The Energy Centre, KNUST

GIS-BASED ENERGY ACCESS PROJECT

A Review of Trends, Policies and Plans for Increasing Energy Access in Ghana

Zero-Order Draft

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Executive Summary

Introduction

The purpose of this paper is to review trends, policies, plans and programmes for increasing access to energy services in Ghana by the year 2015 and beyond. The review, which is being undertaking as a key component of the GIS-based Energy Access Project, seeks to complement existing policies, plans and recommendations from the Energy for Poverty Reduction Action Plan for Ghana (EPRAP) and the Ghana Energy Development and Access Project (GEDAP) to achieve national and regional energy access targets, and the Millennium Development Goals (MDGs).

The need to secure future energy in the forms of electricity and modern cooking fuels is recognized as critical to the achievement of the MDGs, particularly poverty reduction efforts. Ghana's energy sector policy objectives of ensuring reliable, adequate and cost-effective supply of high quality energy services are consistent with the MDGs. Ghana has also subscribed to the energy access targets of the ECOWAS White Paper, which proposes to enable at least 50 percent of the population of West Africa have access to modern energy services, by 2015.

Trends in Ghana's Energy Sector

The trends in the energy sector of Ghana are reviewed with particular emphasis on energy at the household level, namely, electricity, Liquefied Petroleum Gas (LPG) and renewable energy including woodfuels. In the case of electricity there has been a steady upward trend in access rates from 28 percent in 1988 to 43.7 percent in 2000 and about 55 percent in 2008, making Ghana the third highest in sub-Saharan Africa, after Mauritius and South Africa . While access to electricity has been increasing overall, household access in urban areas is nearly three times that of rural households and this is a poignant situation.

Biomass in the form of woodfuel has been the main source of domestic energy for both rural and urban households. Heavy reliance on woodfuels has contributed to a consistent decline in Ghana's forest reserves. Hence, in 1990 government initiated a programme to promote LPG as

an alternative to woodfuels. By 1992, the consumption of LPG had doubled and in 2004 domestic consumption was about ten times higher than in 1990. In addition to LPG, over 200, 000 improved Gyapah cookstoves had been sold by 2006 in Ghana.

The country's renewable energy resources that have been extensively studied as potential resources for modern energy production and utilization are bioenergy, solar, wind and small hydro. Solar energy is abundant in Ghana, but it is mostly utilized in its raw state through open sun-drying. Solar PV is making some contributions to electricity access with over 4500 home systems installed by 2003, but its contribution to the total energy supply is only 0.2 percent. Wind and small hydro systems have also been considered for some specific locations but are yet to make significant impacts on Ghana's energy mix.

Policy Framework for Increasing Energy Access

Since the first attempt to develop a modern legal framework for Ghana's energy industry in 1920, when the Electricity Supply Ordinance was passed, there have been several energy policies, plans and programmes to increase energy access. Successive governments have put in place several policy mechanisms and institutions with the aim of increasing energy access, particularly to the underserved communities. However, the achievements have been modest compared to the challenges ahead. National energy policies and plans have faced major challenges including, inadequate investments, weak institutional framework as well as poor implementation and resource management. Energy sector restructuring, including private sector participation and the creation of new institutions as well as funding mechanisms, has been underway for some time to address the challenges. As far as this review is concerned, these challenges have not gone away and will need to be addressed more broadly within the framework of energy policy and institutions in Ghana as a whole.

Key Issues and Options for Increasing Energy Access

There are indications that current rates of Ghana's electrification are not likely to lead to full electrification by 2020, the target set originally in the NES and reaffirmed by the current government, unless there is a major shift to a trajectory similar to that projected for a leading African country like South Africa.

Ghana is expected to lead the way towards achievement of the ECOWAS target of 100% of the total population having access to improved domestic cooking services by 2015, with close to 10% using LPG. Ghana may therefore well consider expanding and intensifying policy measures for the promotion of LPG to exceed the ECOWAS target and go for a doubling of LPG access from the 2005 rate of 9% to something much closer to 20%, with the rest of population using improved woodfuel-based cooking services, by 2015.

Coupling energy access initiatives with productive uses of energy, essential to industry and agricultural production, is still an issue that needs the concerted effort of policy makers and implementing agencies, public and private, as well as civil society and energy experts. There is also the need to build human and institutional capacity to scale up such enterprise-centered approaches, with a strong emphasis on productive uses especially in rural areas.

Conclusions and Recommendations

The main conclusions and recommendations arising out of this review may be summarized as follows:

1. There is the need for a coherent national energy policy with inputs from a wider section of the public that has precise targets and clearly laid down strategies to achieve the targets. Such strategies should involve funding mechanisms.
2. Efforts must be made towards achieving 100% access to electricity by 2020, and around 20% of the population having access to LPG with the rest of population using improved woodfuel-based cooking services, by 2015.
3. Efforts at promoting and making available renewable energy technologies at cost effective prices must be stepped up. This calls for the passage of the renewable energy law which should establish incentives for the renewable energy industry.
4. Energy access initiatives should be coupled with productive uses of energy, especially in rural areas, and enterprise-centered approaches should also be promoted vigorously.
5. Government must support academic and research institutions in the country to build capacity for more R&D into energy technology and policy so that they can complement government efforts at achieving ‘sustainable’ energy for all in Ghana in the near term.

