GHANA

2012

1. GENERAL INFORMATION

1.1. Country overview

The country became an independent nation on 6th March 1957, and changed its name from Gold Coast to Ghana. On the1st July 1960, Ghana became a Republic with a Constitution. The political and economic development of the country went through a number of convolutions between 1966 and 1990. However, this situation of instability had ceased since the beginning of the 4th Republic, in 1992. The country has since made progress towards steady economic and political growth and stability.

There are ten administrative regions in the country (as shown in Figure 1 below), which are further sub-divided in 212 districts [1]. The city of Accra, on the Atlantic coast, is the administrative as well as the commercial capital. The other big cities are Kumasi, Tamale, Cape Coast and the twin-city of Sekondi-Takoradi.

Figure 1: Map of Ghana according to Regions

1.1.1. Governmental System

Ghana practices a multi-party parliamentary democracy, based on the 1992 constitution. This constitution, which ushered in the Fourth Republic, provides for a unitary state governed by a President and his Cabinet, unicameral parliament and an independent judiciary. The President has a four-year term, and an incumbent can serve for a maximum of two terms. Government decisions are taken at the Cabinet level and endorsed by the Parliament. The Parliament is made up of 230 members, who are elected to represent their constituencies for a four-year term [2]. The system of government is sustained and supported by a well-developed universal suffrage electoral process. The last election, which was held in December 2008, saw the government of the New Patriotic Party losing control of the Parliament and Presidency to the National Democratic Congress. Another election is expected to take place in December 2012.

The central government administration is decentralised to regional and district levels. Consequently, there are ten Regional Co-ordinating Councils and 212 Metropolitan, Municipal and District Assemblies, which serve as a means of involving grass-root participation in the formulation and implementation of government policies and in the general development of their area of jurisdiction [3].

The country has a very vibrant judicial system headed by the Chief Justice. The judicial system is based on Ghanaian common law, customary (traditional) law, and the 1992 constitution. In terms of hierarchy, the Supreme Court of Ghana is at the apex of the judicial system, followed by the Court of Appeal and the High Court of Justice.

1.1.2. Geography and Climate

The country is located about 750 km above the equator on the west coast of Africa. It lies between latitudes 4^o 44' and 11^o 11' north and longitudes 3^o 15' west and 1^o 12' east. Longitude 0^o or the Greenwich Meridian passes through the port city of Tema, which is to the east of the country.

The total area of the country is about 238,540 km^2, which is roughly the size of Great Britain. It stretches about 672 km from the southern-most point to the north, and 357 km from the east to the west. The country shares about 538 km of common land boundary with Burkina Faso in the north, 668 km of common land boundary with La Cote d'Ivoire in the west, and 887 km, of common land boundary with Togo on the east. The Gulf of Guinea, which is part of the Atlantic Ocean, forms the southern boundary of the country.

Ghana's landscape is drained by a number of rivers and streams. The major rivers are the following: the Black Volta, which has its origin in Burkina Faso and then flows along the north-western boundary of the country with La Cote d'Ivoire, before entering the country at its mid-section; the White Volta, which also has its origin in Burkina Faso, then flows into the country at the middle of the northern boundary; and the Oti River, which flows from Togo and enters the country along the north-east of the country. These rivers, flowing from the north, merge at about the middle of the country to form the Volta River. There are other rivers in the west, like the Pra,

Ankobra and Tano rivers, with origins in the highlands of the country. These rivers have good sites for the construction of hydropower plants. Two hydropower plants have been constructed on the Volta River, at Akosombo and Akuse. A third hydropower plant is now under construction at Bui on the Black Volta. There are also a number of coastal lagoons: Lake Bosumtwi, created by a meteorite, and the huge man-made Volta Lake, created after the construction of the hydroelectric dam at Akosombo.

The country's climate can be described as tropical, and is warm and humid. Average temperatures vary between 21^{o}C and 32^{o}C, with relative humidity varying between 50% and 80% [5]. There are two rainy seasons, and major and minor seasons occur throughout most of the southern sector of the country. The major rainy season occurs from April to July, while the minor rainy season occurs from September to November. These rainy seasons are separated by a short, cool dry season in August, and a relatively long dry season from December to April. The northern sector of the country experiences only one main rainy season, which occurs from April to September. The annual average rainfall varies greatly throughout the country, from 1,100 mm in the north to about 2,030 mm in the south. The rainfall is heaviest in south-western parts of the country, where mean annual rainfall is about 2,230 mm [5].

The variations in temperature, rainfall and humidity across the country's landscape are determined by the movement and interaction of the harmattan and the monsoon winds. The harmattan is hot and dry tropical continental winds, which blow from the northeast across the Sahara desert, from December to March, lowering the humidity and creating hot days and cool nights. The monsoon, a cool and moisture-laden tropical maritime wind, blows from the southwest over the Atlantic Ocean from the Gulf of Guinea.

1.1.3. Population

The 2010 Population and Housing Census estimated the country's population at about 24.66 million, compared to about 18.91 million in 2000 [6]. This gives an inter-censal annual population growth rate of about 2.67% p.a. The government's policy objective is to reduce this high annual population growth rate to about 1.50% by 2020 [7].

TABLE 1: POPULATION INFORMATION

							Average annual growth rate (%)
Year	1970	1980	1990	2000	2005	2010	2000 to 2010
Population (millions)	8.56	11.18	14.39	18.91	21.30	24.66	2.70
Population density (inhabitants/km²)	35.88	46.87	60.33	79.27	89.29	103.38	2.69
Urban Population as % of total	28.90	31.20	36.50	43.75	47.63	51.00	1.94
Area (1000 km²)	238.54						

Source: Ghana Statistical Service

The Ghana Statistical Service population projection for the medium variant scenario, assuming the impact of AIDS, indicates that the country's population will increase from about 24.66 million inhabitants in 2010 to about 30.2 million inhabitants in 2025 [6]. If this trend continues, the country's population is expected to reach about 32.0

million inhabitants in 2030, with an average annual growth rate of about 1.88%.According to the projections, the urbanization rate is also expected to increase, from 51% in 2010 to 62.9% in 2025, increasing further to about 63.4% in 2030.

1.1.4. Economic Data

The backbone of the country's economy has been the agricultural sector. This sector accounted for about 47.7% of total GDP in 1970. The sectoral contribution then increased to about 57.6% in 1980, before decreasing to about 29.8% in 2010. The agricultural sector employs more than half of the formal and informal work-force, producing major export products like cocoa and timber. The country was the world's largest cocoa producer in the early 1960s, exporting about 550,000 metric tonnes. Cocoa production declined to about 158,956 metric tonnes in 1983/84 but increased to about 1,004,190 metric tonnes in 2010/2011 crop season [8].

The country's industrial sector is made up of utilities, mining of natural resources (e.g. gold, manganese, diamonds, bauxite and salt), construction and low technology, low value-added light manufacturing activities. The industrial sector accounted for about 18.1% of the total GDP in 1970, but decreased to about 6.2% in 1982. The sector's contribution to total GDP has increased to about 19.1% in 2010 [9]. The manufacturing sub-sector played a significant role in the early 1970s, contributing about 14% of total GDP.

The main manufacturing outfits include Volta Aluminium Company (VALCO), an aluminium smelter, saw-mills and timber processing plants, breweries, textiles-manufacturing operations and oil refining. However, the sub-sector's contribution to total GDP stagnated from 1970 to 1977, and then decreased thereafter to about 2.3% in 1982. The manufacturing sub-sector experienced a steady growth after the Economic Recovery Programme launched in 1983, and by 2010, it was accounting for about 6.4% of total GDP [9]. The industrial sector is expected to receive a significant boost in growth as a result of the commencement of crude oil production from the Jubilee Field in December 2010.

The service sector is the fastest growing sector of the economy, with a growth rate of about 9.8% in 2010, compared to 6.9% for industry and 5.3% for agriculture. In 1970, the service sector accounted for about 34.3% of the total GDP, which increased to about 37.8% in 1982. In 2010, the sector's contribution increased to about 51.1% of total GDP. The tourism and ICT sub-sectors have a lot of potential but have remained unexploited. There are a number of tourist attractions such as waterfalls, beaches, castles and forts and historical sites in the country. The government's strategy is therefore to exploit the huge potential in tourism and ICT, to increase the foreign exchange earnings.

TABLE 2: GROSS DOMESTIC PRODUCT (GDP)

							Average annual growth rate (%)
	1970	**1980**	**1990**	**2000**	**2005**	**2010****	**2000 to 2010****
GDP (millions of current US$)[1]	2,214.10	4,445.23	5,248.94	4,977.49	10,720.35	32,174.58	20.52
GDP (millions of constant 2000	2,549.68		3,266.89	4,977.49	6,364.08	8,779.40	5.84

US$)[2]		2,639.87					
GDP per capita (PPP* US$/capita)[3]	1206.0	992.8	907.1	1066.8	1208.0	1478.5	3.32
GDP per capita (current US$/capita)[4]	255	407	398	260	495	1319	17.63
Sectoral share of GDP[5]							
- **Agriculture**	47.66	57.58	44.85	35.90	38.82	29.8	-1.85
- **Industry**	18.08	11.80	16.77	25.22	24.57	19.1	-2.74
- **Service/Commerce**	34.26	30.62	38.38	38.88	36.60	51.1	2.77

* PPP: Purchasing Power Parity (2005 International dollar) ; ** Latest available data Source: 1,2,3 and 4 from databank.worldbank.org/data; 5 for Ghana Statistical Service, National Accounts Statistics, May 2011

The government's future economic outlook is contained in its current Ghana Shared Growth and Development Agenda (GSGDA) covering a period 2010-2013. The thrust of this development agenda is to maintain macro-economic stability and generate higher levels of shared growth in order to reduce socio-economic inequalities, ensure rapid reduction in poverty and accelerate the achievement of the Millennium Development Goals. Hence, employment and improved standards of living especially for the marginalized are some of the expected outcomes from the implementation of national and various sectoral (i.e. including energy) development policies. Some of the key thematic areas of focus for the GSGDA are:

- Ensuring and sustaining macro-economic stability;
- Accelerated agricultural modernization and natural resource management;
- Oil and gas development;
- Infrastructure, energy and human settlements development;
- Enhanced competitiveness of the private sector; and
- Human development, employment generation and productivity enhancement.

