. For example, support can be provided for implementing the operational phase of an NPP to the extent that the State has demonstrated that it has established the essential elements of a national framework. Advice and guidance on obligations and commitments can be provided during all phases of a programme. The IAEA has recently prepared a number of guidance documents on infrastructure and other considerations for countries planning to launch a nuclear power programme and stands ready to provide expert assistance in this area if requested.

41. While the IAEA can assist, within available resources, with training on all aspects relating to the introduction of nuclear power, the State's own commitment to develop the necessary human resources, skills and core competencies and understanding of the requirements associated with nuclear power programmes is essential. It is also desirable that a State and owner/operator obtain advice from around the world from regulators, operators, users of common technology, and commercial suppliers.

42. With the exception of issues relating to commercial decisions, the IAEA can also assist by providing technical support for the owner/operator for the assessment of potential technology, the managerial approaches that can be used in the implementation of a project, and issues related to ensuring the safe and economic operation of an NPP.

43. The IAEA also works to strengthen the capacity of Member States to manage their development of the energy sector, with the goal of promoting sustainable use of natural resources and increasing access to affordable energy services. A key aspect of this effort is our energy assessment services. Through these services, the Agency trains local experts to develop and use energy planning models tailored to each country's special circumstances.

44. Assistance is also provided in developing comprehensive national legal frameworks under the IAEA's legislative assistance programme.

45. Specific IAEA support can also be sought in assisting the development of regulatory bodies to ensure that they are effective and fully competent to

oversee the licensing of the facility and by providing peer review services concerning all aspects of the nuclear power programme.

E. REFERENCES

46. IAEA publications to assist in the development of the necessary framework for a nuclear power programme include:

- Safety Fundamentals, Requirements and Guides in the IAEA Safety Standards series,;
- Guidance and Recommendations in the IAEA Nuclear Security series;
- *Basic Infrastructure for a Nuclear Power Project*, IAEA-TECDOC-1513, IAEA, Vienna (2006);
- *Potential for Sharing Nuclear Power Infrastructure between Countries*, IAEA-TECDOC-1522, IAEA, Vienna (2006);
- *Handbook on Nuclear Law* (STOIBER, C., BAER, A., PELZER, N., TONHAUSER, W., Eds), IAEA, Vienna (2003).

47. International instruments for Member States to consider adopting prior to beginning a new nuclear power project:

- Comprehensive Safeguards Agreement pursuant to INFCIRC/153 (Corr.);
- Additional Protocol pursuant to INFCIRC/540 (Corr.);
- Convention on Early Notification of a Nuclear Accident (INFCIRC/335);
- Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency (INFCIRC/336);
- Convention on Nuclear Safety (INFCIRC/449);
- Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management (INFCIRC/546);
- Convention on Physical Protection of Nuclear Material (INFCIRC/274), and Amendment;

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

- Joint Protocol Relating to the Application of the Vienna Convention and the Paris Convention (INFCIRC/402);

- Protocol to Amend the 1963 Vienna Convention on Civil Liability for Nuclear Damage and Convention on Supplementary Compensation for Nuclear Damage;

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

MEMBERS OF THE IAEA NUCLEAR POWER SUPPORT GROUP

This document is part of continuing support to Member States considering the introduction of nuclear power, which is coordinated within the IAEA by the Nuclear Power Support Group.

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