1.0 Introduction

The purpose of this paper is to review trends, policies, plans and programmes for increasing access to energy services in Ghana by the year 2015 and beyond. The review seeks to complement existing policies, plans and recommendations from the Energy for Poverty Reduction Action Plan for Ghana (EPRAP) and the Ghana Energy Development and Access Project (GEDAP) to achieve national, regional energy access goals and the Millennium Development Goals (MDGs). The need to secure future energy in the forms of electricity and modern cooking fuels is recognized as critical to the achievement of the MDGs, particularly poverty reduction efforts to improve education, health, water supply and agricultural produce processing in a sustainable environment founded on gender equality and women's empowerment.

The critical role played by energy in achieving sustainable development is well recognized and the disparity existing between urban and rural areas of African countries in terms of access to energy services has been highlighted and widely agreed at the Johannesburg Summit in 2002 as a major concern by the United Nations and other world bodies (WEHAB, 2002; DfID,(2002; IEA, 2002). Lack of access to energy services has been identified as a major challenge to sustainable development and there appears to be a consensus that the provision of affordable, reliable, and socially acceptable energy services is a prerequisite for achieving the MDGs (WEHAB, 2002).

Ghana's energy sector policy objectives of ensuring reliable, adequate and cost-effective supply of high quality energy services for households, industries, agriculture and transport sectors nationwide are consistent with the outlined prerequisites for achieving the MDGs (Energy Commission, 2004). Ghana has also subscribed to the energy access targets of the ECOWAS White Paper, which proposes to enable at least half the population of the West African sub-region have access to modern energy services, by the year 2015 (ECOWAS, 2005).

However, despite governments' intention to increase access to energy services, particularly to the underserved areas, existing policies and plans have not delivered effective results to enable the population derive the full benefit accruing from increased access to energy services. There is

lack of data to determine whether current energy policies and plans will achieve the targets for energy access as set in the governments' policy documents, ECOWAS White Paper for a Regional Policy geared towards Increasing Access to Energy Services, and the MDGs. Policies and plans to provide the enabling environment for improvement in energy access are hardly evaluated and hence there is the need for a continuous research especially for monitoring and evaluation purposes.

For nearly 50 percent of the Ghanaian population who do not have access to grid-electricity and about 90 percent who do not have access to Liquefied Petroleum Gas (LPG) for cooking, most of whom rely on firewood and charcoal, their hope is to have access to improve their quality of life (UNDP Ghana, 2002; Ghana Statistical Service, 2005). This is particularly important because without access to modern energy services in the form of lighting, cooking, refrigeration, motive power, water pumping and communication, human activities are likely to be afflicted with drudgery. The global energy sector faces a number of challenges including lack of access to the electric grid at reasonable prices, volatile oil price markets, high initial cost of renewable energy technologies and widespread lack of awareness of the scale of renewable energy resources, increased greenhouse gas emissions etc (IEA, 2002, 2006; Sawin, 2004; UNDP, 2004). For the most part, the challenges that exist in developing countries are similar to those in the industrialized countries (Sawin, 2004). However, due to several factors including fragile economies, growing population, low investments, and poor energy infrastructure etc. developing countries including Ghana face additional challenges.

Given this context, the paper examines national policies and plans for promoting increased access to energy services in Ghana. It focuses primarily on electricity, cooking fuels and renewable energy. The paper is organized into four sections: Section 2 reviews the trends in Ghana's energy sector within the context of access to energy services at household level. Section 3 discusses the various national energy policies, plans and programmes, the policy mechanisms and institutions, and the key challenges for increasing energy access in Ghana. Section 4 addresses the key issues and options if Ghana is to gear itself to achieve the energy access targets set at both national and regional levels. Section 5 summarizes the main conclusions and recommendations coming out of this review.

2.0 Trends in Ghana's Energy Sector

In this section we review the trends in the energy sector of Ghana with particular emphasis on energy at the household level, namely, electricity, Liquefied Petroleum Gas (LPG) and kerosene, and renewable energy including woodfuels (firewood and charcoal).

2.1 Electricity

The colonial administration of the Gold Coast maintained a diesel generating station and did not intend any rigorous energy programme (Botchway, 2000). Nevertheless, the idea of building a dam across the river Volta to generate electric power and turn Ghana's bauxite into aluminium is credited to Albert Kitson, a geologist in the government of Gold Coast in 1915 (Faber, 1990; Moxon, 1984; Hart, 1980). This idea was taken over by the first President of Ghana whose ambiton was to modernize Ghana through rapid industrialization underpinned by the prime need of providing increased access to cheap electricity for the population (Nkrumah, 1961). This ambition was perhaps triggered by Lenin's dictum of 1921 – "power to the councils of the soviet people and electrification of the whole country" (Lenin, 1920).

Following a number of proposals submitted by different consortia to realize the hydroelectric power potential of the river Volta, the government of Ghana finally initiated the Volta River Project and established the Volta River Authority (VRA) in 1961 for the generation and transmission of power. Four hydroelectric generating units with total capacity 588 MW, including 15 percent overload capacity, were installed in 1965 at Akosombo. Two additional units with capacity of 324 MW, including 15 percent overload capacity, were commissioned in 1972 to bring the total installed capacity of hydropower to 912 MW. In 1981, a second hydro-electric plant was installed at Kpong and this added 160 MW to the installed capacity. Both plants are capable of providing long-term firm energy of approximately 4,800 GWh/year. On the long-term average, however, the potential energy available from the two plants is estimated to be 6,100 GWh/year (Abakah, 1993; Yankah, 1999).