The government's strategy hinges on the promotion of private investments in the manufacturing and agricultural sectors. This strategy is expected to diversify the country's export basket and avoid the adverse impacts of fluctuating world market prices of cocoa and other primary export commodities. The long-term projected average annual GDP growth rate has been estimated at 6-8%, which is expected to be accompanied by structural change in the economy [10].

1.2. Energy Information

In terms of energy resources endowments, the country cannot be compared to countries like Egypt, Libya, Algeria, Nigeria, Angola, Democratic Republic of Congo and South Africa. Until the discovery of oil and gas in the country, hydropower potential used to be the largest indigenous commercial energy resource. It has been estimated that the country has about 2,500 MW of hydropower potential, about 60% of which would have been exploited by the end of 2013 [11]. The major exploited hydropower potentials are the 1,020 MW Akosombo Hydropower and 160 MW Kpong Hydropower plants on the Volta River. A third 400 MW Bui Hydropower plant on the Black Volta is under construction, expected to come online in 2013. The

cost of the project was estimated to be about US$ 600 million [12]. The country's hydropower systems sometimes suffer from low capacity utilization due to perennial droughts, for example in 1983/84, 1997/98 and 2006/07.

In 2007, commercial quantities of crude oil and associated natural gas were discovered at about 63 km off-shore at the Cape Three Points sedimentary basin. Appraisal of the find in the Jubilee Fields indicates about 1.8 billion barrels of crude oil originally-in-place, with reserves of about 800 million barrels [13]. Since this discovery, a number of other discoveries have also been made to increase the country's total crude oil find to 3.8 billion barrels of oil-in-place, with reserves of about 1.7 billion barrels and 985 million barrels of condensate [13]. Some of these oil discoveries are associated with natural gas deposits. Non-associated natural gas deposits have also been discovered. Total natural gas deposits have been estimated at over 10.0 TCF (trillion cubic feet) gas-in-place, with 6.396 TCF as recoverable [14].

Crude oil production from the Jubilee Field began in December 2010. Daily crude oil production rates in 2011 have been about 70,000 barrels on average, which is far lower than the anticipated 120,000 barrels [15]. In 2011, the total crude oil production from the Jubilee Field was about 23.76 million barrels [15]. Furthermore, about 650 barrels of crude oil per day is being produced from the off-shore Saltpond Fields, which were discovered in 1974, but not put into commercial production because it was then uneconomic due to low crude oil prices [15]. Alongside the production of crude oil from the Jubilee Field is natural gas, which was being produced at about 100 mmscf per day (million standard cubic feet) on average, in 2011 [15]. A large proportion of the gas is re-injected into the oil reservoir to boost pressure, while some is used as fuel on the rig and the rest flared. In 2011, a total of 29.94 $*10^3$ mmscf of gas was produced from the Jubilee Field [15].

The Energy Commission has undertaken a wind resource assessment along the coast of the country, east of the Greenwich Meridian. The results indicate that there exist wind regimes with speeds between the range of about 5.5m/s and 6.2m/s. An evaluation by experts from Risoe of the potential of the wind regime to generate electricity established a potential of about 300-500 MW [16]. The average annual solar irradiation in different parts of the country ranges from 4.4 kWh/m^2/day to 5.6 kWh/m^2/day [16]. This large solar potential can be harnessed for electricity and process heating purposes. However, the current cost of the technology is excessive and not easily affordable. In order to promote the deployment of renewable sources of energy, the government enacted a Renewable Energy Law in 2011. A feed-in tariff scheme is also being developed, to promote investment in renewable energy technologies.

The country imports about 45,000 BPSD and 15,000 BPSD of crude oil for refining into petroleum products and electricity generation respectively [15]. As a result of the inadequate capacity of the refinery, about 1.59 million metric tonnes of refined petroleum products were imported into the country in 2010 [15]. The country has also been importing natural gas from Nigeria for electricity generation since 2010, through the West African Gas Pipeline. In 2010 and 2011, about 14.62*103 mmscf and 28.58*103 mmscf of natural gas was imported, which were 33% and 65% respectively of 43.8*103 mmscf [15]. This was the expected amount.

1.2.1. Estimated Available Energy

The country's domestic energy resources are crude oil, natural gas, hydropower, and other renewable energy sources like wind, solar and traditional biomass. The table below shows the reserves of these energy resources.

TABLE 3. ESTIMATED AVAILABLE ENERGY SOURCES

	Estimated available energy sources					
	Fossil Fuels			Nuclear	Renewables	
	Solid	Liquid	Gas	Uranium	Hydro	Other Renewable
Total amount in specific units*	0	383.57	66106.82	0	1580	300
Total amount in Exajoule (EJ)	0	16.769	1173.667	0	0.0299	0.002554

* Solid, Liquid: Million tons; Gas: Billion m3; Uranium: Metric tons; Hydro, Renewable: MW
Sources of data: Ghana National Petroleum Corporation; Volta River Authority; Energy Commission
Note: *Other renewable in this case is only wind (total annual production). It excludes solar and traditional biomass*

1.2.2. Energy Statistics

TABLE 4. ENERGY STATISTICS *(Units: Exa Joule – EJ)*

	1970	1980	1990	2000	2005	2010*	Average annual growth rate (%) 2000 to 2010*
Energy consumption**							
- Total	0.046758	0.053348	0.056273	0.114674	0.11286	0.157141	3.20
- Solids***	0	0	0	0	0	0	0
- Liquids *	0.036697	0.03662	0.039633	0.089749	0.091564	0.114457	2.46
- Gases	0	0	0	0	0	0.014873	0
- Nuclear	0	0	0	0	0	0	0
- Hydro **	0.010061	0.016728	0.01664	0.024925	0.021296	0.027811	0.27
- Other Renewables	0	0	0	0	0	0	0
Energy production							
- Total	0.010374	0.018998	0.020595	0.023795	0.020263	0.034968	3.92
- Solids***	0	0	0	0	0	0	0
- Liquids	0	0	0	0	0	0.007732	not applicable
- Gases	0	0	0	0	0	0.002053	not applicable
- Nuclear	0	0	0	0	0	0	0
- Hydro	0.010374	0.018998	0.020595	0.023795	0.020263	0.025183	0.57
- Other Renewables	0	0	0	0	0	0	0
Net import (Import - Export)							
- Total	0.036697	0.038200	0.036903	0.091447	0.092196	0.111237	1.98

* Latest available data
** Energy consumption = Primary energy consumption + Net import (Import - Export) of secondary energy.
*** Solid fuels include coal, lignite
Note: Data excludes traditional biomass
Source: Energy Statistical Bulletin 2000 – 2011, Energy Commission Publication, April 2012

1.2.3. Energy policy

The Ghanaian energy sector went through a phase change in the mid-1990s, triggered by a shift in the overall policy framework. Prior to the mid-1990s, the country's energy sector was financed by the government and managed by public utilities and companies. Some private oil marketing companies were however involved in the distribution and marketing of petroleum products. In 1994, the government initiated the process of reforming and restructuring the energy sector to improve operational efficiency, and increased consumer access to electricity and petroleum products.

The objective of the policy shift was (i) to create an environment, which can attract private investment for the expansion of electricity generation and refinery capacity; (ii) to deploy technical innovation; (iii) to ensure realistic energy pricing policy and competition; and (iv) to incorporate use of renewable energy resources into the country's energy mix [17]. The policy sought to phase out the government's involvement as owner and manager of energy business and re-focus its role on policy-making and market regulation. Consequently, with the government out of the energy business, it can save public funds to improve social infrastructure.

In the pursuit of the reform, the Public Utilities and Regulatory Commission was established in 1997 by a Parliamentary Act, Act 536. Among other functions, this intended to (i) regulate utility tariffs; (ii) ensure customer protection and (iii) promote competition in the provision of energy services [18]. This was followed by another Parliamentary Act in 1997, Act 541, which established the Energy Commission in order to, among other functions, (i) regulate technical standards in the provision of energy *(excluding crude oil and natural gas)*; (ii) prepare, review and periodically update indicative energy plans to ensure that all energy requirements of the economy are met in a sustainable manner; and (iii) formulate national energy policies for the development and utilization of indigenous energy resources, in particular renewable energy sources: solar, wind and biomass [19].

Furthermore, the National Petroleum Authority was established in 2005 by a Parliamentary Act, Act 691. Among other things, it was to (i) regulate the price of petroleum products; (ii) establish standards in the downstream petroleum sector; and (iii) promote competition in the supply of petroleum products [20]. The energy sector reform policy is expected to limit the role of government to the operation of the electricity transmission network, market regulation and energy sector planning.

The restructuring of the energy sector was undertaken in order to create an environment where market forces are allowed to play and drive competition, thereby improving operational efficiency and reducing the costs of service delivery. Consequently, the electricity generation, oil refining and importation of crude oil and refined products sub-sectors have all been liberalized to promote competition. Currently, there are three companies (a private, public-private and public) generating electricity in the country. A two-tier Wholesale Electricity Market (i.e. contract or

unregulated and regulated) has also been established for the sale and purchase of bulk electricity. In the contract market, electricity consumers are free to negotiate for the price and quantity of electricity with their suppliers. The price of electricity outside the contract market is regulated by PURC.

