VCDNP

EXPANDING ACCESS TO PEACEFUL USES OF NUCLEAR POWER

Case study
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Cover image:
Two Pressurized Water Reactors (PWRs) under construction at the Kudankulam nuclear power plant, India
(Photo: Petr Pavlicek / IAEA)

Summary[1]

Access to affordable, reliable, and sustainable energy is critical for the wellbeing of countries and their citizens. Yet, more than two billion people still use wood and other traditional biomass to cook their meals. The September 2021 United Nations (UN) High-Level Dialogue on Energy encouraged governments and the international community to take renewed action to "achieve a sustainable energy future that leaves no one behind"[2]. The World Bank in its 2022 report on tracking UN Sustainable Development Goals (SDG) 7 estimated that 670 million people will continue to lack access to electricity in 2030, most of them in Sub-Saharan Africa.

Nuclear power is a low-carbon energy source and an indispensable tool for achieving the UN Sustainable Development Goals (SDGs).[3] Countries interested in introducing nuclear power to their energy mix face many challenges. The objectives of this case study are to:

- demonstrate how the International Atomic Energy Agency (IAEA) supports countries embarking on nuclear power;
- describe how Ghana, a lower-middle income country, was able to successfully complete the foundational steps towards embarking on nuclear power, through methodical implementation of the first phase of the IAEA's Milestones Approach; and
- draw lessons learned from the path followed and the activities implemented by Ghana that can benefit other countries interested in or already embarking on new nuclear power programmes.

1 This case study was developed with the support of the International Science and Technology Center (ISTC) in Kazakhstan.

2 IEA, IRENA, UNSD, World Bank, WHO. 2022. Tracking SDG7: The Energy Progress Report. World Bank, Washington DC. © World Bank. License: Creative Commons Attribution—Non-Commercial 3.0 IGO (CC BY-NC 3.0 IGO).

3 UN Economic Commission for Europe (UNECE), Use of Nuclear Fuel Resources for Sustainable Development – Entry Pathways, Geneva, 2021.

Introduction

Energy lies at the heart of the UN Sustainable Development Goals and the Paris Agreement on Climate Change. Ensuring access to affordable, reliable, sustainable and modern energy for all will open a new world of opportunities for billions of people through economic growth, job opportunities, empowered women, children and youth, better education and health, more sustainable, equitable and inclusive communities, and greater protection from, and resilience to, climate change.[4]

The increasing need for a clean, affordable energy source necessitates technology options for low carbon electricity generation, particularly for baseload power plants. This requirement is met by nuclear power. The International Atomic Energy Agency (IAEA) in its vision for peaceful uses, notes that nuclear energy has the potential to be a reliable, sustainable and environmentally friendly energy source that can contribute to the accessibility of affordable energy services in all interested countries for present and future generations. Any use of nuclear energy should be beneficial, responsible and sustainable, with due regard to the protection of people and the environment, non-proliferation, and security[5]. Nuclear power requires careful planning, with investment in time and resources, and numerous investigative studies, due to the nuclear safety, security and safeguards requirements associated with the possession and handling of nuclear material and the long-term commitment required for nuclear power.

Prior to entering into negotiations with a supplier of nuclear power technology, a country wanting to include nuclear power as part of its energy mix will need to consider, inter alia, the development and adoption of a range of relevant policies, the implementation of appropriate legal, regulatory and institutional frameworks, and the development of the required human resources. A wide range of studies and evaluations will be required to develop new physical infrastructure or enhance existing infrastructure (for example, the national electrical grid, radioactive waste management facilities, environmental monitoring systems). All these activities are typically referred to as "development of the infrastructure needed for a nuclear power programme". For a country that does not already have nuclear power, it may take 10 to 15 years to develop the necessary nuclear infrastructure and construct its first nuclear power plant (NPP).