The global oil crisis in the 1970's provided the momentum for the establishment of a Ministry of Fuel and Power, which was changed to Ministry of Mines and Energy. The objective of the Ministry was, among other things, to formulate, coordinate and supervise policies relating to the energy sector. During the national energy crisis in 1982-1983 induced by a major regional

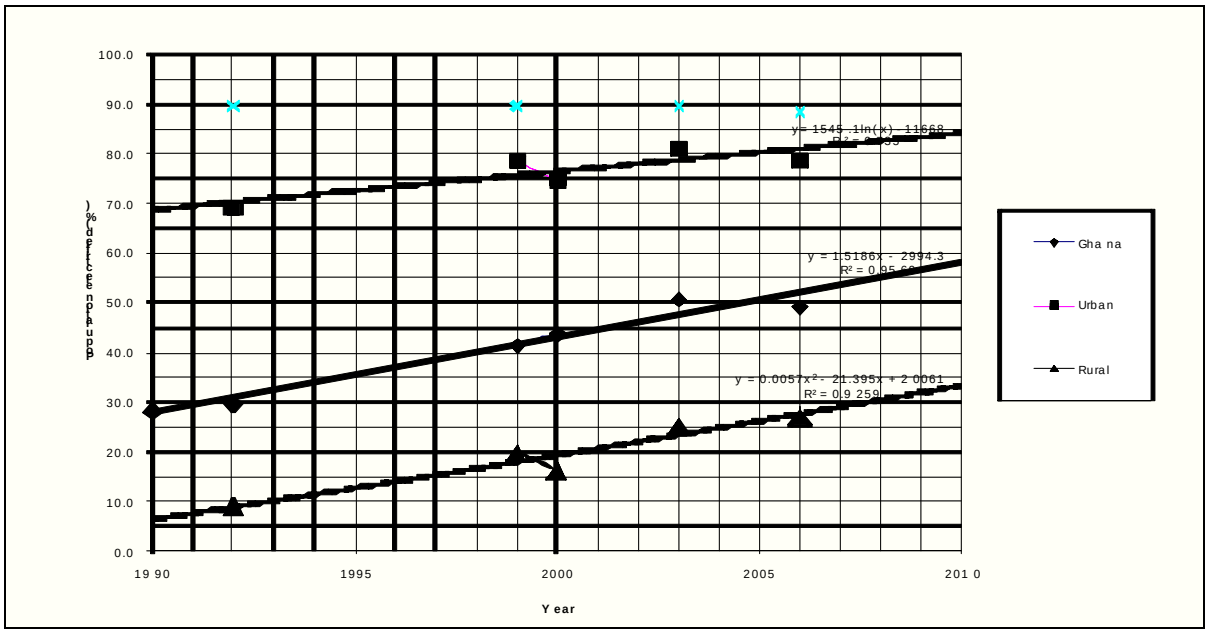
drought, the National Energy Board (NEB) was created in 1983 to plan for the comprehensive development and utilization of energy resources, particularly to promote the use of renewable energy and cleaner forms of energy, assess public agreements relating to energy and advise government on energy issues (Akuffo, 1992). The NEB actually became operational in 1985 and rose from a tottering public institution to become a dynamic national agency for energy planning and policy analysis but unfortunately there were institutional tensions which grew to head with the turn of the decade and the NEB was eventually dissolved in 1991 (Brew-Hammond, 1998).

An Economic Recovery Programme (ERP) embarked on in 1983 helped to reverse the economic decline caused by a combination of inappropriate policies and exogenous shocks both domestic and international (World Bank, 1989). Encouraged by the achievements of the ERP, in 1989-1990 government committed itself to increase access to electricity for all parts of the country over a 30-year period in a programme known as the National Electrification Scheme (NES). In order to extend electricity to the northern regions of Ghana, where there was no grid electricity, the legislation that established the Volta River Authority (VRA) and the Electricity Corporation of Ghana (ECG) were amended to put the VRA directly in charge of the Northern Electrification Programme (NEP).

In 1987 the VRA created the Northern Electricity Department (NED) and took over the additional responsibility for extending electricity to the northern regions of Ghana (Brew-Hammond, 1996; Yankah, 1999). Through the creation of the NED and implementation of the Northern Electrification and System Reinforcement Project (NESRP) as well as the Rural Electrification Programme (REP), grid-electricity was extended to the Brong Ahafo, Northern, Upper-East and Upper-West regions (Yankah, 1999). The NESRP was followed by the Self-Help Electrification Project (SHEP) to support the efforts of rural communities to provide power for themselves. In 1990, the VRA rehabilitated and re-commissioned the Tema Diesel Generating Station which has a capacity of providing supplementary generation of 30MW thereby raising the total capacity of electrical power to about 1,102MW.