In the case of the petroleum sector, market liberalization was expected to promote efficient market operation and realistic pricing of petroleum products. The number of companies operating in various segments of the sub-sector increased with the market liberalization. The number of companies importing refined petroleum products increased from one (i.e. Tema Oil Refinery) before 2005 to 8 in 2010. Similarly, the number of oil companies distributing and marketing refined products has also increased, and there are 58 oil marketing and 19 LPG marketing companies in 2010. Alongside this expansion in the number of companies distributing and marketing of refined petroleum products is a drastic increase in the number of service or retail outlets, which has brought products closer to consumers. This rapid increase in industry players is a result of the new policy to increase competition and bring petroleum products closer to consumers. The government also established the Bulk Oil Storage and Transportation (BOST) Company Ltd. to expand capacity and maintain strategic petroleum products reserves.

The main aim of the government's energy strategy is to facilitate the sustainable exploitation and efficient use of domestic energy resources to enhance energy supply security and to promote economic growth and improvement in quality of life of Ghanaians. In this regard, the government seeks to develop the small and medium hydropower resources in the country for multiple purposes, including electricity generation and job-creation. A Renewable Energy Law has also been enacted in December 2011, and a feed-in-tariff scheme is being developed to promote the exploitation of renewable energy sources like solar and wind. The government expects renewable energy sources to account for about 10% of the total primary energy mix by 2020.

The country depends entirely on foreign sources for all of its crude oil supply. Imports of crude oil and petroleum products account for a substantial proportion of the country's annual foreign exchange earnings, which undermines economic growth. In an effort to address this situation, the government established the Ghana National Petroleum Corporation (GNPC) in 1984, to facilitate rapid exploration and development of hydrocarbon resources in the country. In 2001, GNPC was restructured to focus on its core business of the technical evaluation of the hydrocarbon potentials in the country and aggressive promotion of the exploratory blocks. The fiscal and regulatory frameworks for exploration were reviewed, to attract foreign investors and intensify exploration activities.

In 2007, commercial quantities of crude oil and natural gas were discovered in the off-shore Cape Three Points sedimentary basin. The government's policy is to monetize the natural gas by stripping it of Liquefied Petroleum Gas (LPG), and use the dry natural gas for electricity generation and other industrial uses. The LPG is expected to be sold in the domestic market, with the excess exported.

The impact of climate change on the country includes a rise in average temperature, variability in rain fall, changes in the intensity and pattern of extreme weather events

and a rise in sea level [5]. The country depends on hydropower generation for much of its electricity supply. Reduced rainfall and iterant droughts have affected electricity supply from the hydropower systems, especially in 1983/84, 1997/98 and 2006/07, when there was drastic shortfall in electricity generation from the hydropower systems. These led to about a year long National Load shedding exercise. Hence, extreme weather patterns will pose a lot of danger to the development and sustainability of mini- and small hydropower facilities, as most of them could dry out completely in the dry seasons.

Other extreme weather conditions which affect hydropower generation include observed rise in mean surface temperatures, which has led to increased evaporation of water from the 8,500 sq km surface area of the Volta Lake [21]. This results in the loss of high volumes of water which could have been used for hydro generation. On the other hand, there have been severe rainstorms, especially in the catchment area of the Volta River. These rainstorms lead to excessive water inflows in the Volta Lake, which tend to threaten the safety of the dam. In November 2010, the Volta River Authority was forced to spill water from the dam when the water level in the reservoir reached a height of 277.1 ft (the maximum height is 278 ft). This is the highest level reached since the dam was constructed in 1961.

The development of renewable energy sources like wind, solar and biomass-based electricity generation, which depend so much on weather patterns, could also be threatened by climate change and by extreme weather variability. Furthermore, persistent droughts experienced in the country are known to adversely affect the growth and availability of fuel wood, especially in the savannah zones, where there is high dependency.

In an effort to secure energy supply and promote inter-regional energy trade, the country imports natural gas from richly endowed Nigeria through the West African Gas Pipeline, and trades in electricity with its neighbors.

1.3. The electricity system

1.3.1. Electricity policy and decision making process

The main policies that govern the electricity sector are formulated by the Ministry of Energy. The Ministry is also responsible for the monitoring and evaluating of policies, programmes and projects in the electricity sector. The Energy Commission, a quasi-independent body established by the Energy Commission Act 1997 (Act 541), is the government's energy policy advisor and makes national energy policy recommendations to the Minister of Energy. The Commission advises the Minister of Energy on national energy policies for the efficient, economic and safe supply of electricity and natural gas, having due regard for the economy. In addition, the Commission is to formulate national policies for the development and utilization of indigenous energy resources, in particular renewable energy: solar, wind and biomass.

There has been a shift in the electricity sector policy direction since the mid-1990s. The electricity sector has been reformed to attract private sector investment and state-of-the-art technology to electricity generation. As part of the reform, the Volta River

Development Act (Act 61), which established the Volta River Authority, was revised in 2005 into the Volta River Development Amendment Act, Act 692 [22]. The new Act 692 ceded the electricity transmission function of VRA to a new company, Ghana Grid Company (GRIDCo) Limited, incorporated on December 15, 2006, as a private liability company under the Companies code 1963, Act 179. GRIDCo is expected to provide fair and non-discriminatory transmission services to all electricity market participants.

The reform policy expects the establishment of a Wholesale Electricity Market to promote competitive electricity pricing. In 2008, Parliament enacted Wholesale Electricity Market – Technical Rules (Legislative Instrument n^{o}.1934) and Wholesale Electricity Market – Operational Regulations (Legislative Instrument n^{o}.1937), which effectively establish the Wholesale Electricity Supply Market

The planning of the electricity sector system is the responsibility of the Energy Commission. The Commission has been given the mandate to prepare, review and periodically update indicative national energy plans, to ensure that all reasonable demands for energy are met. The Commission has undertaken the Strategic National Energy Plan (2006-2020) and Planning for Sustainable Energy Development – Ghana Country Study (2004-2030) studies, and is currently in the process to Updating the Strategic National Energy Plan. The Energy Commission and the Ghana Grid Company have also undertaken a Generation Master-plan Study for Ghana.

Two power system planning studies have taken place in the recent past. The Energy Commission and other stakeholders under the IAEA National TC project GHA/0/008 undertook "Planning for Sustainable Energy Development – Ghana Country Study". The other study, "Generation Master-plan Study for Ghana", was undertaken by Tractebel Engineering on behalf of Energy Commission and GRIDCo Ltd. These two studies were based on Bui Hydropower plant coming online in 2013, the use of natural gas from Nigeria imported through the West African Gas Pipeline, and domestic Jubilee Fields for electricity generation. The least-cost capacity requirements for the two studies are shown in Figures 2 below.

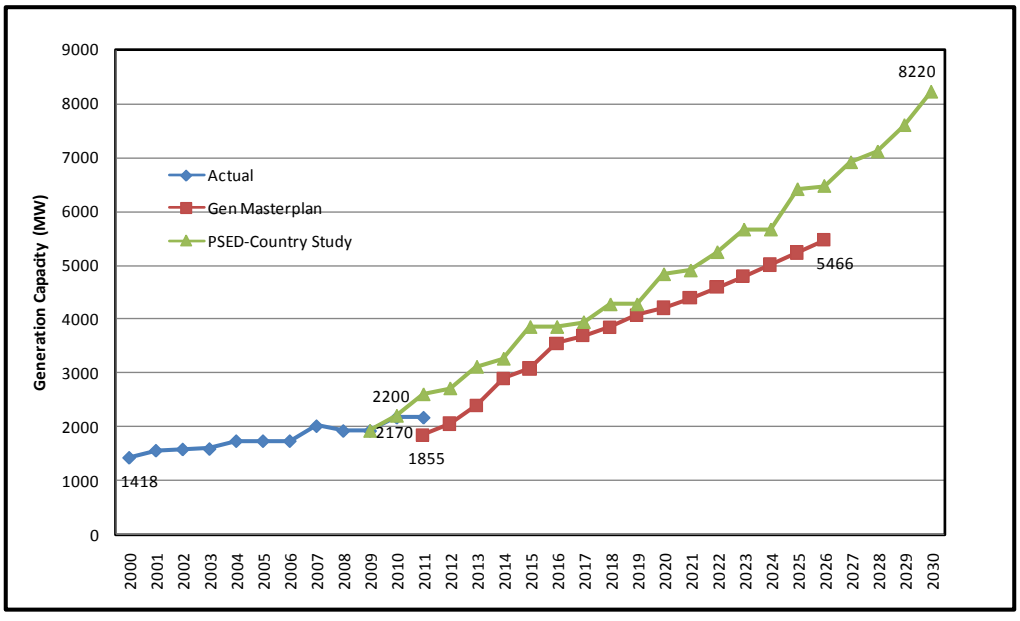


Figure 2: Actual and Projected Electricity Generation Capacity

The actual generation capacity increased from about 1,418 MW in 2000, at an annual growth rate of about 4.3%, to 2,170 MW in 2010. The low growth rate in capacity additions to the generation system during this period can be attributed to lower demand due to the absence of Volta Aluminium Company, an aluminium smelter, and inability to attract adequate investment for capacity expansion. Hence, there was a high degree of suppressed demand in the electricity system during this period. According to the results of the "Planning for Sustainable Energy Development – Ghana Country Study", the generation capacity is expected to increase from 2,200 MW in 2010 to 8,220 MW in 2030, at an annual growth rate of 6.8%. In the case of the results of the Generation Master-plan Study for Ghana, the generation requirement is expected to increase from 1,855 MW in 2011 to 5,466 MW in 2026, at an annual growth rate of 7.5%.

