NUCLEAR POWER FOR FUTURE ELECTRICITY GENERATION IN GHANA: ISSUES AND CHALLENGES

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Abstract. Ghana's electricity demand has been estimated to be growing at a high rate of about 7% per annum over the last ten years. This is due to the relatively high population growth, economic aspiration of the country and the extension of electricity to rural areas. Electricity supply, on the contrary, has been unable to meet the demand due to high dependency on rain-fed hydropower plants, which started operating in 1965 and currently account for about 68% of the total installed capacity. Within the last 28 years, climatic changes and draughts have caused the nation to experience three major power crises. These climate changes resulted in low inflows and thus reduced power generation from hydropower systems. To complement the hydropower systems, the Government in 1997 installed thermal plants based on light crude oil. However, due to the high crude oil prices on the international market in recent times have made the operation of these plants very expensive. Ghana's crude oil find can boost its energy supply when the oil exploration begins somewhere in 2010. For rural cooking, domestic biomass is employed. Ghana has no domestic coal resources. The Government of Ghana is concerned with: limited further growth potential of domestic hydro; high cost of imported oil and gas and environmental issues associated with use of imported coal. Small Solar and wind generation exist in some sectors, but potential large-scale development is not envisioned for the near future. With these in mind, the President of Ghana set up a Committee involving Stakeholder Institutions to formulate the Nuclear Power Policy and develop the basic elements of Nuclear Infrastructure and to assess the viability of introducing the nuclear power option in Ghana's energy mix. Cabinet took a decision to include the nuclear power for electricity generation after the Committee submitted his report to the President in 2008.

1. INTRODUCTION

Ghana gained her independence in the same year as the first commercial nuclear power plant was built, i.e., in 1957. Ghana is signatory to 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 25th November 1964. The project was intended to introduce nuclear science and technology into the country and to exploit the peaceful applications of nuclear energy for national development [1]. The project was abandoned after the first president was removed from power in 1966 through a military coup de tat. We are now therefore further away from where we started off.

Ghana's electricity demand has been estimated to be growing at a high rate of about 7% per annum over the last ten years. This is due to the relatively high population growth, economic aspiration of the country and the extension of electricity to rural areas. Electricity supply, on the contrary, has been unable to meet the demand due to high dependency on rain-fed hydropower plants, which started operating in 1965 and currently account for about 68% of the total installed capacity. Within the last 28 years, climatic changes and draughts have caused the nation to experience three major power crises.

Ghana Atomic Energy Commission (GAEC) in Collaboration with the University of Ghana with assistance from the International Atomic Energy Agency (IAEA) has established the Graduate School of Nuclear and Allied Sciences to develop human resource base for the take off of the nuclear programme.

Ghana has participated and is still participating in coordinated research projects with the IAEA which help to increase the nuclear knowledge base of the country. GAEC is in close contact with other International Nuclear Agencies such as Global Nuclear Energy Partnership GNEP).

Ghana's Growth and Poverty Reduction Strategy (GPRS) is focus on the transformation of the Ghanaian economy from its current low income status into a middle income with a per capita income of about US$ 1,000 by 2015. This requires cost competitive, environmentally friendly and reliable source of grid electricity.

2. ELECTRICITY SUPPLY OPTIONS IN GHANA

Ghana's peak electricity demand is projected to exceed the generating capacity of 3,000 MW in 2015 with corresponding energy demand estimated at 26,600 GWh and 4,400 MW in 2020 and with 33,000 GWh energy demand. Development of the Bui dam to form cascade with the Akosombo and Kpong dams will increase capacity to 1,600 MW. Medium hydropower projects at Pwalugu on White Volta, Juale on Oti River, Hemang on Pra River and those on Ankobra and Tano can only provide a total of 425 MW. Contributions from renewable energy sources such as solar, wind, biomass will produce 380-500 MW, which cannot exceed 10% of the required total demand. Table 1 gives comparative cost assessment of possible energy sources for introduction of electricity into Ghana's energy mix. It can be seen that a 400 AP-600 NPP is very cost effective as compared to the small dams.

Table 1. Comparative Cost Assessment of Possible Sources of Energy in Ghana

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	400	4.0 – 6.0

3. NATIONAL POSITION

Nuclear Power Planning Committee (NPPC) involving Stakeholder Institutions was established by the President of Ghana in 2008 for the formulation of the Nuclear Power Policy and development of the basic elements of nuclear infrastructure. The Committee made recommendations on the following key issues to Government.

- Economics of nuclear power
- Legal, regulatory and legislative aspects on nuclear power
- Environmental and siting aspects of nuclear Power
- Selection of type of reactor
- Nuclear fuel cycle including waste management
- Role of government and private sector in the development of the programme
- Availability of the industrial base
- Human resource needs
- Extent of the uranium resources in the country and impact on the fuel policy
- Public acceptance

Based on these recommendations, the government took a cabinet decision in 2008 to introduce nuclear energy into Ghana's energy mix.