Between 1990 and 2001, electricity consumption grew from 4457GWh to 6033GWh at an average rate of 9.42 percent per annum, excluding the Volta Aluminium Company, VALCO, whose

aluminium smelter at Tema consumed around 40% of total electricity supply in the mid-1990s (Energy Commission, 2004). The growth of consumption, as compared with population growth of 2.67 percent, was due to an impressive increase in access to electricity from 28 percent in 1988, 32 percent in 1992, 43.7 percent in 2000 to over 50 percent in 2005 (Energy Commission, 2004; Ministry of Energy, 2006; Ghana Statistical Service, 2007; Akuffo, 2009). The percentage of households with access to electricity continued to expand at the rate higher than envisaged under the Growth and Poverty Reduction Strategy (NDPC, 2007). Electricity access rate of Ghana was estimated to be 54 percent in 2007 (Akuffo, 2009) and 55 percent in 2008 (World Bank, 2008) making Ghana the third highest in sub-Saharan Africa, after Mauritius and South Africa. Figure 1 demonstrates the trends in electrification in Ghana for urban, rural and national.

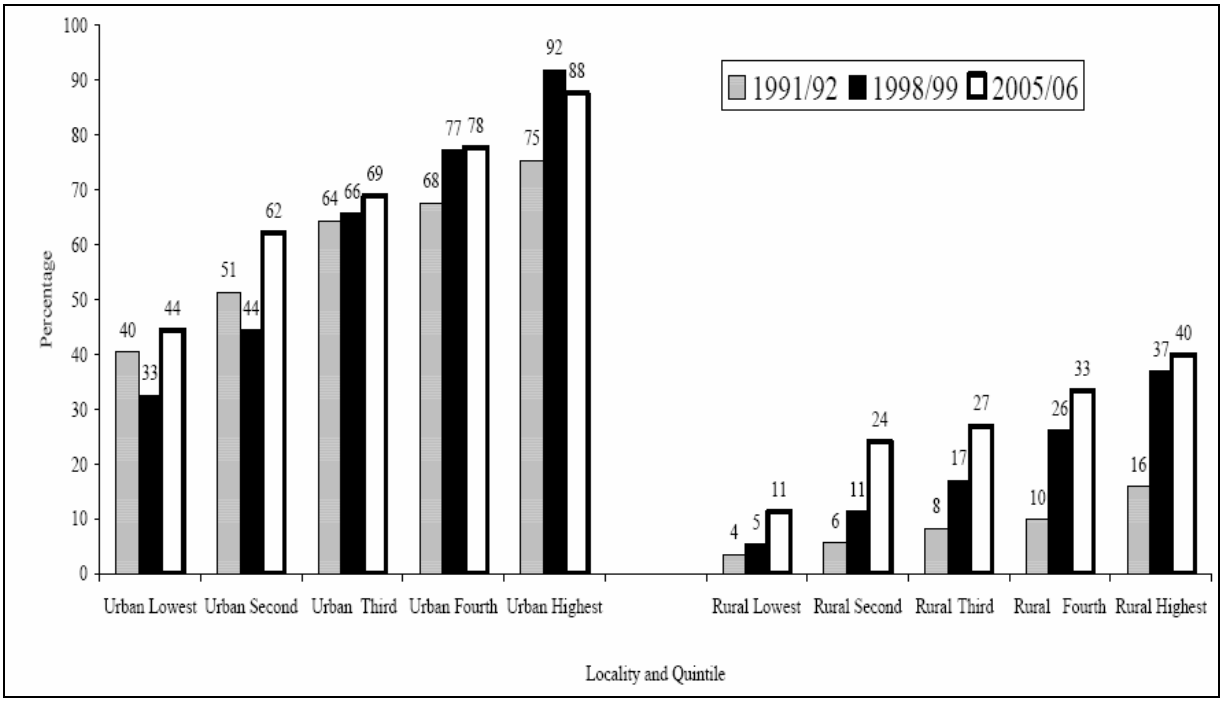


Source: Akuffo, 2009

Figure 1: Trends in Electrification in Ghana

While access to electricity has been increasing overall, the levels of access in urban areas is much higher than in rural areas and this is confirmed by Ghana Statistical Service (2007) which reports that the proportion of households in urban areas having access to electricity is nearly three

times that of households in rural areas. This dichotomy between rural and urban areas is revealed in a more poignant fashion in Figure 2.



Source: Ghana Statistical Service, 2007

Figure 2: Percentage of households using electricity by locality and standard of living quintile

The energy crisis experienced by the sector in the year 2006 spurred the government and VRA to review their long-term electricity policy in terms of the electricity generating mix required for the nation's long term needs as well as investments required (NDPC, 2007; Sackey, 2007). Significant investments have been made in thermal plants and system upgrading with the completion of VRA's 126 MW Thermal 1 Project and several independent power projects at various stages of advancement, all at Tema. The development of new hydroelectricity projects is