The results of the studies show that the dominant fuel for electricity generation in the future is expected to shift from hydropower to fossil fuels. This is expected to be associated with a higher level of emissions from the electricity generating system. The results for Planning for Sustainable Energy Development – Ghana Country Study show that nuclear power is favoured only under assumptions of strict environmental regulations and a moratorium on importation of fuels for electricity generation excepting natural gas imports from Nigeria.

It is expected that future investment in generation capacity expansions will also require investment in network expansions, to ensure reliability of supply and that the electricity generated gets to customers.

1.3.2. Structure of electric power sector

The organizational structure of the electricity sector is shown in Figure 3 below:

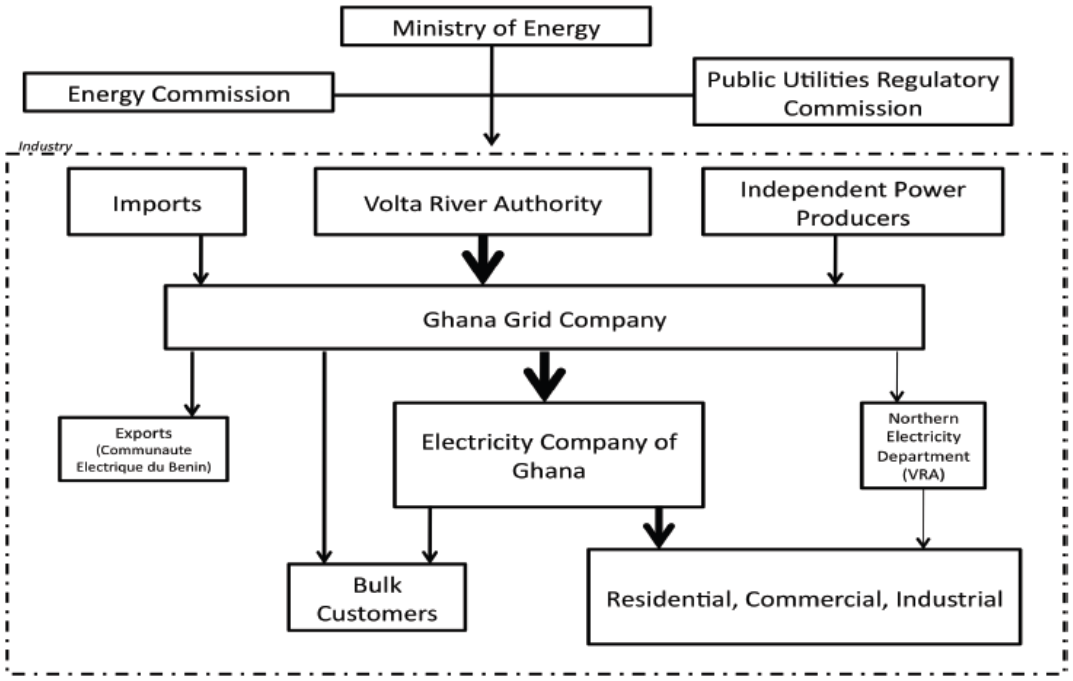


Figure 3: Structure of Ghana Electricity System

(Source: Power Sector Reform and Regulation in Africa – Chapter 6)

The country's electricity generation system is made up of two hydropower and six thermal power plants. The two hydropower plants are located on the Volta River at Akosombo and Kpong, in the Eastern Region of the country. The plant at Akosombo has a capacity of 1,020 MW, while that at Kpong has a capacity of 160 MW. Together, the hydropower plants account for about 54% of the total installed capacity. The two plants are managed and operated by Volta River Authority, a public utility.

Two of the six thermal power plants, which account for about 56% of the total thermal power capacity, are located at Aboadze near Takoradi, in the Western Region, while the rest are in Tema near Accra, in the Greater Accra Region. The thermal power plants at Aboadze comprise one 330MW combined cycle power plant, operated by Volta River Authority, and one 220 MW simple-cycle combustion turbine, owned and operated by Takoradi International Company Ltd, which is 90% owned by the Abu Dhabi National Energy Company (TAQA) and 10% by Volta River Authority. In 2010, TAQA signed a Memorandum of Understanding with the Government of Ghana and the Volta River Authority in relation to the expansion of their power plant into a 330 MW combined cycle by adding a 110MW steam generator turbine. In July 2012, the African Development Bank (AfDB) Group approved a sum of US$60 million for the project [23]. These two plants can be operated on light crude oil or natural gas. At present, they run mostly on light crude oil, due to challenges of natural gas availability.

The remaining four thermal power plants comprise: one 200MW combined cycle plant, owned and operated by Sunon Asogli Power Company, which runs on natural gas delivered via the West African Gas Pipeline; one 110MW simple-cycle combustion turbine, owned and operated by the Volta River Authority, which runs on light crude oil or natural gas; and two diesel generators. One of the two diesel generators (49.5MW) is owned and operated by Volta River Authority, and the other 80MW generator is owned by a consortium of mining companies but operated by the Volta River Authority.

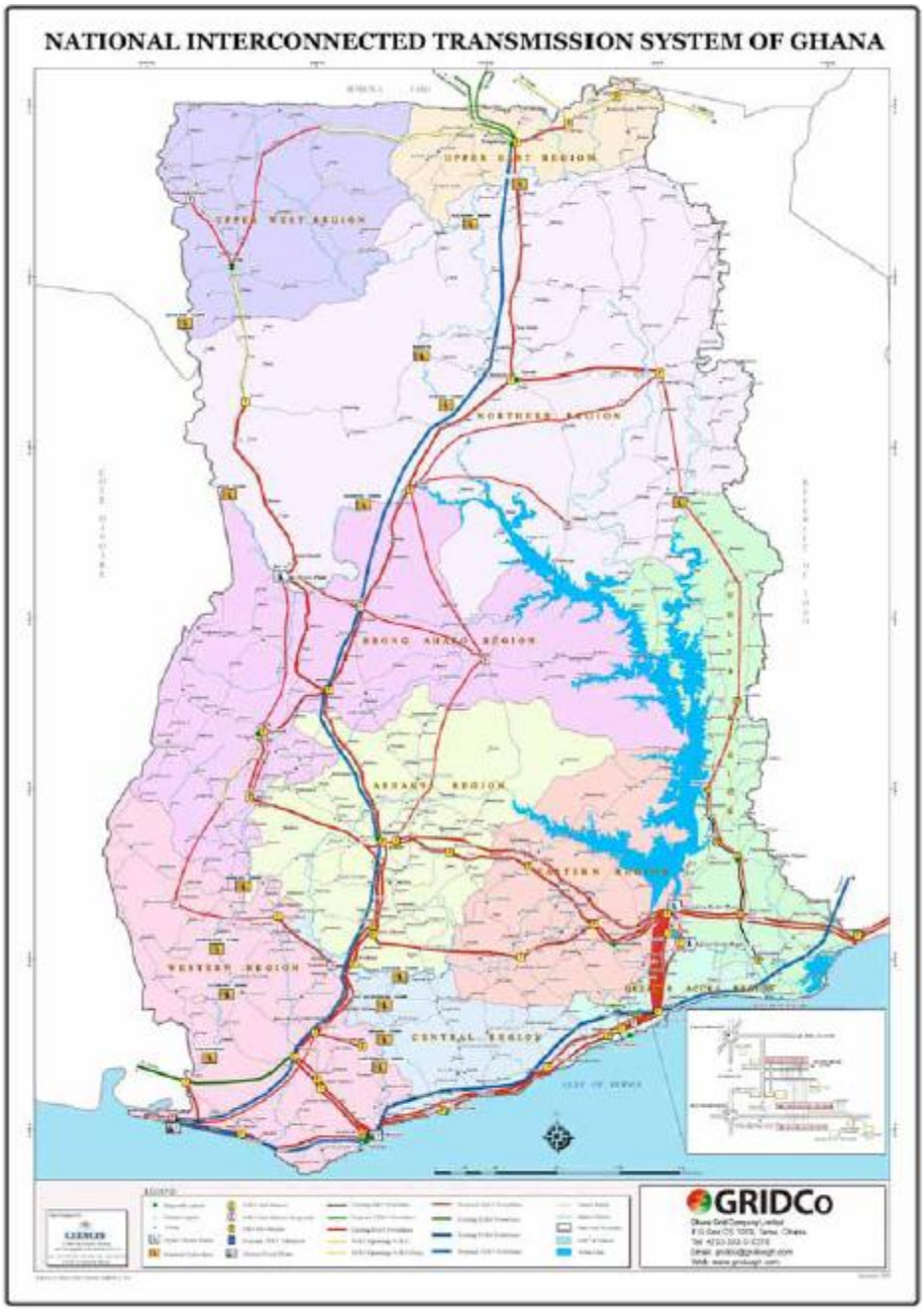
In 2010, these power plants had a total installed capacity of about 2,170 MW, of which about 1,790 MW was available capacity due to various technical and hydrological constraints. These plants generated a total of 10,167 GWh of electricity in 2010, about 40% more than the amount generated by the power plants operating in 2000.

