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# Experience, reviews, discussions

## Resource Needs for Nuclear Power Generation in Ghana

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Nuclear power is a proven technology that has served humanity for the past fifty years. It has provided electricity for several countries and shall continue to serve as a viable base load source of electric power. The need for skilled human resources for nuclear practice cannot be overlooked in the quest of any nation to adopt the technology. The Ghana Atomic Energy Commission and the University of Ghana in collaboration with the International Atomic Energy Agency have thus started a Graduate School of Nuclear and Allied Sciences to provide the human resources needed for nuclear power generation in Ghana. The School currently offers second degree courses as well as doctor of philosophy courses. Financial, land and water resource needs for nuclear power generation have been discussed. Availability of the national grid due to the deregulation of the electric power sector has also been discussed. Nuclear Fuel availability has been discussed along with the steps Ghana has to go through to obtain the technology to her development. The legal and legislative framework for nuclear power generation has also been presented. The programs currently available from the IAEA to assist Ghana to develop nuclear power have also been discussed. Conclusions have been drawn based on the discussions made.

Key words: *resource needs, nuclear power, legal, electricity grid.*

### 1. Introduction

Ghana gained her independence in the same year as the first commercial nuclear power plant was built, i.e. in the United States in 1957. Ghana is a signatory of the non-proliferation treaty and this allows her to utilize nuclear technology for peaceful purposes. The first president of the country cut the sod for the Ghana Nuclear Reactor Project (GNRP) on the 25th November, 1964 (GAEC 2006). The project was intended to introduce nuclear science and technology into the country and to exploit the peaceful applications of nuclear energy to national development.

The country is further away from where we started off. This paper seeks to discuss the human resource needs and how we are addressing it, the financial obligations, the land and water resources, an access to the national grid, nuclear fuel availability, milestones for nuclear power generation, legal and regulatory framework and the programs available from the International Atomic Energy Agency (IAEA) to assist Ghana to develop nuclear power.

It is hoped that henceforth the nation shall be ready to continue in the quest for nuclear power generation in Ghana.

## 2. Human resources

Typically, the operating organization responsible for a Nuclear Power Plant (NPP) has a staff of 200–1000 persons, who collectively have a variety of scientific, engineering and other technical backgrounds in the fields needed to effectively and safely operate and maintain the plant (IAEA 2007a). 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 thermal hydraulics and technical areas such as radiation protection, radioactive waste management, quality management, maintenance and spare parts management.

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 nonproliferation considerations.

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

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.

Regulatory 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. 30–50 staff members would be necessary for starting the implementation of a nuclear power plant program. 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).

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

In response to the above requirements, the Ghana Atomic Energy Commission (GAEC) has jointly established the Graduate School of Nuclear and Allied Sciences with the University of Ghana in collaboration with the IAEA (Amuasi 2009).

The vision of the School is to be a leading graduate school producing high caliber nuclear scientists and engineers for health care, industry, and the environment and for the socio-economic development of Ghana and Africa. The mission of the School is for the preservation, maintenance and enhancement of nuclear knowledge in Ghana and Africa, for the provision of high quality teaching, research, entrepreneurship training, service and development through graduate programs in nuclear sciences and technology. There are currently ten programs and five Departments in the School.

The Department of Nuclear Sciences and Applications currently offers courses leading to the award of Master of Philosophy in Applied Nuclear Physics, Nuclear and Radiochemistry, Nuclear and Environmental Protection and Nuclear Earth Sciences. The Department of Nuclear Safety and Security currently offers a course leading to the award of Master of Philosophy in Radiation Protection.

The Department of Nuclear Agriculture and Radiation Processing currently offers courses leading to the award of Master of Philosophy in Nuclear Agriculture with options in Mutation Breeding and Plant Biotechnology, and Soil, Water and Crop Nutrition; and Radiation Processing with options in Radiation Processing: Food, Medical Supplies and Polymers, Radiation Entomology and Food Science and Post-harvest Technology. The Department of Medical Physics currently offers a course leading to the award of Master of Philosophy in Medical Physics.

The Department of Nuclear Engineering currently offers courses leading to the award of Master of Philosophy in Nuclear Engineering with options in Reactor Physics and Reactor Engineering; and Computational Nuclear Sciences and Engineering.

The training currently ongoing at the School of Nuclear and Allied Sciences and the envisaged training in the universities and polytechnics can be utilized to provide the human resources necessary for nuclear power generation in Ghana.

## 3. Financial resource

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.