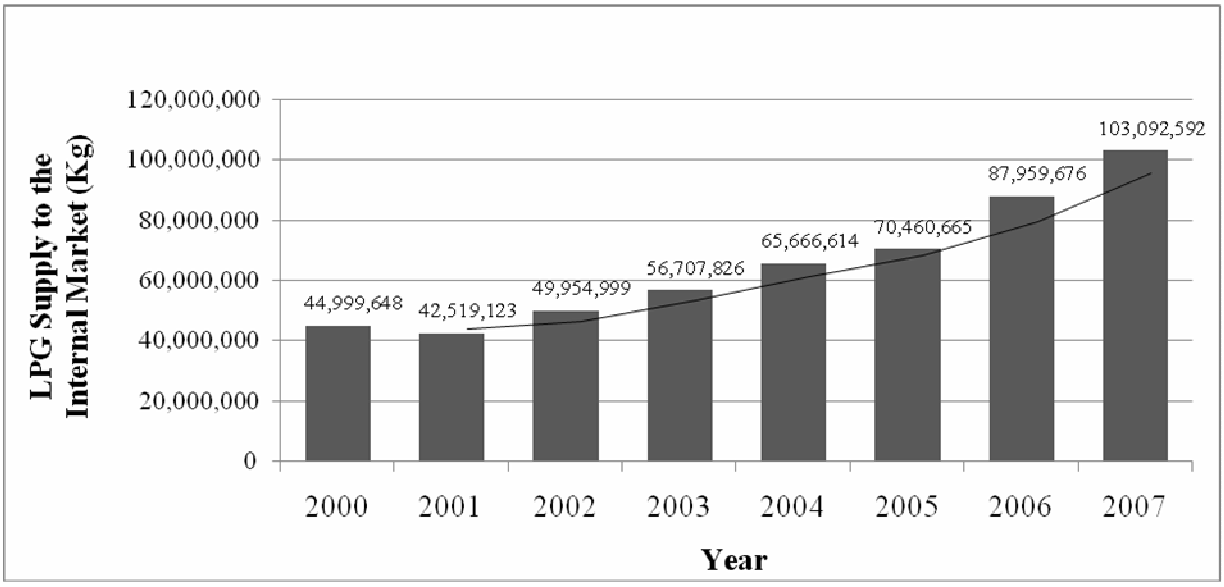
also ongoing with the construction of the 400 MW Bui Power Station by the Chinese (Sino Hydro) and there is the likelihood of work starting soon on the Western rivers[1].

2.2 Liquefied Petroleum Gas (LPG)

In Ghana LPG is used as a fuel for cooking and transport. In 1990, the Government of Ghana (GoG) initiated a programme to promote LPG as an alternate energy source to charcoal and firewood. Initially the promotion focused on urban households, public installations using catering facilities as well as informal sector food vendors. Alongside the promotions, educational campaigns were undertaken to communicate health, environment and safety precautions as well as the benefits that can be derived from utilising LPG. Government's initiative bore fruit since the consumption of LPG doubled in 1992, and by 2004 domestic consumption was over 60,000 tonnes/year which was estimated to be about ten times higher than the quantities consumed before the promotional programme was launched (UNDP Ghana, 2004). Though the LPG drive was successful, it is observed that patronage was skewed in favour of urban dwellers (Denton, 2006; UNDP Ghana, 2004). Denton (2006) argues that given the high consumption of charcoal in urban areas, concentration in the urban areas is a positive step to reverse the rates of deforestation and thus reduce demand for charcoal and woodfuel.

Out of the 6% of households in 2004, and about 9 percent in 2005 using LPG as their primary source of fuel for cooking, 70% resided in Greater Accra and Ashanti regions; in Accra about 22.7% in 2004 and about 30.4 percent in 2005 of households used LPG (UNDP Ghana, 2004; Ghana Statistical Service, 2005; Ministry of Energy, 2006). Urban access to LPG was estimated to be 17.2 percent and in contrast, LPG in rural areas accounted for about 1.2 percent of total national consumption. As of December 2003, there were 98 LPG filling stations in Ghana, 64 of which are situated in the Greater Accra region and only one station each in the Upper East and Upper West regions. In 2004, the Government with financial support from the United Nations Development Programme (UNDP) under its Rural LPG Challenge programme re-launched the LPG campaign programme to focus on the Northern regions of Ghana (Denton, 2006).

1. Earlier studies and surveys on the Bui hydropower project were conducted by the then Soviet Union in 1964, followed by the Australians (Snowy Mountains Engineering Corporation) in 1976, and then the French (Coyne et Belier) in 1995.



Source: Plotted from Energy Commission, 2007

Figure 3: LPG Supply to the Internal Market (2000-2007)

Currently, enough LPG is produced locally to meet domestic demand, with surplus for export; occasionally when the need arises some quantities are imported. For example in the year 2007, the Tema Oil Refinery (TOR) exported about 9,616 tonnes of LPG and imported about 47, 226 tonnes to meet local demand (see Energy Commission, 2007b). Figure 3 demonstrates the quantity of LPG (kilogrammes) supplied to the internal market of Ghana from the year 2000 to 2007. Some authors have reported that one of the key constraints to the initial promotion of LPG was the relatively high upfront cost compared to that of woodfuel with the cost of the cylinder contributing significantly to the high cost (UNDP Ghana, 2004, Denton, 2006).

It is interesting to note that there is quite a relatively high propensity for private entrepreneurs interested in clean energy services to enter the LPG retailing and appliances market. In the African Rural Energy Enterprise Development (AREED) Initiative the majority of investments in the Ghana portfolio went to LPG transporters, retailers and LPG stove manufacturers (Amissah-Arthur, 2008). A case in point is one private entrepreneur who took an initial loan of about US$ 38,000, paid it off in two years down and then went for about US$ 255,000; by the end of the third year this entrepreneur owned 3 LPG stations in Ghana and had a daily sales volume of about US$ 7,000 (Yankey, 2008).