Table 5: Installed Capacity and Electricity Generation in 2010

Company	Installed Capacity in 2010 (MW)	Electricity Generation in 2010 (%)
Volta River Authority	1749.5	87.2
Hydropower	1180	68.8
Thermal	569.5	18.4
Takoradi International Company	220	11.4
Hydropower	0	0.0
Thermal	220	11.4
Sunon Asogli Power Company	200	1.4
Hydropower	0	0.0
Thermal	200	1.4
Total	2169.5	100.0

Source: Computed from Energy Statistical Bulletin 2000-2011, publication of Energy Commission, April 2012

The electricity transmission system of the country is interconnected with the networks of CIE (Compagnie Ivoirienne d'Electricité) of Cote D'Ivoire at Elubo, via a 225kV transmission line, CEB (Communaute Electrique du Benin) of Togo and Benin at Lome, via a 161kV transmission line in the south, and at Dapaong in the north via 33kV low voltage lines, and that of SONABEL of Burkina Faso at Po and Leo, via a 33kV transmission line. The Ghana Grid Company Ltd manages the country's transmission network and acts as the Independent System Operator (ISO), and therefore has dispatch responsibility. The country's National Interconnected Transmission System is shown in Figure 4 below.



Figue 4: National Interconnected Transmission System (Source: GRIDCo)

The transmission network connects the electricity generation sites at Akosombo, Kpong, Aboadze and Tema to the various load centres in the country. The network is made up of more than 40 primary substations (transformation and switching substations), linked by over 4,315.5 km of high voltage transmission lines. About 3,888.1 km and 132 km of the transmission system are energized at 161kV and 69kV respectively. Furthermore, 73.4 km of the transmission is also energized at 225kV. The current total installed transformer capacity of the network is 2,915 MVA [24].

There is an on-going project to replace all the 161kV lines with 330kV as the primary voltage. About 219.5 km of the 161kV lines have already been replaced with 330kV lines. There is a regional effort to integrate the transmission networks of ECOWAS member states to facilitate power trade among the regional entities. In this regard, the West African Power Pool (WAPP) has begun efforts to build regional transmission lines to interconnect major load centres. One such regional transmission line is the 330kV Aboadze-Volta (Tema)-Lome (Togo)-Sakete (Benin)-Ikeja West (Nigeria) transmission line. There are also plans to build additional regional lines such as the 330kV Takoradi (on the coast)-Kumasi-Han (in the north) transmission line [24]. Upon completion of these projects, the country's primary transmission backbone will be 330 kV, which will provide significant reinforcement and increased power transfer capability from generators to load centres. In 2010, the transmission network transported about 10,232.1GWh of electricity with 3.7% losses, compare to the 8,066.2GWh transmitted 2000 with 2.8% losses on transmission [15].

The high transmission voltages are reduced to 34.5kV, 11.5kv and 6.6kV at primary substations, for supply to bulk customers and/or onward distribution to end-users throughout the country. Electricity distribution in the country is undertaken by two public distribution companies (Electricity Company of Ghana Ltd. (ECG) and Northern Electricity Distribution Company Ltd (NEDCo)) and one private distribution company (Enclave Power Distribution Company Ltd.). ECG distributes electricity in the southern sector of the country to a total customer population of 2,120,564, as of the end of 2010 [25]. On the other hand, NEDCo distributes electricity in the northern sector of the country to a total population of 342,207 [26].

Figure 5: Electricity Distribution Zones: *ECG (yellow) and NEDCo (red)*
Source: Ghana Wholesale Power Reliability Assessment Final Report 2010

As at the end of 2010, the electricity distribution network of Electricity Company of Ghana comprised of 26 bulk supply points, 98 of 33/11 primary substations and about 8,787 secondary sub-stations. The sub-transmission lines are made up of about 14,177 km of 33 kV lines, 15,521 km of 11 kV lines and 1,458,355 of LV lines. In 2010, ECG distributed a total of 6,771.3GWh of electricity, of which 26.9% was accounted for as losses, compared to 3,989 GWh in 2000, with 27% losses (both commercial and technical) [15].

The total distribution network of Northern Electricity Distribution Company Ltd. (NEDCo) is made of 5 bulk supply points, 7,832 km of low voltage lines and 5,486 km of medium voltage lines [26]. In 2010, NEDCo distributed a total of 635 GWh of electricity, of which 25.5% was accounted for as losses, compared to 330 GWh in 2000, with 30% losses (both commercial and technical) [15].

The Enclave Power Company is a private electricity distribution company operating in the Tema Free Zone area.

1.3.3. Main indicators

TABLE 6. ELECTRICITY PRODUCTION, CONSUMPTION AND CAPACITY

	Average annual growth rate (%)

	1970	1980	1990	2000	2005	2010*	2000 to 2010*
Capacity of electrical plants (GWe)							
- Thermal	0.06	0.06	0	0.47	0.55	0.9895	7.7.
- Hydro	0.59	0.91	1.07	0.95	1.18	1.18	2.2
- Nuclear	0	0	0	0	0	0	0
- Wind	0	0	0	0	0	0	0
- Geothermal	0	0	0	0	0	0	0
- other renewable	0	0	0	0	0	0	0
- Total	0.65	0.97	1.07	1.42	1.73	2.14	4.3
Electricity production (TW.h)							
- Thermal	0.04	0.04	0.01	0.61	1.16	3.14277	17.8
- Hydro	2.88	5.28	5.72	6.61	5.63	6.995409	0.6
- Nuclear	0	0	0	0	0	0	0
- Wind	0	0	0	0	0	0	0
- Geothermal	0	0	0	0	0	0	0
- other renewable	0	0	0	0	0	0	0
- Total (1)	2.92	5.32	5.73	7.22	6.79	10.13818	3.4
Total Electricity consumption (TW.h)	2.79	4.65	4.62	6.92	5.92	7.725313	1.1

(1) Electricity transmission losses are not deducted.
* Latest available data
Source: Volta River Authority, Ghana Energy Statistical Bulletin - 2011,
Note: Capacities are recorded as gross

TABLE 7: ENERGY RELATED RATIOS

	1970	1980	1990	2000	2005	2010*
Energy consumption per capita (GJ/capita)	5.4624	4.7717	3.9106	6.0642	5.2986	6.3723
Electricity consumption per capita (kW.h/capita)	326.48	415.61	321.20	366.13	277.73	313.27
Electricity production/Energy production (%)	31.8966	38.4417	40.2376	39.9529	28.3929	47.4997
Nuclear/Total electricity (%)	0	0	0	0	0	0
Ratio of external dependency (%) (1)	78.4828	71.6053	65.5785	79.7452	81.6906	70.7880

(1) Net import / Total energy consumption.
* Latest available data
Source: Calculated from data from Volta River Authority, Tema Oil Refinery and National Petroleum Authority
Note: Data excludes Traditional Biomass

2. NUCLEAR POWER SITUATION

2.1. Historical development and current organizational structure

2.1.1. Overview

The country's attempt to acquire nuclear power technology dates back to 1961. The government took a decision at that time to initiate the Kwabenya Nuclear Reactor Project. The objectives of the project were to introduce nuclear science and technology into the country, and to exploit nuclear energy in its peaceful applications for the solution of problems of national development. The government therefore set up the Ghana Atomic Energy Committee, to implement the nuclear project. The Committee was later replaced by Ghana Atomic Energy Commission (GAEC), through an Act of Parliament (Act 204) in 1963. The main functions of the

Commission include the promotion, development and utilization of peaceful applications of nuclear and biotechnological techniques for the economic and social advancement of Ghana [27]. In 2000, new Ghana Atomic Energy Commission Act 588 superseded Act 204.

The main rationale behind the country's nuclear power ambitions can be found in the speech delivered by Dr. Kwame Nkrumah, the first president of the Republic of Ghana, on November 25, 1964. In this speech, the president declared: *We have been compelled to enter the field of Atomic Energy, because this already promises to yield the greatest economic source of power since the beginning of man. Our success in this field will enable us to solve the many-sided problems which face us all, in all the spheres of our development in Ghana and Africa* [28]. Hence, the nuclear programme was expected to build local human capacity in the area of nuclear research and deploy nuclear reactor technology to secure the country's long-term energy independence.

The initial agenda of GAEC therefore included the building a nuclear research reactor, to facilitate the development of manpower and promote plans to undertake a nuclear power programme. The implementation of the project began with the training of Ghanaians and development of manpower in fields of nuclear science and technology, to support the introduction of nuclear power for electricity generation in the country in order to support rapid socio-economic development. As part of the project, a bilateral agreement with the former United Soviet Socialist Republic (USSR) was to provide scientists and technicians to man the initial stages. The construction of physical infrastructure for the implementation of the project had reached an advanced stage, with the project expected to take off by the end of 1966, when a military coup d'etat on February 24, 1966, terminated the project.

In 1973, a new management committee and a Reactor Technical committee were established to reactivate the reactor project. The new management committee made efforts to acquire a 1 MW reactor belonging to Frankfurt University, in the Federal Republic of Germany. All documentation with regards to the acquisition of the reactor was signed by the government, and payments towards the dismantling of the reactor in Germany, its shipment to Ghana and subsequent assembly at the project site at Kwabenya were all concluded. However, before the shipments were made, another coup d'etat in the country forced the government of the former FRG to cancel all the arrangements, which once again stalled the country's effort to embark on a nuclear power programme.

These events resulted in the waning of government interest in the development of a nuclear power programme, and the exodus of the core of the country's nuclear experts. A long lull in nuclear power development lasted until 1997/98, when the country experienced a drastic shortfall in electricity generation as a result of poor inflows into the Volta Lake, the reservoir of the Akosombo Hydropower plant. This situation led to almost one national load-shedding exercise and had enormous impact on socio-economic development. The issue of electricity supply security became a national concern, and nuclear power was proposed to offer a solution to the perennial shortfalls in hydropower generation. However, when the crisis faded away, interest in nuclear power also waned.