To prepare for a nuclear power program 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 program,, but it will increase as the need arises for providing technical and regulatory supervision and the associated training of the staff. The total cost of providing the necessary infrastructure would not be a large fraction of the cost of the first NPP, but it 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 program can also have benefits for society in many unrelated fields. The cost associated with the production of electricity from the various sources available to the country is presented in Table 1 below.

*Table 1. Comparison of costs associated with electricity sources in Ghana (Nyarko 2008)*

| TYPE OF POWER PLANT | CAPACITY (MW) | GENERATION COST (CENTS/KWH) |
|---|---|---|
| Bui Hydro | 400 | 6.9 |
| Juale Hydro | 87 | 8.1 |
| Pwalugu Hydro | 48 | 9.3 |
| Awisam Hydro | 50 | 12.6 |
| Hemang Hydro | 80 | 11.4 |
| Takoradi Gas Combined Cycle | 300 | 5.0– 5.5 |
| AP 600 – Nuclear | 600 | 4.0 – 6.0 |

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. Sensitivity of the electricity generation cost to the price of fuel is much lower for nuclear plants than for fossil fuelled power plants.

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 the staff to implement a nuclear power program 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.

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 Ghana that she has fully complied with all international standards might help foster an environment in which financial costs are reduced.

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.

## 4. Land / water resource

The total land area of the country is about 238,460 sq km and shares 2,093 km of land borders with three neighbouring countries (Burkina Faso {538 km} at the north; Cote d’ Ivoire {668 km} at the west and Togo {887 km} at the east). It also has 539 km of the coastline with the Gulf of Guinea in the Atlantic Ocean (IAEA 2009). The country is demarcated into 10 administrative regions as shown in Figure 1 below with Accra on the coast as the capital. The country has a tropical climate with the temperatures generally between 21 and 32 $^{o}$ C. There are two main rainy seasons, from March to July and from September to October, separated by a short cool dry season in August and a relatively long dry season in the southern segment of the country from mid-October to March. The northern segment of the country has a long dry season and a short rainy season.

Ghana is endowed with vast land resource and water resources. This resource can be used to house and cool the nuclear reactor, respectively. The country has access to sea water as well. This can create an avenue for deployment of a desalination plant for distilling water for use and for providing salt which can assist the nation in making brine for oil production.

## 5. Access to national grid

In 1994, the government of Ghana took the initiative to reform the power sector to do away with public monopoly and promote competition, enhance transparency in the regulation of the sector, improve operational efficiency through management accountability in the existing public utilities, and attract private sector participation (IAEA 2009). The decision to reform the power sector was taken in fulfillment of a World Bank conditionality that was attached to an International Development Agency (IDA) credit facility granted to the government on behalf of the Volta River Authority (VRA) to build a 330 MW thermal power plant at Aboadze near Takoradi.


*Fig. 1.* *Map of Ghana (IAEA 2009)*

The first step in reforming the power sector was commercialization of the operation of the sector utilities. In February 1997, under the Statutory Corporations (Conversion to Companies) 1993 Act 461, the Electricity Corporation of Ghana was converted into the Electricity Company of Ghana (ECG), a limited liability company registered under the Ghana Companies Code of 1963 (Act 179). This was in fulfillment of the commitment the government made to the World Bank under the ERP/SAP in the early 1980s. Under the reform process, the two distribution utilities (i.e. ECG and NED) were expected to be merged and then split into five strategic business units or concession zones to compete among themselves. The distribution utilities are expected to operate in regulated electricity market where the maximum demand of a customer will not exceed 5 MW.

Under the reform process, the government is expected to create a de-regulated or Wholesale Power Supply Market where the demand of a customer exceeds 5 MW. In the deregulated or Wholesale Power Supply Market, customers will be free to choose their supplier and negotiate and enter into contracts for the purchase of their electricity. An Independent System Operator is expected to be privy to these negotiations. The set of Rules and Regulations governing the Wholesale Power Supply Market is before Parliament as a bill to be enacted into a Legislative Instrument.

Hitherto, VRA was in charge and operated the transmission system. However, under the reform process, the generation and transmission functions of VRA have been unbundled by the VRA Act 46 Amended. The transmission infrastructure will still remain public owned and managed by an electricity transmission utility. The government has established the Grid Company of Ghana (GRIDCO) to control and operate the transmission system, which will be an open access and non-discriminatory facility. The function of the transmission system as a common carrier facility is critical to promoting competition in the restructured domestic electricity market and the West African Power Pool. The electricity network of the country is as shown in Figure 2 below.