2.3 Renewable Energy Sources

The country's renewable energy resources that have been extensively studied as potential resources for energy production and utilization are bioenergy (particularly, solid biomass and biogas), solar, wind and small hydro.

2.3.1 Woodfuel (Firewood and Charcoal)

Biomass in the form of woodfuel is the most prominent renewable energy resource in Ghana. It was estimated in 1990 that woodfuels constituted about 80 percent of Ghana's average annual energy production (Ministry of Energy & Mines, 1991). In 1992, the Forestry Department of Ghana also estimated the total area covered by five official forest reserves to be 25,593.46 sq km, and 72,404 sq km for unreserved forests (Abakah, 1995). Over the years, woodfuel in the form of firewood and charcoal have been the main sources of domestic energy for both rural and urban households and Ghana's forest reserves have reduced consistently over time (Nketiah et al., 2001).

As far as woodfuel consumption in Ghana is concerned, between 1984 and 1991, it was estimated that the average annual firewood and charcoal consumption growth rate of Ghana was about 2.5 and 2.8 percent respectively (see Abakah, 1995). In 1985 it was estimated that about 10.7 million tonnes of wood was consumed in the country. Out of this, 2.1 million tonnes (20 percent) was for industrial and commercial use, while 8.6 million tonnes (80 percent) was used for charcoal and firewood. Charcoal production alone amounted to about 3.3 million tonnes of wood (Turkson, 1990). The estimated woodfuel consumption in million tonnes from 2000 to 2007 is shown in Table 1. The data indicate an increase in charcoal consumption from between 12.1 and 14.6 million tonnes in the year 2000 to 11.1 and 13.1 million tonnes in the year 2007.

Table 1: Estimated Woodfuel Consumption (in million tonnes), 2000-2007

Est. Consumption (million tonnes)	2000	2001	2002	2003	2004	2005	2006*	2007
Wood used as firewood	7.1	8.0	8.3	8.6	8.7	8.8	-	9-10.8
Wood for charcoal production	5.0-7.5	5.2-7.8	5.4-8.1	5.6-8.4	5.8-8.5	5.8-8.5	-	2.1-2.3
Total primary woodfuel consumed	12.1-14.6	13.2-15.8	13.7-16.4	14.2-17	14.5-17.2	14.6-17.3	-	11.1-13.1

Source: Energy Commission, 2007, 2005.

* 2006 data not available

Energy Commission (2009) reports that firewood and charcoal contribute about 63 percent to the total energy supplied to the consumer compared to 27 percent for petroleum products, and 9 percent for electricity. A breakdown of the national energy balance data reveals that the residential sector of the country consumes the largest share of the energy supply due to the high reliance on woodfuel to meet mostly domestic needs. Table 2 demonstrates the percentage share of woodfuel consumption in Ghana from the year 2000 to 2005. The percentage distribution for 2005 is shown in Figure 4.

Table 2: Percentage Share of Woodfuel Consumption in Ghana (2000-2005)

Sector	2000	2001	2002	2003	2004	2005
Residential	72.3	71.8	71.3	70.8	71	71
Agriculture & Fisheries	0.1	0.1	0.1	0.1	0.1	0.1
Industry	24.5	25.9	25.4	25.8	25.7	25.7
Commercial & Services	3.1	32	32	32	32	3.2

Source: Energy Commission, 2005

In addition to firewood and charcoal there are other biomass resources in the form of agricultural and forest wastes, animal wastes, sawdusts etc. The lack of comprehensive data and national programmes to indicate the actual total availability of biomass including agricultural, forest and woodprocessing wastes, including sawdust, goes back a long way (Turkson, 1990; Abakah,

1995). This is due to the difficult task of monitoring and measuring the volume and weight of woodfuel harvested by families and individuals scattered over the entire country. Nonetheless, Energy commission (2005) has recently indicated the following estimated potential reserves: wood for fuel (813-850 million tonnes), wood processing residue (1 million tonnes/year), and agricultural residues (1 million tonnes/year).