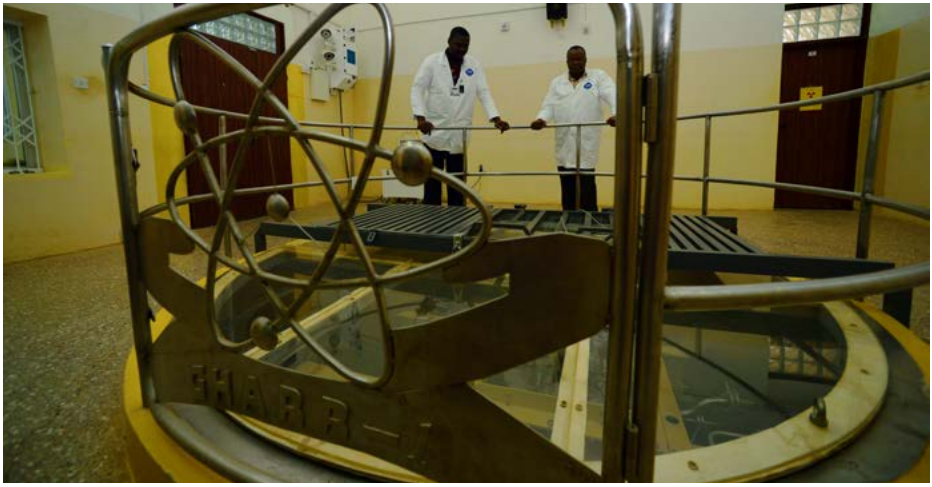
It is often the case that a country considering nuclear power already has some infrastructure and experience with radiation safety, nuclear security, emergency preparedness and safeguards as a result of other nuclear activities related, for example,

4 UN Sustainable Development Goals: Energy sdgs.un.org/topics/energy

5 Nuclear Energy Basic Principles, IAEA Nuclear Energy Series No. NE-BP, IAEA, Vienna (2008)

to health, agriculture and scientific research. Building on existing knowledge and capabilities, human resource development facilities and programmes, and the legal and regulatory framework can greatly assist a country in establishing the infrastructure necessary for nuclear power.

Ghana is one of these countries, with a research reactor operated by the National Nuclear Research Institute in Accra and trained local staff to run and oversee it. However, Ghana is a lower-middle income country[6], which means that it is less resourced than an upper-middle income country and has more challenges related to providing its citizens with essential services such as water and electricity. Given the political commitment and the significant financial and human resource investment required by a country embarking on nuclear power, Ghana's successful completion of key foundational steps towards producing nuclear power is noteworthy and provides valuable lessons and best practices for other countries. This case study describes the path followed and the activities implemented by Ghana to complete the first phase and successfully transition into Phase 2 of the IAEA Milestones Approach. Key aspects of Ghana's implementation of its programme and lessons learned are described. Sharing these key aspects and lessons learned could benefit other countries interested in or already embarking on new nuclear power programmes.



National Nuclear Research Institute, Ghana Atomic Energy Commission (GAEC), Accra, Ghana, January 2013 (Photo: Dean Calma/IAEA)

6 World Bank Data https://data.worldbank.org/country/XN

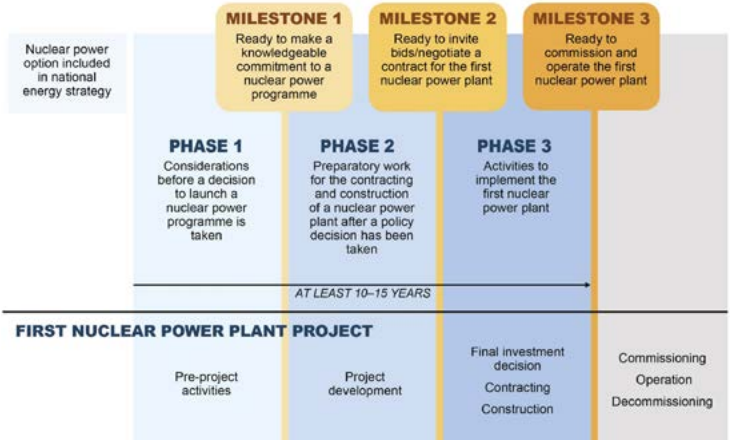
IAEA Milestone Approach

The IAEA Milestones Approach is a programme management framework intended to help Member States that are considering or embarking on a new nuclear power programme. This approach is set out in the IAEA Nuclear Energy Series NG-G-3.1 (Rev. 1) Milestones in the Development of a National Infrastructure for Nuclear Power and describes a three phased approach, covering 19 different infrastructure issues that the Member State should address. Each of the three phases culminates in a milestone that represents the achievement of the objectives expected for the phase.