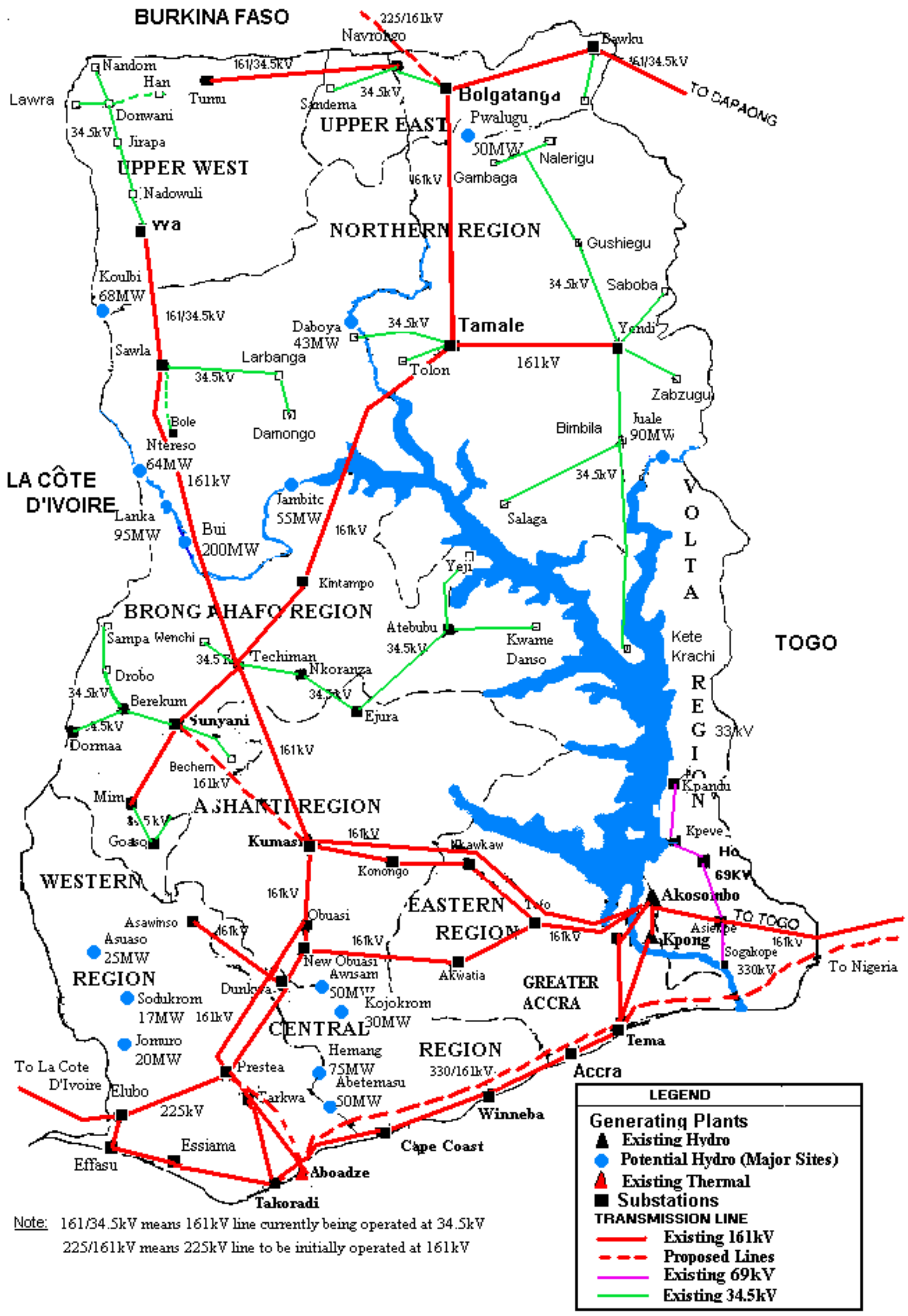


*Fig. 2.* *Map of Ghana showing Transmission Grid (IAEA 2009)*

Under the reform process, the generation segment of the electricity industry has been opened for participation by other interested power generators in addition to VRA to generate and supply the Wholesale Power Supply Market and the regulated market.

Power producers can trade among themselves or sell power directly to distribution companies, major consumers, intermediaries or the wholesale market.

The government in October and November 1997 established the Public Utilities Regulatory Commission (PURC) by the Public Utilities Regulatory Commission Act (Act 538) and the Energy Commission (EC) by the Energy Commission Act (Act 541), respectively for the transparent regulation of the power sector. The main functions of the PURC are to receive tariff adjustment proposals from public utilities, vet the proposals and approve electricity rates to be charged by the utilities and also develop and enforce regulations to protect the interest of consumers. The Energy Commission is to advise the Minister of Energy on strategies to achieve efficient, economical and safe supply of electricity. The EC also prepares indicative energy plans for the government, grants license to control entry to and exit from the energy sector by commercial operators, monitors licensees to ensure compliance to conditions of their license, rules of practice and standards of performance.