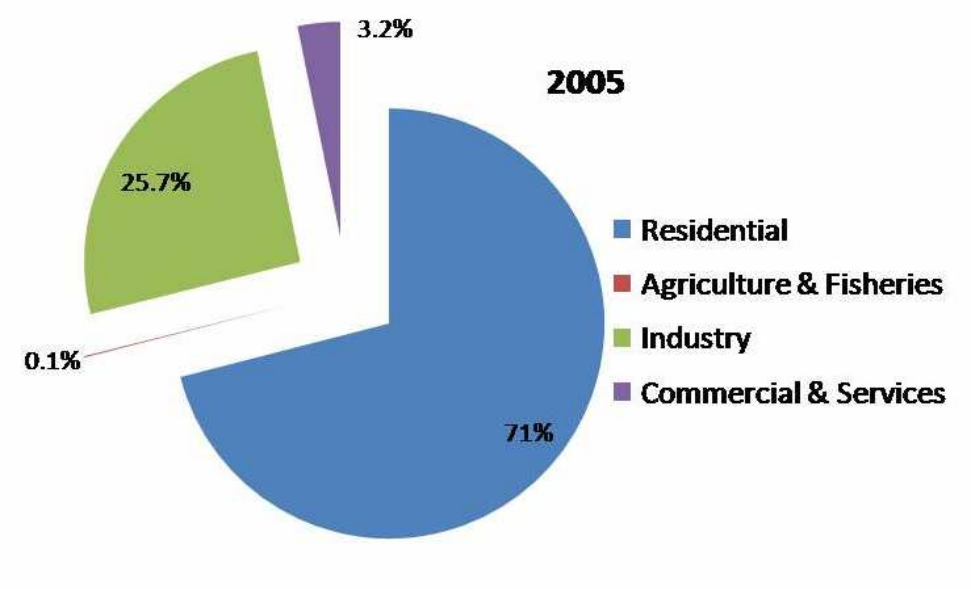


Figure 4: Percentage Distribution of Woodfuel Consumption in Ghana

The high consumption of firewood and charcoal has given rise to a massive exploitation of forest resources and this has resulted in rapid deteriorating environment and ecological damage, evidenced by high rates of desertification and deforestation (Abakah, 1993). Woodfuel provided 86 percent of urban household energy in 1987 (Quaye, 1992). The figure for rural households was much higher. What must be a source of concern to all Ghanaians is that about 90 percent of the woodfuels used in Ghana is supplied directly from the natural forest with the remaining 10 percent coming from wood waste including logging and sawmill residue and planted forest (Ministry of Energy, 2006; Energy Commission, 2006b). UNDP Ghana (2004) reported the country's tropical forest area to have reduced to 25 percent of its original size And they estimated that the average person in Ghana uses about 640kg of fuelwood per year, nearly 22,000 hectares (2 percent) of the forest are depleted each year, and the forest growth is less than

half of fuelwood demand. This implies that fuelwood use in Ghana, strictly speaking, is not a renewable and sustainable source of energy since consumption does not match annual growth rate and afforestation (Turkson, 1990, UNDP Ghana, 2004).

It is widely agreed that the continuous reliance on fuelwood for cooking has negative health impacts. Inefficient and poorly ventilated cookstoves cause indoor air pollution. Major international organizations have classed indoor air pollution from cooking with biomass in developing countries among the four most critical global environmental problems (Cecelski, 2003; Warwick and Doig 2004; IEA, 2006;). Women and children are primarily affected as they suffer from acute respiratory infections caused by the smoke (Quaye, 1992; UNDP Ghana, 2004). In a study on Biomass Energy in Rural Households in Ghana, Quaye (1992) found that rural women were being burdened with the problem of having to spend 1.5 - 6.5 hours per week looking for fuelwood by traveling about 3.0 - 6.4 kilometers. Currently an estimated household labour time of about 1 to 5 hours has been reported (see UNDP Ghana, 2004). Rural women are therefore constrained by the amount of time they can invest in income-generating activities daily and hence the need to assess other time-saving, cleaner and affordable cooking technologies and fuels, like improved cookstoves and LPG (discussed previously in Section 2.3.1).

In order to reduce the consumption of woodfuels and to reduce indoor air pollution in cooking places, there have been some efforts toward disseminating improved cookstoves in the country. Such efforts have not only been directed at the household level but also at the institutional level including the school feeding programme. Among the prominent cookstoves that have been introduced in Ghana are the Ahibenso and the Gyapa. The Ahibenso stove was introduced in the early 1990s and some 40,000 stoves had been sold by 1993 (Togobo, per. comm.). Initially, the stove was an all-metal type and hence became hot and easily worn out in a short period of use. The Technology Consultancy Centre under the financial support of UNDP/GEF Small Grants Programme, developed an improved Ahibenso cookstove, which had the inside layer insulated with refractory linings. Compared to the traditional cookstoves being sold on the market the new insulated Ahibenso could save about 18.4% on charcoal consumption (TCC, 2008). Current data on access and impacts are not available and the stove is not very popular in the country these days as compared with Gyapa.

Gyapa stove was introduced in 2002 by Enterprise works and over 200,000 had been sold by 2006 through a vigorous marketing campaign (EnterpriseWorks/Vita, 2009). Additionally, households have saved an average of $37 per year with a total annual savings of $3.6 million. The improved stoves have reduced indoor air pollution and over the stoves' 3-year lifespan have conserved the equivalent of more than 27,606 hectares of forest (Ibid). The Gyapa stove has remained popular with Ghanaians and still continues to sell in various towns across the country. A programme supported by the UNDP and the Ministry of Energy has trained some women in the use of local materials to construct improved cookstoves.

2.3.2 Other Forms of Bioenergy

The data on other forms of bioenergy (solid biomass as well as liquid and gaseous biofuel) resources in Ghana is sketchy and needs upgrading. There are forms of solid biomass, like agro-processing and municipal wastes, which are used for power generation but data on their contribution to national electricity supply is currently unavailable. With respect to agro-processing wastes, tremendous opportunities exist to generate electricity from crop residues, waste from palm oil and lumber processing.