In **Phase 1** a series of studies are conducted to enable the country to understand the implications, requirements, international obligations, risks and benefits of a nuclear power programme. At the end of Phase 1 a comprehensive report is prepared to enable the government to make a knowledgeable decision on whether to continue and commit to a nuclear power programme.

Phase 2 involves the development of national policies and a legal and regulatory framework for nuclear power, establishment or enhancement of the nuclear regulatory body and the owner/operator organisation, development of the required human resources, and completion of key studies. It also involves the development of user requirement specifications for engagement with potential suppliers. At the end of Phase 2, the country is ready to invite bids or negotiate a contract for the first nuclear power plant.

Phase 3 is the period during which the financial and contractual commitments are made and construction of the NPP is carried out. At the end of Phase 3 the designated operator organisation is ready to operate the first nuclear power plant.



Milestones in the Development of a National Infrastructure for Nuclear Power[7] (Photo/IAEA)

7 IAEA Nuclear Energy Series No. NG-G-3.1 (Rev. 1), IAEA, Vienna (2015).

Elements of Ghana's success

Ghana has been able to methodically progress through Phase 1 of the Milestones Approach. What are some of the key elements that contributed to this success? At a side event[8] organized by the VCDNP and the Permanent Mission of Ghana to the UN in Vienna during the 65th IAEA General Conference in 2021, senior officials from key organisations provided insights into the Ghana nuclear power programme.

Establishment of GNPPO and its technical support

Prof. Ben Nyarko, previously Director General of the Ghana Atomic Energy Commission (GAEC) and Deputy Chair of the Ghana Nuclear Power Programme Organisation (GNPPO) explained that early establishment of the GNPPO was a key element of Ghana's nuclear power programme. He emphasised the importance of involving other Government and non-government institutions in the GNPPO and having a structured and well thought out approach or roadmap for consistency. Another key element has been the provision of technical support to the GNPPO, addressing all 19 infrastructure issues of the IAEA Milestones Approach. The Nuclear Power Institute under GAEC admirably performed this role: providing the the technical support itself or coordinating the support of other competent organisations within Ghana; coordinating the IAEA INIR Phase 1 mission to Ghana; establishing a management system for Phase 1activities; and coordinating the consolidation of the results of the Phase 1 studies into a comprehensive report for submission to the Government.

Safety, security and safeguards (3S) regulator

Dr. Nii Allotey, Director General of Ghana's Nuclear Regulatory Authority (GNRA), believes that, while it is not essential, assigning nuclear safety, security and safeguards all within the mandate of the GNRA has been beneficial. Having the three areas together under one regulatory authority has facilitated good synergy and understanding between the three areas, limited coordination problems between the relevant personnel, supported the development of robust and well-integrated regulations and helped to identify any interface loopholes during implementation.

8 https://vcdnp.org/ghanas-successful-implementation-of-phase-1-of-the-iaea-milestones-approach

Roadmap of Ghana's Nuclear Power Programme (Photo/Nuclear Power Ghana)

Nuclear 3-S concept: safety, security and safeguards

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

Also referred to as the 3S concept, nuclear safety, security and safeguards are three technical areas which need to be addressed in establishing and implementing an adequate legislative and regulatory framework for the peaceful use of nuclear energy. Measures taken to address one of these key areas can contribute to addressing the others as well. For example, the adoption of measures for physical protection of nuclear material can also help to ensure the safe use of this material, while also protecting against its diversion for malicious purposes. Each of the 3Ss is important in its own right but if implemented independently and not in coordination with the others, the collective efficacy of the 3Ss can be undermined. To be truly effective, nuclear safety, security, and safeguards implementation programmes need to fully address their complementary and competing aims.

The fundamental nuclear safety objective is to protect people and the environment from the harmful effects of ionising radiation. A comprehensive safety framework needs to be developed that ensures the attainment of this objective. The IAEA provides guidance in its Safety Fundamentals, Safety Requirements and Safety Guides for ensuring safety, reflecting an international consensus on what constitutes a high level of safety. The Safety Standards Series contain a roadmap for safety infrastructure development for use by countries contemplating the introduction of nuclear power. It is incumbent on the government, the owner/operator organisation and the regulatory body to develop awareness of safety issues and maintain a safety culture throughout the entire nuclear power programme.