The activities of the past years have created the opportunity for variable sources of electricity to come upstream. Nuclear power can therefore be sourced to provide reliable and safe electric production and distribution in Ghana.

## 6. Nuclear fuel availability

There are proven reserves of coal sufficient for more than 200 years, of natural gas for 60 years and of oil for 40 years at the current levels of use (IAEA 1997a, 2006a). There are efforts under way to increase the oil and gas resources through improved recovery techniques and oil-shale and tar-sand processing that are estimated to be capable of at least doubling the resource base. Depending on their specific economics, new technologies to further increase fossil fuel extraction could be developed. But, financing of necessary investments and price volatility could then become leading concerns.

Known uranium reserves with reactors operating primarily on a once-through cycle without reprocessing of spent fuel assure a sufficient fuel supply for at least 50 years at the current levels of use, the same order of magnitude as today's proven resources of natural gas and oil. Estimates of additional undiscovered (speculative) resources could add more than 100 years. Unconventional uranium resources are also available such as the uranium contained in sea water and phosphates that could increase resources by many multiples of current reserves, but as with speculative fossil reserves, these would not necessarily be an economic energy resource. Over the long term, recycling plutonium from reprocessed spent fuel in thermal reactors as mixed oxide fuel and the introduction of fast breeder reactors to also convert non-fissionable uranium into plutonium would increase the energy potential of today's known uranium reserves by up to 70 times, enough for more than 3000 years at today's levels of use. Uranium used in a complete fuel cycle not only maintains, but also significantly increases the resource base.

Additionally, thorium, which, like uranium, has no significant use other than as a reactor fuel, is another energy resource although it does not contain a fissionable isotope as uranium does. It can be used in a breeding fuel cycle with either fissionable uranium or plutonium and converted to a fissionable isotope of uranium. Indigenous thorium in a number of countries with limited uranium deposits could make this an attractive option.

From a strategic perspective, the need to have a secure and diverse energy supply to reduce reliance on imported energy and price fluctuations can be of paramount national interest. Sixty-five per cent of proven oil reserves are in one region of the world — the Middle East. Natural gas pipelines can be thousands of kilometres in length and pass through a number of countries on the way to the consumer. Hydropower can depend on watersheds fed by several countries. Clearly, where indigenous fossil fuel resources are lacking, nuclear power can contribute substantially to security of supply and the energy mix as it does in Finland, France, Sweden, the Republic of Korea and Japan.

Strategic fuel inventories to last many years can be readily established as the quantity of fuel required is small.

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 – Global Fuel Supply.

## 7. Milestones for nuclear power generation

In preparing the infrastructure to introduce nuclear power, there are several activities that need to be completed (IAEA 2007b). These activities can be split into three progressive phases of development. The duration of these phases will depend upon the degree of commitment and resources applied. A description of the conditions that would be expected to be achieved by the end of each phase is provided. The term 'infrastructure milestone' refers to the conditions necessary to demonstrate that the phase has been successfully completed. The 'infrastructure milestone' is thus a description of a set of conditions and does not necessarily have specific time based implications. It should be noted that decisions taken early in the process, such as turnkey purchase versus indigenous construction, can greatly influence the resources necessary to create the required infrastructure. The development of infrastructure necessary to support a nuclear power program would be expected to proceed through phases 1–3, leading to the achievement of the corresponding milestones, while at the same time many other specific activities are progressing in order to ensure implementation of the first nuclear power plant project. The three program phases of development are:

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

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

– Milestone 1: Ready to make a knowledgeable commitment to a nuclear program;
– Milestone 2: Ready to invite bids for the first nuclear power plant;
– Milestone 3: Ready to commission and operate the first nuclear power plant.

A schematic representation of the phases and milestones is given in Figure 3.