The prospects of nuclear power came to the fore again in 2007, when the country's hydropower generation was crippled due to protracted drought in the sub-region, from 2003 to 2006. The situation was aggravated by the following two factors: (i) drastic curtailment in electricity supply from Cote d'Ivoire due to shortfall in their hydrogenation because of the drought; and (ii) very high crude oil prices which made thermal electricity generation very expensive. Thermal electricity generation was unable to make up the shortfall in hydropower generation. The country was left with no other option than to resort to a nationwide load-shedding exercise from August 2006 to September 2007.

As a response to the electricity supply crisis, in April 2007, the government announced its intention to deploy nuclear power for electricity generation. A Nuclear Power Committee was therefore inaugurated in May 2007. The Committee was tasked with the responsibility of assessing the viability of nuclear power in the country's energy system and developing a roadmap for deployment of nuclear power for electricity generation in the country. After its assessment, the Committee recommended that nuclear power should play a significant role in the country's future electricity generation mix. A roadmap was developed for launching the country's first nuclear power plant of capacity 400 MW in 2018. The Committee also recommended the establishment of a Presidential Commission on Nuclear Power Development, which will act as NEPIO (Nuclear Energy Programme Implementation Organization), to see to the implementation of the Roadmap [29].

The government thereafter took a Cabinet decision, in December 2008, to implement the recommendations of the Presidential Committee on Nuclear Power just before the elections in December 2008. The change of government after the election created a hiatus in implementation of the country's nuclear power programme. The country was however awarded an IAEA national TC project, GHA/0/011 - "Evaluating the role of Nuclear Power in Ghana's future electricity generation mix", under the auspices of the Ghana Atomic Energy Commission. In April 2011, about seven working groups were established to assist in various aspects of the planning of the country's nuclear power programme. The Ministry of Energy also established a nuclear power unit within its setup to deal with all issues associated with the planning and implementation of the nuclear power programme in the country [30].

The Ministry of Energy is expected to established and inaugurate the country's Nuclear Energy Programme Implementation Organization on July 25, 2012. The country's NEPIO will be expected to co-ordinate the activities of all stakeholder institutions involved in the planning of the nuclear power programme.

2.1.2. Current organizational chart(s)

The organizational structure envisaged for the implementation of the country's nuclear power programme and the relationships between the various stakeholders is shown in Figure 6, below.

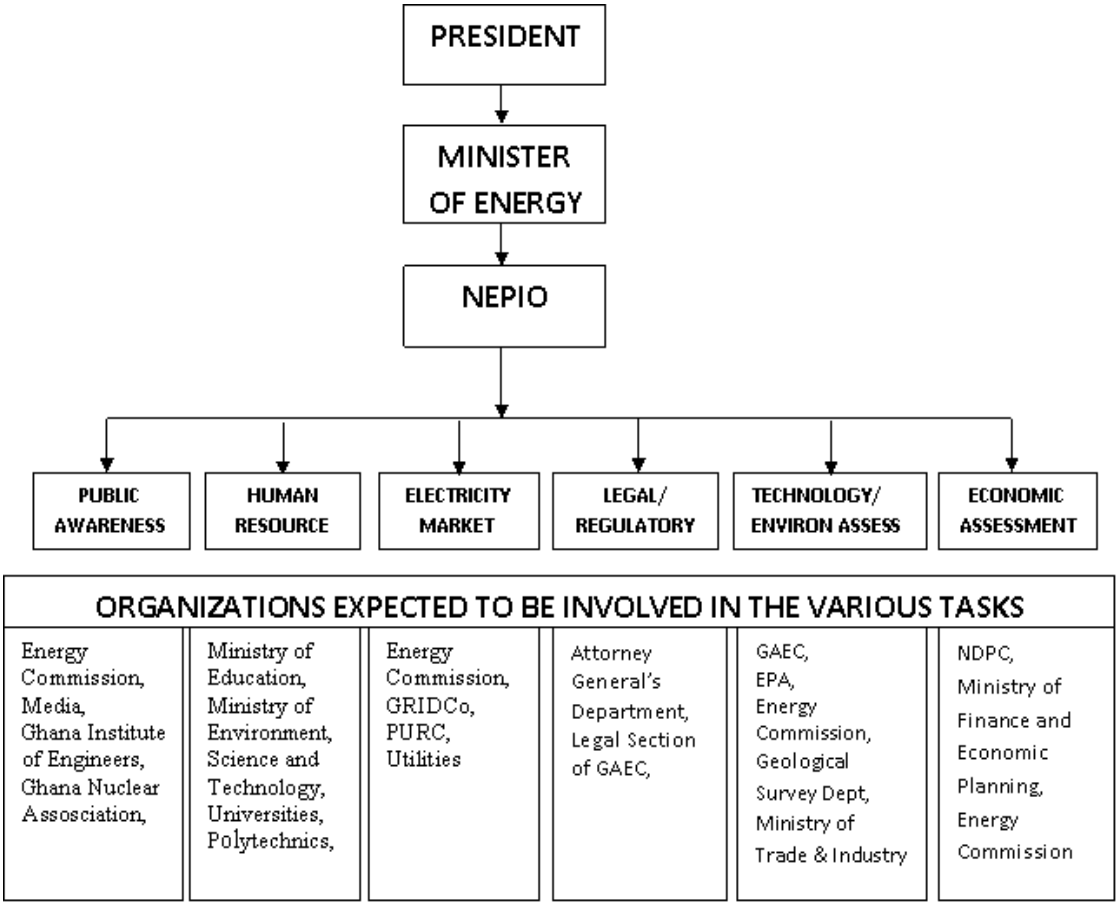


Figure 6: Working Groups to undertake various aspects of TCP GHA/0/011.

The main stakeholders who will take part in the various working groups for the implementation of the IAEA national TCP GHA/0/011 are listed in Table 8, below. The placement of these stakeholders in the various working groups is a result of their functions. The main functions of these ministries and agencies are not limited to those listed.

Table 8: Main Organizations and their Functions

Organization	Main functions
Ministry of Energy	1. Formulation, implementation and monitoring of energy policies 2. Liaising with other agencies on matters relating to power 3. Supervision of state-owned power utilities to ensure adequate, reliable and cost-effective service provision
Ministry of Environment Science and Technology	1. Provision of leadership and guidance for the environment, science and technology within the broad sector of the economy through policy formulation and implementation 2. Ensuring the establishment of regulatory framework and the setting of standards to govern the activities of science and technology and the management of the environment for sustainable development 3. Ensuring the co-ordination, supervision, monitoring and

	evaluation of activities of environment, science and technology, while fulfilling national benefits-sharing commitments
Ministry of Finance and Economic Planning	1. Formulate and implement sound fiscal and financial policies 2. Effective mobilization and efficient allocation of resources 3. Improve public financial management
Ghana Atomic Energy Commission	1. Advise government on matters relating to nuclear energy, science and technology 2. Make proposals to government for legislation in the field of nuclear radiation and radioactive waste management 3. Collaborate with universities and research institutes for the purpose of conducting research into matters connected with peaceful uses of nuclear energy and technology
Energy Commission	1. Advise Minister of Energy on national energy policies 2. Indicative energy planning at the national level 3. Licensing and technical regulation of the activities of all electricity sector operators
Public Utilities and Regulatory Commission	1. Provide guidelines for rates to be charged by public utilities 2. Monitor standards of performance for provision of utility services 3. Protect interests of both consumers and providers of utility services 4. Promote fair competition
National Development Planning Commission	1. Undertake studies and make recommendations on development and socio-economic issues 2. Formulate comprehensive national development planning strategies and ensure that the strategies, including consequential policies and programmes, are effectively carried out 3. Prepare broad national development plans
Ghana Grid Company	1. Undertake economic dispatch and transmission of electricity from wholesale suppliers (generating companies) to bulk customers 2. Provide fair and non-discriminatory transmission services to all power-market participants 3. Carry out transmission system planning and implement necessary investments to provide the capacity to reliably transmit electric energy and manage the wholesale power market
Environmental Protection Agency	1. Create awareness to mainstream environment into the development process at the national, regional, district and community levels 2. Ensure that the implementation of environmental policy and planning are integrated and consistent with the country's desire for effective, long-term maintenance of environmental quality 3. Ensure environmentally sound and efficient use of both renewable and non-renewable resources in the process of national development
Universities and polytechnics	1. Research and training of manpower
Ghana Nuclear Regulatory Authority[1]	1. Licensing of nuclear power plants and nuclear facilities 2. Performing regulatory activities 3. Training and organizing personnel, according to the Nuclear Law

Note: 1- The Ghana Nuclear Bill proposed the formation of Ghana Nuclear Regulatory Authority

The Ghana Atomic Energy Commission (GAEC) is expected to play a leadership role in the implementation of the country's nuclear power programme. The Commission has established four institutes and a school. The institutes are the Radiation Protection Institute (RPI), Biotechnology and Nuclear Agriculture Research Institute (BNARI), Radiological and Medical Research Institute (RAMSRI) and National Nuclear Research Institute (NNRI). They are intended to research into peaceful and safe

applications of nuclear energy, science and technology, and biotechnology, in sectors such as agriculture, energy, environment, geology, health and industry [31].

The School of Allied and Nuclear Sciences (SNAS), under GAEC, trains postgraduate students in the techniques of nuclear science application in areas such as agriculture and medicine. The research activities include but not limited to the operation of the Ghana Research Reactor 1 facility *(a 30 kW miniature neutron-source Chinese research reactor)* for research in neutron and neutron physics, particle radiation transport, nuclear instrumentation and exploitation of nuclear energy for power generation.

Other government organizations aside from those listed, which can offer technical support for the implementation of the nuclear power programme, especially in determining appropriate sites, include Geological Survey Department, Hydrological Services Department, Water Resources Commission and the National Disaster Management Organization.