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

A country must implement a comprehensive safeguards system, in compliance with the IAEA safeguards requirements, to ensure that there is no risk of proliferation of nuclear weapons through diversion or theft of nuclear material in its nuclear power

programme and that all nuclear material is accounted for and protected. By concluding a comprehensive safeguards agreement with the IAEA, the country undertakes to accept IAEA safeguards on all nuclear material in all peaceful nuclear activities within its territory, under its jurisdiction or carried out under its control anywhere. This also requires the development of the appropriate culture, systems and practices to ensure that all staff are aware of their responsibilities and of the importance of their actions.

Safeguards comprehensive training exercise at Dukovany NPP. Czech Republic, 11 June 2015
(Photo: Dean Calma / IAEA)

National and international partnerships

Dr Allotey emphasises the importance of the level of cooperation that has been achieved with other organisations and agencies in Ghana, such as the Environmental Protection Agency. Detailed Memoranda of Understanding have been developed, while platforms such as the Nuclear Security Committee strengthen cooperation with other organisations. Bilateral agreements with international bodies including nuclear regulators, such as the United States Nuclear Regulatory Commission, the Canadian Nuclear Safety

Commission, and the European Union Instrument for Nuclear Safety Cooperation are being implemented, providing support for the development of regulations, regulatory systems and training of GNRA staff. Dr Allotey commented that, through appropriate cooperation with bilateral partners and other national and international agencies, the GNRA is building its capacity to be an effective independent regulator for Ghana's nuclear power programme.

Activities of owner/operator

All 19 infrastructure issues of the Milestones Approach are important and must be addressed. Many of these activities fall under the responsibility of the owner/operator of the proposed NPP. Hence, Ghana took steps to establish Nuclear Power Ghana (NPG) as the future owner/operator already in Phase 1. Dr Stephen Yamoah, Executive Director of NPG, explained its approach, namely to group the 19 infrastructure issues into four thematic areas that take the inter-relationship between the infrastructure issues into account. These four thematic areas are: (1) studies and selection for a preferred site; (2) financial aspects that lead to the selection of a vendor or a strategic partner; (3) stakeholder engagement with communities, organisations, and institutions, including the development of a virtual information centre (and later a physical information centre) and activities related to education and awareness building for secondary and tertiary students and the public; and (4) planning, preparation and development of related nuclear project infrastructure. This latter thematic area includes the development of a safety, security and safeguards programme, policies and strategies for the fuel cycle and radioactive waste management, integrated management systems and human resource development. Dr Yamoah described the comprehensive and integrated five-year workplan developed to identify the key activities to be implemented, monitored, and completed by NPG in Phase 2. A risk management framework has been developed to support the implementation of the NPP project.

IAEA support

Prof. Nyarko described Ghana's long involvement with the IAEA in the peaceful uses of nuclear technology for non-power applications, through GAEC. The year 2013 marked the 50th anniversary of successful cooperation between Ghana and the IAEA, five decades during which the IAEA provided technical cooperation support to the country in all thematic areas in which the IAEA operates, including human health, agriculture and food security, water and the environment, industry, education and training, and also safety and security. As a result of half a century of cooperation, Ghana now has the capacity not only to meet its own needs but also to provide education and training in the application of nuclear technology for peaceful purposes to other countries in Africa. In recent years, the involvement of the IAEA has included support in the implementation of the Milestones Approach for the development of the infrastructure needed for

Ghana's nuclear power programme. Prof. Nyarko anticipates that the implementation of the nuclear power programme in Ghana will contribute to the further expansion of the peaceful use of nuclear technology in all applications, power and non-power, in Ghana, West Africa and Africa overall.

Dr. Kwaku Aning, a former Deputy Director General and Head of the IAEA's Department of Technical Cooperation is currently the Chairman of the governing board of GAEC. He explains the importance of cooperation with the IAEA for Ghana and notes that his country is an excellent example of long-standing national cooperation with the IAEA that has resulted in significant achievements and steady advances in science and technology. The technical cooperation achievements include substantial human resource development and the establishment of the Graduate School of Nuclear and Allied Sciences at the University of Ghana in 2006.