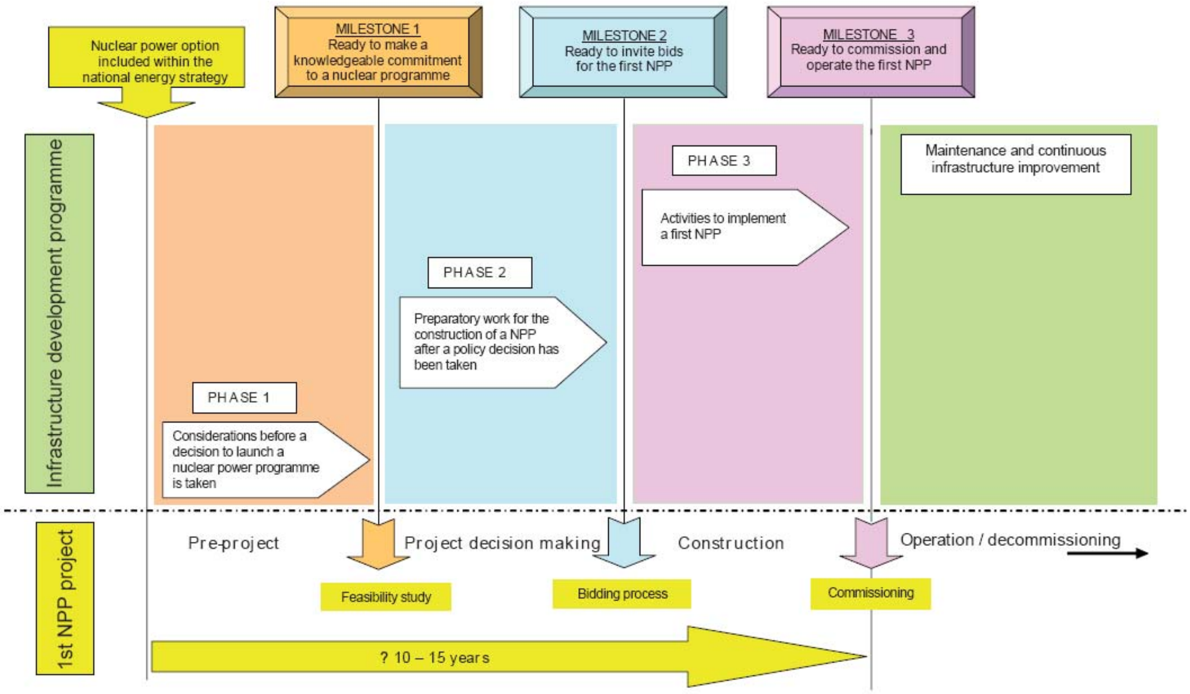


*Fig. 3. Infrastructure Development Program (IAEA 2007b)*

There are three major organizational entities typically involved in the development of a nuclear power program: the government, the owner/operator of the nuclear power plant and the regulatory body. Each has a specific role to play, with responsibilities changing as the program advances. In the discussion here, it is assumed that the government will form a group to study and initially promote the development of the program. In this paper, this group is called the 'Nuclear Energy Program Implementing Organization' (NEPIO). It should be noted that this designation is used here for illustrative purposes only. Similarly, the owner/operator organization may be State owned, be part of a utility or be another commercial entity. The regulatory body is effectively independent of the owner/operator and other government agencies responsible for developing the nuclear program, but may exist within the government. An example of a NEPIO is as shown in Figure 4.

The NEPIO should therefore be formed to implement the country's decision to construct our first NPP.

## 8. Legal and regulatory framework

The legislative framework for nuclear power generation has two main aspects: national and international.

At the national level, the existing legislative framework for radiation, waste, transport safety, environmental protection, etc., is relevant and needs to be taken into account. These include local land use controls, environmental matters (e.g. air and water quality and wildlife protection), the economic regulation of electric power utilities, the occupational health and safety of workers, general administrative procedures of governmental bodies, transport, the export and import of nuclear material, intellectual property rights, insurance and liability for non-nuclear damage, emergency management, criminal laws and procedures and taxation.