2.2. Nuclear power plants: Overview

2.2.1. Status and performance of nuclear power plants

NOT APPLICABLE – No nuclear power plant is yet in operation in the country.

2.2.2. Plant upgrading, plant life management and license renewals

NOT APPLICABLE

2.3. Future development of Nuclear Power

The government has taken the decision to deploy nuclear power for electricity generation in the future. In order to actualize the government's decision, the Ghana Atomic Energy Commission, acting on behalf of the government, submitted a proposal to the International Atomic Energy Agency for support in undertaking a study to evaluate the role nuclear power will play in the country's future electricity generation. The country was awarded a national TCP GHA/0/011: "Evaluating the role of nuclear power in Ghana's future electricity generation mix".

2.3.1. Nuclear power development strategy

The successful implementation of the IAEA TCP GHA/0/011: "Evaluating the role of nuclear power in Ghana's future electricity generation mix" is expected to present the framework for developing the country's nuclear power development strategy. A Nuclear Energy Programme Implementation Organization has been established to manage the activities of seven working groups. The seven working groups will address issues with regards to the following:

(i) Siting Grid Infrastructure Assessment

This working group is expected to undertake a series of studies to develop a strategy for the determination of potential sites, evaluation of these sites for characterization, and final determination. It will also assess the national grid and its interconnection with the West African Power Pool, and develop a strategy for nuclear power operation suitable for the national grid or in the context of the West African Power Pool.

(ii) Techno-economic Assessment, Financing and Procurement

This working group is expected to review future electricity generation expansion plans to determine the role of nuclear power and undertake a comprehensive techno-economic assessment of these plans. The group is also expected to develop a strategy for funding the nuclear power programme, long-term spent fuel handling and final disposal, waste management and decommissioning of the nuclear power plant.

(iii) Legal and Regulatory Issues

This working group will address all legal and regulatory issues pertaining to the country's nuclear power programme. A Nuclear Bill has been drafted, which proposed the establishment of a Nuclear Regulatory Authority to be in charge of licensing nuclear power plants and all nuclear related facilities and in charge of undertaking nuclear regulatory activities. The Bill has been submitted to Cabinet for approval.

(iv) Technology Assessment

This group is expected to undertake the assessment of specific technologies suitable to be adopted for the country's nuclear power project for electricity supply and for a policy for nuclear fuel acquisition. It is also expected to develop a strategy for management of the various levels of nuclear waste.

(v) Human Resource Development

This working group is expected to undertake assessment of human resource requirements at all stages of the nuclear power programme, and to develop a strategy for human resource development.

(vi) Nuclear Power Project Management

This working group is expected to develop the nuclear power project framework, activities and time scales. It is also expected to develop best strategy or type of contract for securing a nuclear power plant e.g. turnkey, split package or multi packages.

(vii) Stakeholder Involvement

This working group is expected to develop a comprehensive Communication Strategy for public awareness campaigns and for ensuring the involvement of all stakeholders.

2.3.2. Project management

Refer to section 2.1.2

2.3.3. Project funding

The government is funding all activities related to the implementation of the nuclear power programme. The Techno-economic Assessment, Financing and Procurement working groups are expected to develop a strategy for funding the nuclear power project.

2.3.4. Electric grid development

A study to assess the national electricity grid in the context of the West African Power Pool, the required expansion and the upgrade that might be required for the implementation of a nuclear power programme, is expected to be undertaken as part of the IAEA national TCP GHA/0/011: "Evaluating the role of nuclear power in Ghana's future electricity generation mix".

2.3.5. Site Selection

A preliminary potential site mapping has been undertaken as part of the implementation of IAEA national TCP GHA/0/011: "Evaluating the role of nuclear power in Ghana's future electricity generation mix". The working group dealing with siting issues is expected to undertake further assessment of the sites that have been mapped out for characterization, to determine such factors as source of cooling water, transport and grid infrastructure, for the ranking of the nuclear power plant site.

2.4. Organizations involved in construction of NPPs

NOT APPLICABLE

2.5. Organizations involved in operation of NPPs

NOT APPLICABLE

2.6. Organizations involved in decommissioning of NPPs

NOT APPLICABLE

2.7. Fuel cycle including waste management

A strategy for management of the various levels of waste (interim storage of spent fuel and ultimate disposal of high-level waste) is expected to be developed by the Technology Assessment working group. The country is not expected to be involved in the full nuclear fuel cycle (mining and milling, uranium conversion, uranium enrichment, fuel fabrication, fuel reprocessing).

2.8. Research and development

2.8.1. R&D organizations

NOT APPLICABLE

2.8.2. Development of advanced nuclear technologies

NOT APPLICABLE

2.8.3. International co-operation and initiatives

Ghana is a member of international co-operations and initiatives, which have the potential to enhance human resource development, transfer of nuclear science and technology know-how, and the implementation of the nuclear power programme in the country.

On September 28, 1960, Ghana became a member of the International Atomic Energy Agency. Since then, the country has benefited immensely from its membership of the IAEA in terms of capacity training and sourcing for equipment in the field of nuclear science and applications. On October 14, 1994, the IAEA facilitated an agreement between the government of Ghana and that of the People's Republic of China for the purchase of a 30 kW miniature neutron source research reactor and for the supply of fuel elements (enriched uranium) for the reactor. This was part of the Agency's TCP GHA/1/010 entitled "Miniature Neutron Source Reactor" [32].

On September 16, 2007, the country joined a group of fifteen other countries to respond to the United States of America government's initiative to form the Global Nuclear Energy Partnership (GNEP). The GNEP is to provide a forum for cooperation among participating states, in an effort to explore mutually beneficial approaches to ensure that the use of nuclear energy for peaceful purposes proceeds in a manner that is efficient and meets the highest standards of safety, security and non-proliferation. The first ever GNEP meeting in Africa was held in Accra, Ghana, on June 16-17, 2010, where the partnership adopted "International Framework for Nuclear Energy Co-operation" instead of the Global Nuclear Energy Partnership [33].

The country is also a member of African Regional Cooperative Agreement for Research, Development and Training related to Nuclear Science and Technology, or AFRA. This regional initiative seeks to identify and prioritize regional cooperation opportunities for the sustainable promotion of peaceful applications of nuclear science and technology. It also seeks to promote the implementation of nuclear power programmes in countries in the context of African socio-economic development.

In November 2011, the government of Ghana signed an agreement with Rosatom, Russia's state-owned nuclear energy corporation. This memorandum of co-operation provides for "a number of specific areas of co-operation", including creating the infrastructure to support the development of nuclear energy in the country. In order to accomplish the terms of this memorandum, a working group will be established to study potential joint projects and draft framework agreements on areas of co-operation, leading to the construction of a nuclear power plant in the future [34].

2.9. Human resources development

The Ghana Atomic Energy Commission has four institutes for training and research in the promotion, development and utilization of the peaceful application of nuclear and biotechnological techniques for economic and social advancement in Ghana. In collaboration with University of Ghana and with the assistance of the International Atomic Energy Agency, it has also established the School of Nuclear and Allied Sciences (SNAS). SNAS offers courses in nuclear sciences at the post-graduate level. Student enrolment has increased from 36 in various fields of nuclear science at the MPhil level, in 2006/07 when the programme started, to 55 students in various fields of nuclear science at the MPhil level, in 2009/10. The school also admitted 14 PhD students at various levels of study [35]. In the Nuclear Engineering Programme, there are two options, which are Reactor Physics or Reactor Engineering. The organizational structure of the graduate School of Nuclear and Allied Sciences is shown in Figure 6 below:

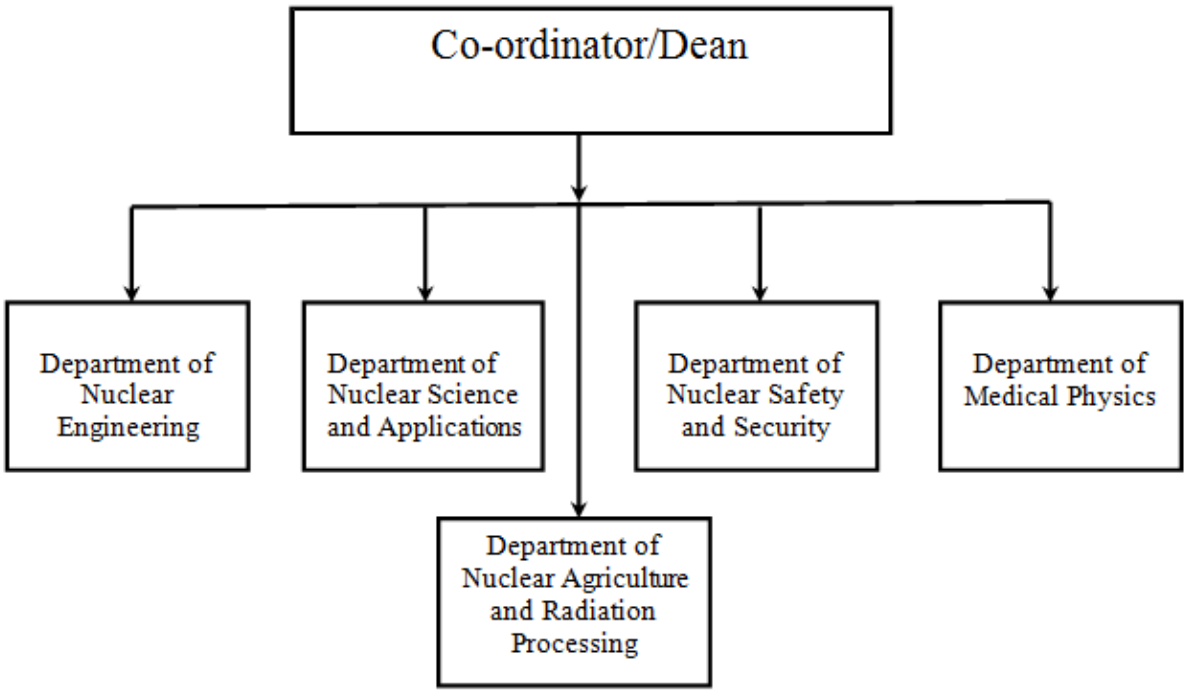


Figure 7: Structure of School of Nuclear and Allied Sciences

2.10. Stakeholder Communication

An effective Stakeholders' Communication Strategy is expected to be developed by the Stakeholders Involvement Working Group, under the IAEA TCP GHA/0/011. The strategy is expected to address issues of public awareness and of communication within stakeholders (e.g. general public, government, industry media and neighbouring countries).