IAEA support to newcomer countries

To support countries implementing the Milestones Approach, the IAEA has prepared other guidance documents.[9] The IAEA technical departments, mainly through the IAEA technical cooperation programme, provide — upon request by a Member State — training and expert advice on nuclear safety, security and safeguards matters, and peer review and advisory services.

Countries embarking on a new nuclear power programme need to establish a coherent and comprehensive national legal framework, not only to implement relevant international instruments to which they are parties but also to establish the duties and responsibilities of the various organisations required for the programme's success. The IAEA Office of Legal Affairs offers a comprehensive legislative assistance programme covering the main branches of nuclear law: safety; security; safeguards; and civil liability for nuclear damage.

The Division of Nuclear Installation Safety supports Member States in establishing the appropriate safety infrastructure and in continuously improving the safety of nuclear installations during site evaluation, design, construction and operation. The Division contributes to the development of safety standards for nuclear installations and provides safety reviews and advisory services to support their effective application.

The IAEA Division of Nuclear Security provides review and advisory services to Member States to establish or enhance the necessary infrastructure to protect nuclear and other radioactive material from theft and diversion, protect nuclear installations and transport against sabotage and other malicious acts, and combat illicit trafficking in nuclear and other radioactive material. In a new nuclear power programme, the IAEA focuses on knowledge building through workshops and training courses on the methodology to develop a design basis threat, the physical protection of a plant and the development of nuclear security culture.

The IAEA's Department of Safeguards provides training for all Member States in implementing safeguards under their comprehensive safeguards agreement (INFCIRC/153), additional protocol (INFCIRC/540) and small quantities protocol (GOV/267), as applicable. In general, these training objectives are targeted towards establishing and maintaining the State System of Accounting for and Control of Nuclear Material (SSAC) as required by a comprehensive safeguards agreement.

9 https://www.iaea.org/topics/infrastructure-development/bibliography

In addition, the IAEA offers the Integrated Nuclear Infrastructure Review (INIR) service — based on the Milestones Approach — to both embarking countries and those that are expanding their nuclear power programme. The INIR service helps to ensure that the infrastructure required for the safe, secure and sustainable use of nuclear power is developed and implemented in a responsible and orderly manner. Since its launch in 2009, the INIR service has been widely used by countries in the development or expansion of their nuclear power programmes.

Officials from the IAEA and the Government of Ghana at the the INIR Phase 1 Mission Report handover ceremony in Accra, on 24 May 2017. (Photo: IAEA)

Lessons learned from Ghana

- Ensure political commitment to the goal of producing nuclear power. This is essential. In Ghana the Government has not wavered from this commitment since making the decision to embark on nuclear power and has matched the commitment by investing in the partnerships and the development of human resources necessary to realise their goal.

- Establish an organisation to implement the nuclear energy programme (referred to as a Nuclear Energy Programme Implementing Organisation (NEPIO) by the IAEA) early on with well-defined objectives and mandate (in Ghana this is the GNPPO).

- Assemble a dedicated and competent team as the technical support to the NEPIO in order to address the 19 infrastructure issues. The Nuclear Power Institute under GAEC performed this role: providing the technical support itself or coordinating the support of other competent organisations within Ghana; coordinating the IAEA INIR Phase 1 mission to Ghana; establishing a management system for Phase 1 activities; and coordinating the production of a comprehensive report at the end of Phase 1.

- Establish national project(s) with the IAEA Technical Cooperation Department and identify people who are committed to working in nuclear and are able to cooperate with IAEA departments to achieve the project objectives.

- Ensure close cooperation on nuclear safety, security and safeguards. This has been achieved in Ghana by placing them all under the mandate of one regulatory authority, the Ghana Nuclear Regulatory Authority. This has facilitated good synergy and understanding between the three areas, minimised coordination problems between the relevant personnel, supported the development of robust and well-integrated regulations and has helped identify potential interface loopholes during implementation.

- Invest in nuclear training and education programmes. In addition to the resources available at the IAEA, there are many opportunities to collaborate with research and educational institutions in countries with established nuclear power programmes.

- Promote the benefits of a nuclear power programme for future generations in public engagement strategies. In Ghana, the nuclear power operator has engaged extensively with the public — in particular the youth — promoting nuclear power as an investment in their future.