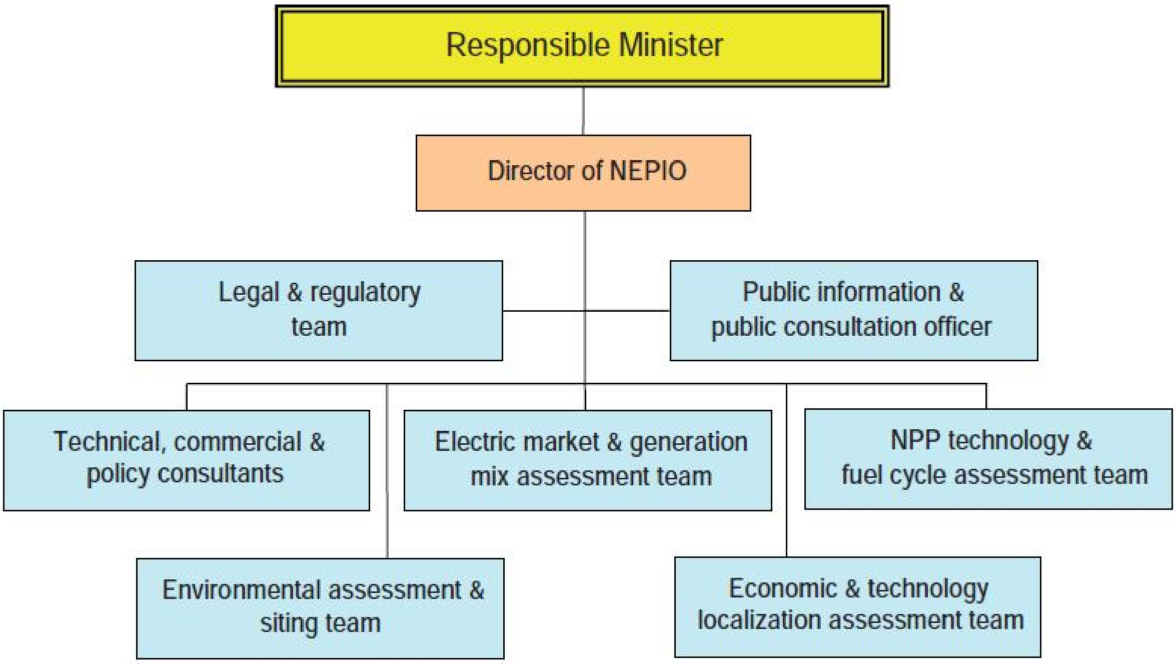


*Fig. 4. Example of NEPIO (IAEA 2007b)*

A comprehensive nuclear law should therefore touch on all the above and more (IAEA 2006b). Some of the basic elements to be considered are discussed below (Stoiber et al. 2003). Legislations dealing with the national energy policy including economic and commercial considerations, with a clear designation of responsible institutions or bodies, including their relationships with nuclear power (IAEA 2006c); Legislations dealing with establishing effectively independent regulatory authorities, with clear mandate on the responsibility for safety, security and safeguards (IAEA 1997b). This includes a system of licensing, inspection and enforcement covering all subject areas of nuclear law, such as radiation protection, radioactive material and radiation sources, the safety of nuclear installations, emergency preparedness and response, mining and milling of radioactive materials, transportation- including infrastructure and modes of transport, radioactive waste and spent fuel, nuclear liability and compensation, safeguards, export and import controls, and physical protection of nuclear and radioactive materials..

Legislation is required to be enacted pursuant to the relevant non-proliferation undertakings of Ghana (IAEA 1972) and Legislation with clear responsibilities and liabilities for the operation of nuclear facilities and the handling and safeguarding of nuclear material (IAEA 1980, 2011).

Legislation to protect foreign investment which includes the financial aspects, the roles of foreign entities, vendors and suppliers, financing strategy, funding or guarantees and intellectual property rights needs to be put in place to enable foreign partners to provide the necessary assistance for the introduction of nuclear power in Ghana.

Legislation establishing an effectively independent regulatory body with full authority to implement the functions assigned to it by the enabling legislation needs to be enacted.

Legislation dealing with fuel cycle issues in general, and the ownership of nuclear material, in particular needs to be promulgated to indicate the manner in which the nuclear fuel and spent fuel shall be catered for.

Provisions are to be made for the development of human resources and physical facilities to ensure the continued integrity of the nuclear program.

Legislation specifying the allowed ownership of nuclear facilities and nuclear materials is required to be promulgated.

The country’s commitment to use nuclear power for peaceful purposes shall have to be strengthened, and a comprehensive legislative oversight for nuclear power to be established.

Legislation dealing with the roles of national government, local government, stakeholders and the public are to be enacted to provide a basis for public participation in the implementation of the nuclear power programme.

The legislative framework shall have to be maintained and amended as necessary during the life of the nuclear power programme.

All the above legislation, including the financial aspects, needs to have been developed, promulgated and in force prior to proceeding with a request for bid for the first power plant.

There is a draft bill covering most of the above issues under consideration at the Ministry of Environment Science and Technology.

At the international level, there are some basic international legal instruments that Ghana has to ratify and implement to show commitment to peaceful use and application of nuclear technology which are discussed below. Convention on the Early Notification of a Nuclear Accident which seeks to strengthen the international response to nuclear accidents by providing a mechanism of the rapid information exchange to minimize trans-boundary radiological consequences (IAEA 1986a).