3. NATIONAL LAWS AND REGULATIONS

The Ghana Atomic Energy Commission and stakeholders, with assistance from the International Atomic Energy Agency, have drafted the Ghana Nuclear Energy Bill, 2009 to pave the way for peaceful uses of nuclear energy in Ghana. The Bill, which has been submitted to the Cabinet for consideration before being laid before Parliament, proposes the establishment of Ghana Nuclear Regulatory Authority. The chapters of the Ghana Nuclear Energy Bill are listed below:

- Part 1: Introductory Provisions
- Part 2: The Ghana Nuclear Regulatory Authority
- Part 3: Regulatory Activities
- Part 4: Provisions for Reactors
- Part 5: Transportation of Nuclear Materials
- Part 6: Safeguards and Prohibitions
- Part 7: Provisions on Mining and Processing
- Part 8: Provisions on Nuclear Liability
- Part 9: Inspection and Enforcements
- Part 10: Offences, Penalties and Appeals
- Part 11: General Provisions

3.1. Regulatory framework

3.1.1. Regulatory authority(s)

In 1993, the Provisional National Defence Council Law 308 established a twelve-member Radiation Protection Board and issued concurrently a Legislative Instrument LI 1559, which prescribed the mandate and responsibilities of the Board as a licensing and regulatory Authority for the purpose of Radiation Protection and Waste Safety. Hence, to facilitate the mandate of the Board, the Ghana Atomic Energy Commission, in pursuit of Ghana Atomic Energy Commission Act, 2000: Act 588, established the Radiation Protection Institute (RPI) in February 2002. The organizational chart of the Radiation Protection Institute is shown in Figure 7, below.

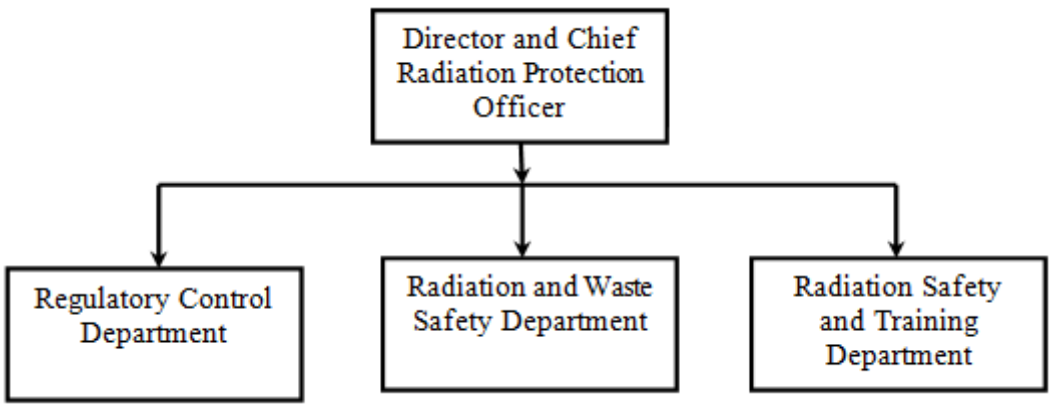


Figure 8: Structure of Radiation Protection Institute *(under the Radiation Protection Board, expected to be transformed in Ghana Nuclear Regulatory Authority)*

The Ghana Nuclear Energy Bill, 2009 proposed that the Radiation Protection Board and the Radiation Protection Institute become transformed into the Ghana Nuclear Regulatory Authority.

3.1.2. Licensing Process

The Radiation Protection Board issues licenses to persons who purchase, manufacture, acquire imports, sell or deal in, store, use, dispose of or export, any kind of irradiating device or radioactive material, or any other source of ionizing radiation [36]. The steps for the application of a license are as listed below:

1. Such a person shall apply using the prescribed form for an appropriate license or renewal to the Board;

2. On receiving an application for a license or for a renewal, the Board may, on payment of the prescribed fee, issue to the applicant the appropriate license or renew the license;
3. A license issued under this paragraph may:

   (a) authorise the licensee to own, purchase, acquire, import, export, posses, sell or deal in, store, install, use or dispose of, as the case may be, irradiating devices, radioactive materials or other sources of ionizing radiation;

   (b) Be specific with regard to the process, operation or facility;

   (c) Be valid for such period as the Board may determine;

   (d) Contain such other conditions as the Board considers necessary to impose for the safe disposal of all radioactive material resulting from the proposed operation, process or facility; and

   (e) Be in such form as the Board shall determine.

4. A license issued under this paragraph may:

   (a) Be amended at any time on written notice to the holder by the Board, if in its opinion, the amendment is necessary for the purpose of public safety; and

   (b) Be suspended or revoked by the Board if the holder fails to comply with the conditions contained in the license or laid down in this Instrument or in any regulations, and where a license is suspended or revoked the holder shall take such steps as may be directed by the Board to ensure that no radiation hazards occur.

5. Licenses that are issued under this Instrument shall be in addition to any license required under any other enactment.

3.2. Main national laws and regulations in nuclear power

The main laws and regulation dealing with nuclear power are listed below:

(i) Laws establishing institutions charged with different responsibilities relating to nuclear power:

- Ghana Atomic Energy Commission Act 1963 (Act 204); Government of Ghana Printing Department. *(This law established the Ghana Atomic Energy Commission in 1963, to replace Ghana Atomic Energy Committee and to promote the development and the peaceful applications of nuclear techniques for the benefit of Ghana).*

- Provisional National Defence Council (PNDC) Law 308, 1993; State Publishing Corporation. *(The law established the Radiation Protection Board in 1993. Concurrently, the legislative instrument LI 1559 was issued, which prescribed the responsibilities of the Board as a licensing and regulatory authority for the purpose of Radiation Protection and waste safety).*

- Ghana Atomic Energy Commission Act 2000 (Act 588); State Publishing Company. *(This is an amendment of Act 204).*

(ii) Civil nuclear liability:

The laws dealing with civil nuclear liability are provisions in the Ghana Nuclear Bill, 2009, which has been submitted to the Cabinet for consideration.

(iii) Establishing a regulatory body:

The establishment of Ghana Nuclear Regulatory Authority has been proposed by Ghana Nuclear Bill, 2009, which has been submitted to the Cabinet for consideration.

(iv) Implementing IAEA safeguards:

The Ghana Atomic Energy Commission, in operating the Ghana Research Reactor 1 facility, adheres strictly to IAEA safeguards.

(v) Rules for environmental protection:

The rules governing environmental protection are enshrined in the Environmental Protection Agency Act, 1994 (Act 490).

(vi) Protection of intellectual property rights:

The country has a Copyright Law Provisional National Defence Council (PNDC) Law 110, which protects Intellectual Property Rights.

(vii) Import and export controls of nuclear material and items and security principles, including physical protection of nuclear material and facilities and protection of sensitive information:

The mandate to license and regulate the import and export of nuclear materials and items and ensure the physical protection of nuclear materials and facilities is established by the PNDC Law 308, 1993 and LI 1559.

(viii) Roles of national government, local government, and stakeholders:

The role of the government is being defined by the establishment of the NEPIO, and the roles of local governments and other stakeholders will be articulated by the Working Group in charge of Stakeholder Involvement.

Main Regulations in Nuclear Power:

The Ghana Nuclear Energy Bill, 2009 proposed that the Radiation Protection Board and the Radiation Protection Institute be transformed into the Ghana Nuclear Regulatory Authority. The Regulatory Authority is expected to draft regulations with respect to all aspects of the use of nuclear materials and the operation of nuclear power plants.

(ix) Regulation for establishing an authorization system and responsibilities of the operator, inspection and enforcement:

- Site selection and approval
- Radiation protection, including protection of workers, public and environment
- Safety of nuclear installations
- Radioactive waste and spent fuel management, including storage and disposal
- Decommissioning, including funding and institutional control
- Mining and milling
- Emergency preparedness
- Transport of radioactive material)

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Appendix 1: International, Multilateral and Bilateral Agreements

The IAEA has awarded a national TCP GHA/0/011, which will form the basis of the development of a Country Nuclear Power Programme Strategy. This project, which has different dimensions, seeks to address the 19 issues and is on-going. Along with the establishment of the NEPIO for the project, it is believed that the pace of the implementation of the project will increase in tempo.

On October 14, 1994, the country entered a Project and Supply Agreement with the People's Republic of China concerning the supply of enriched uranium for a miniature 30 kW neutron research reactor.

In November 2011, the country also signed a Memorandum of co-operation with Russia's state-owned nuclear energy corporation Rosatom, which will lead to the creation of infrastructure to support the development of nuclear energy in the country.

Appendix 2: main organizations, institutions and companies involved in nuclear power related activities

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