4. HUMAN RESOURCE DEVELOPMENT

Human resource capacity building currently in place is in two forms i.e., degree and non-degree awarding programmes.

In the degree awarding category, Ghana Atomic Energy Commission (GAEC) has established the Graduate School of Nuclear and Allied Sciences in collaboration with the University of Ghana with assistance from the International Atomic Energy Agency (IAEA) to award masters and Ph.D. degrees in nuclear science. The first batch of 37 masters students were admitted in 2006/7 academic year into 6 programmers. The school currently has 5 departments offering 10 accredited programmes. Programmes in place which are directly related to the nuclear power programme are

- Nuclear Engineering
- Applied Nuclear Physics
- Nuclear and Environmental protection
- Nuclear and Radiochemistry
- Nuclear Security and Safety
- Radiation Protection

The non degree training programmes involve the use of the 30kW Research Reactor in teaching and training of scientists and technicians in the field of reactor operation, physics, safety, engineering, maintenance etc. There are also IAEA Technical Cooperation Projects (TCs) such as GHA0008; Planning for sustainable energy development, GHA0009; Human resource development and nuclear technology support, GHA0011; Evaluating the role of nuclear power in future options for electricity generation and coordinated research projects such as Core Conversion and Benchmarking for safety etc., all these assistance have helped to increase the nuclear knowledge base of the country. Participation in IAEA training courses and workshops on national, regional and international levels are still ongoing. GAEC is in close contact with other International Nuclear Agencies such as Global Nuclear Energy Partnership (GNEP) etc.

5. 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 is been taken into account in the legal and regulatory infrastructure development. 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 nuclear damage, emergency management, criminal laws and taxation.

A comprehensive nuclear law touching on all the above and more have been considered. Some of the basic elements considered are: [2-16].

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.

Legislations dealing with establishing effectively independent regulatory authorities, with clear mandate on the responsibility for safety, security and safeguards. 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. Ghana's regulatory body is currently part of the promoting organization. A bill has been promulgated for parliamentary approval to establish an independent regulatory body.

Legislation required to be enacted pursuant to the relevant non-proliferation undertakings of the country.
Legislation with clear responsibilities and liabilities for the operation of nuclear facilities and the handling and safeguarding of nuclear material.

Legislation on foreign investment protection which includes the financial aspects, the roles of foreign entities, vendors and suppliers, financing strategy, funding or guarantees and intellectual property rights.
Legislation establishing an effectively independent regulatory body with full authority to implement the functions assigned to it by the enabling legislation.

Legislation dealing with fuel cycle issues in general and the ownership of nuclear material.
Provisions to be made for the development of human resources and physical facilities to ensure the continued integrity of the nuclear programme.

Legislation that specifies the allowed ownership of nuclear facilities and nuclear materials.
The commitment to use nuclear power for peaceful purposes and a comprehensive legislative oversight to be established in the country.

Legislation dealing with the roles of national government, local government, stakeholders and the public.
The legislative framework to maintained and amended as necessary during the life of the nuclear power programme.

All the above legislation, including the financial aspects, need to be 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.

6. SOME OTHER KEY ISSUES AND CHALLENGES

Other key issues that are essential for a country embarking on nuclear power programme to consider at both local and international levels have been investigated. The following have been considered:
Nuclear Safety – Ghana has experience in operating a research reactor for almost 15 years with good safety record.

Funding and financing – Financing of 1st NPP could be by Governments, private or through bilateral negotiation.

Legislative framework – Conventions and treaties are being processed for parliamentary approval.

Safeguards – Ghana is a signatory to NPT and Additional Protocol.

Radiation protection – Ghana has well established Radiation Protection Infrastructure that can be upgraded to deal with all emerging radiations.

Electrical grid – Ghana's grid size limits power level to about 1,000 MW.

Stakeholder involvement – All Stakeholders in the energy sector are currently involve in the NPP planning 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 coastline with the Gulf of Guinea in the Atlantic Ocean [17]. 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 Ghana to deploy a desalination plant for distilling water for use and for providing salt which can assist the nation in making brine for its oil production.

7. CONCLUSION

Ghana will require a secure electricity supply to meet expected future demand which is an essential requirement for economic development as envisaged under the government's growth and poverty reduction strategy. The existing installed capacity of almost 2000 MW inclusive of the emergency power plants will have to more than double in order to meet the peak power demand in 2020. But the existing fuel mix for grid power generation in Ghana will not be able to securely meet the future supply requirements for transforming the Ghanaian economy into a middle income status. The only alternative to avert supply disruptions is to explore other energy sources such as nuclear energy for electricity generation.

Nuclear energy is a mature technology which is expected to play an expanded role in meeting the growing demand for electricity in a safe and secure manner without contributing to global warming. Water cooled reactors will be ideal for Ghana due to vast water resources in Ghana. Ghana has to accelerate its infrastructure development if the 2018 target set for the inclusion of nuclear power in its energy mix is to be met.

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