The Convention on the Assistance in the Case of a Nuclear Accident or Radiological Emergency which strengthens the international response to a nuclear accident of radiological emergency, including a terrorist or other malicious act, by providing a mutual assistance mechanism with a view to minimizing the consequences of such accidents or emergencies and protecting life, property and the environment against the effects of radioactive releases (IAEA 1986b).

Convention on Nuclear Safety which is the first legally binding international treaty to address the safety of nuclear installations and seeks to ensure that such installations are operated in a safe, well-regulated and environmentally sound manner (IAEA 1994).

Joint Convention on the Safety of the Spent Fuel Management and on the Safety of the Radioactive Waste Management which is the first legally binding international treaty on the safety of both spent fuel management and radioactive waste management (IAEA 1997c). It represents a commitment by participating States to achieve and maintain a high level of safety in these areas as part of a global regime for ensuring the protection of people and the environment.

Convention on Physical Protection of the Nuclear Material (CPPNM) which is one of the thirteen counter-terrorism instruments and it is the only internationally legally binding undertaking in the area of physical protection of nuclear material (IAEA 1980). Ghana has ratified this convention but has not yet ratified its amendment.

Amendment to the CPPNM which makes it legally binding for States parties to protect nuclear facilities and material in peaceful domestic use, storage as well as transport (USA 2007). It also provides for expanded cooperation between and among States regarding measures to locate and recover stolen or smuggled nuclear material, mitigate any radiological consequences of sabotage, and prevent and combat related offences.

The African Nuclear Weapon Free Zone (Pelindaba) Treaty (NWFZs) which contributes to controlling the spread of weapons of mass destruction and it is an important step towards a nuclear-weapon-free world (IAEA 1996a).

Vienna Convention on Civil Liability for Nuclear Damage which was based on the civil law concept and had the following main principles: liability of the operator is absolute, that is to say, the operator is held liable irrespective of fault (IAEA 1996b, 2007c).

The Joint Protocol Relating to the Application of the Vienna and Paris Conventions: Following the Chernobyl accident, it was realized that a nuclear incident could cause damage of an extreme magnitude in the areas far beyond the territory of the incident state (IAEA 1992). That, in addition to damage to individuals and property there could be an extensive damage to the environment, too. Incidentally, the then Soviet Union where Chernobyl was located, was not a party to any of the existing regimes and therefore could not be of benefit to any of the victim states. The Joint Protocol established a link between the two Conventions combining them into one expanded liability regime.

Convention on Supplementary Compensation for Nuclear Damage which gives the opportunity to all States to join, regardless of whether they are parties to any existing nuclear liability conventions or have nuclear installations on their territories (IAEA 1998). And it gives a better definition of nuclear damage which includes concept environmental damage and preventive measures. The Supplementary Convention amended most of the provisions of the 1963 Convention. This makes it possible for new states to become a Party to the Protocol without ratification of the 1963 Convention. And existing Parties to the 1963 Convention who have not ratified the Protocol will still be recognized under the Supplementary Convention.

Comprehensive Nuclear-Test-Ban Treaty (CTBT) whose main objective is to promote the peaceful use of nuclear technology while at the same time, ensuring the rest of the world that, it would not be used for arms race (UNO 1996). It is a result of the efforts by the international community to adopt international agreements and other positive measures in the field of nuclear disarmament, including reductions in arsenals of nuclear weapons, as well as the prevention of nuclear proliferation. It therefore addresses the need for continued systematic and progressive efforts to reduce nuclear weapons globally, with the ultimate goal of eliminating those weapons, and complete disarmament under strict and effective international control. It also recognizes the cessation of all nuclear weapon test explosions and other nuclear explosions. The Treaty further constrains the development and qualitative improvement of nuclear weapons and ends the development of new types of nuclear weapons.

Memoranda have been prepared on the following Conventions and Treaties for consideration of the Cabinet and Ratification or accession by the Parliament: Amendment to the Convention on the Physical Protection of Nuclear Material (CPPNM), The Convention on Nuclear Safety, and The Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management (Akaho 2009).

Draft Memos that have been prepared are: Convention on Early Notification of a Nuclear Accident, Convention on Assistance in the case of Nuclear Accident or Radiological Emergency, Vienna Convention on Civil Liability for Nuclear Damage and Protocol to Amend the 1963 Vienna Convention on Civil Liability for Nuclear Damage and Convention on Supplementary Compensation for Nuclear Damage.

## 9. Programs available from IAEA to assist Ghana to develop nuclear power

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 programs (IAEA 1997a). For example, support can be obtained for implementing the operational phase of an NPP to the extent that Ghana 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 program. The IAEA has recently prepared a number of guidance documents on infrastructure and other considerations for the countries planning to launch a nuclear power program and stands ready to provide expert assistance in this area if requested. Presently, there are national, regional and international programs that are in place to support nuclear new comers.

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

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.

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 the 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. Through execution of several projects including, RAF/0/016, GHA/0/008, GHA/0/010 and GHA/0/011, the IAEA has provided meaningful assistance in Ghana's quest for nuclear power introduction.

Through RAF/0/016 on the Sustainable Energy Development for Sub-Saharan Africa, the IAEA assisted Ghana to enhance our capacity for long-term strategic planning of energy systems (Dzobo 2009). In 2004, the Ghana Atomic Energy Commission (GAEC) on behalf of the government submitted a proposal to the IAEA for a Technical Cooperation (TC) National project for Energy and Nuclear Power Planning Study. However, the Agency wanted Ghana to further strengthen its energy planning capabilities in the use of IAEA energy planning tools and therefore approved a TC National Project GHA/0/008: "Planning for Sustainable Energy Development - Ghana Country Study" for 2005 – 2008. Through GHA/0/008, the Ghana Energy Commission and the IAEA organized three National Training Workshops in Accra on uses of MAED model in April 2006, WASP IV model in March 2007 and MESSAGE model in June 2007. Two members of the National Project Team visited the Energy Research Centre, the University of Cape Town under the IAEA fellowship program to improve their skills in the use of the MESSAGE model.

The National Project Team after the training was able to use the MAED model to perform energy demand projections (2004 – 2030) based on three scenarios formulated. The WASP IV model has been used to undertake optimal expansion planning of the electricity generation system taking into account issues like lack of domestic energy resources and dependency on energy imports. The MESSAGE model has been used for the analyses of the optimal energy mix. The results of these analyses were used to prepare "Planning for Sustainable Energy Development – Ghana Country Study Report" (IAEA 2009).

GHA/0/010 on "Establishment of the Postgraduate School of Nuclear and Allied Sciences" has been initiated to train human resource for introduction of nuclear power in Ghana (Amuasi 2009). GHA/0/011 on "Evaluating the Role of Nuclear Power in Future Options for Electricity Generation" has been initiated to establish a nuclear power plant operating organization, identify the specific sites for nuclear power plant operation, identify and develop appropriate grid infrastructure, engage in a bidding process, develop appropriate financing strategies for nuclear power plant construction, develop relevant areas of study for universities and polytechnics in human resource development and to complete the development of the regulatory framework for nuclear power operation in Ghana (Nyarko et al. 2011).

The discussion here brings to light the active role the IAEA is playing in Ghana's quest for nuclear power generation.

## 10. Conclusions

With the competition envisaged in the deregulation of the electricity sector, nuclear power can be utilized to ensure value for money for the Ghanaian consumer. The training currently ongoing at the School of Nuclear and Allied Sciences and the envisaged training in the universities and polytechnics can be utilized to provide the human resources necessary for nuclear power generation in the country.

Due to the credit-worthiness of the country, she can easily attract investors into the nuclear power generation program to reduce the burden on the Government. The country is endowed with the land and water resources that are relevant for nuclear power generation. The IAEA has shown through her numerous assistance packages for Ghana that she can be a reliable partner in our quest for nuclear power generation in the country. The Legislature is requested to expedite action on the passage of the bills currently before her so that we can progress to the next milestone of our nuclear power program.

Ghana needs to take concrete steps to utilize this opportunity to develop our nuclear practice and provide access to proven technology for her people. This will go a long way to help us attain our goal of economic development.

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# Patirtis, apžvalgos, diskusijos

## Išteklių poreikis atominės energijos gamybai Ganoje

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Per pastaruosius dešimtmečius atominė energija teikė reikšmingą naudą žmonijai. Šiai energetikai gaminti būtini geri atominės energetikos specialistai. Ganos atominės energetikos komisija ir Ganos universitetas, bendradarbiaudami su Tarptautine atominės energetikos agentūra (IAEA), įsteigė Atominės energetikos mokyklą, siekdami užtikrinti žmogiškųjų išteklių poreikį atominės energijos gamybai Ganoje. Straipsnyje analizuojami finansinių, žemės ir vandens išteklių poreikiai atominės energijos gamybai. Analizuota esama nacionalinė energetinė sistema. Aptarti branduolinio kuro poreikių šaltiniai, taip pat galimybė išgauti branduolinį kurą Ganoje. Aptartos teisinė sistema ir programa, kurią remia IAEA, kad Ganoje būtų plėtojama atominė energetika.

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