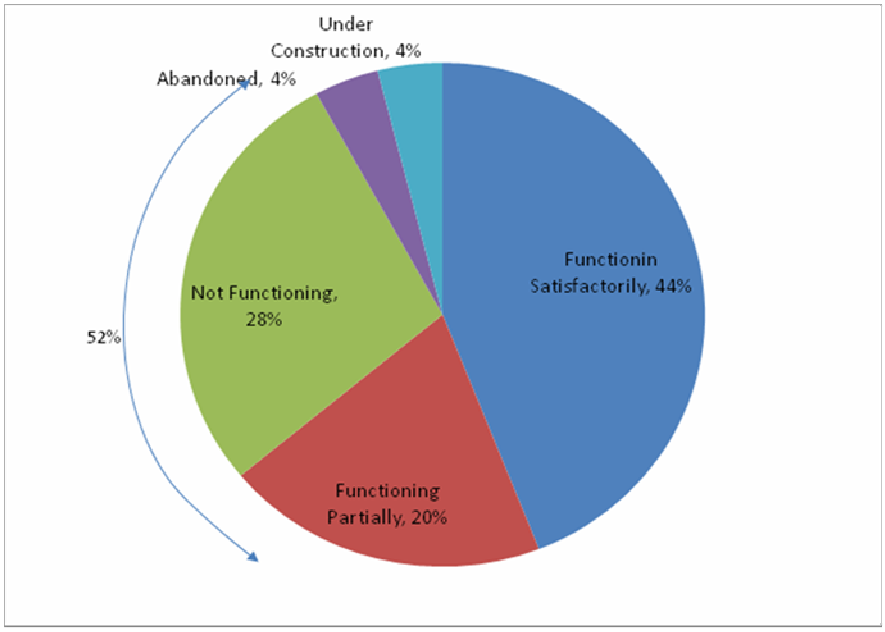
Interest in the cultivation biofuel feedstocks and production of liquid biofuels for export is growing with biofuel projects gradually gaining grounds in the country. Ghana has attracted the interest of several nations including Brazil, Norway, Israel, China, Germany, The Netherlands, Italy and India to cultivate jatropha and other crops for biodiesel. Indian alternative energy companies have entered Ghana and have begun processes to cultivate crops for biofuels in the country. India's largest investment in Ghana's biofuels sector is reported to be about US$45 million (€33 million) by the Ghana subsidiary of the Indian company Hazel Mercantile based in Mumbai (Alternative Energy Africa, 2009). The company which is a distributor of chemicals and petrochemical products intends to cultivate jatropha to produce biofuel and planning to cultivate about 50,000 hectares. Already an Israeli firm has secured about 100,000 hectares of land for jatropha and other oil-bearing crops. The Netherlands has started with about 100 acres in the northern part of the country. The Chinese too have started a pilot project and German, Belgian and Italian companies have also commenced activities.

There are also a number of community-based, smaller scale biofuel projects also underway in different parts of the country. The oldest is probably the Gbimsi Women's Project near Tamale where Jatropha oil is being used as a supplement to regular diesel for powering grain mills, followed by the Busunu Jatropha-based rural electrification project near Damongo. The Ministry of Local Government has also been implementing a Jatropha promotion programme for small farmers for a few years.

With respect to research and development in the area of liquid biofuels, there is some activity in a few of the universities and research institutions in Ghana. KNUST in particular has on-going research on the agronomy of Jatropha and other crops in the College of Agriculture and and Natural Resources, biofuel conversions processes for different feedstocks in the Colleges of Science and Engineering, machinery for processing and utilization of biomass/biofuels in the College of Engineering, and economics of biofuels involving a multi-disciplinary team from the Colleges of Engineering, Agriculture and Natural Resources, and partners outside the university.

Biogas is yet to make significant impact in the energy sector of Ghana despite its potential for lighting and cooking services in schools, hospitals, slaughterhouses and households etc. The utilisation of biogas technology for cooking in residential households and small power generation has not been successful as most of the household biogas plants built in the country have been abandoned (Energy Commission, 2006b). High unit cost (50 US cents/kWh) of electricity generated from biogas as compared to 13-20 US cents/kWh for diesel and gasoline is an issue of concern, particularly in the context of access to modern energy services for the poor living in rural and peri-urban communities.

Recent studies by Bensah (2009) in which he surveyed fifty (50) biogas installations across the country and conducted interviews with both plant users and service providers, have revealed that 58% of biogas installations in Ghana are institutional, 28% are household units, and the remaining 14% are community plants. The majority of these digesters are fixed-dome (82 %) with water-jacket floating-drums (8 %) ranking second, and sanitation is the main motivational reason for people using biogas plants. The functional status of the 50 plants surveyed is shown in Figure 5 which reveals the rather worrisome feature that as many as 52% of the installations are either functioning partially, not functioning or abandoned.



Source: Data from Bensah (2009)

Figure 5: Functional Status of Biogas Plants in Ghana

Reasons for non-functionality include non-availability of dung, breakdown of balloon gasholders, absence of maintenance services, lack of operational knowledge, gas leakages and bad odour in toilet chambers of biolatrines. Bensah (2008) therefore recommends the development of a national biogas programme using standardized designs to minimize the maintenance challenges, and focussing on three major areas – agricultural fertilizer production, sanitation and energy – in order to improve the system economics with respect to financial as well as non-financial returns on investment.

2.3.3 Solar Energy

By virtue of Ghana's geographical location in the tropics, solar radiation is available almost throughout the year. The country receives on average 4.0 - 6.5 kWh/m^2/day of solar radiation and sunshine duration of about 1800-3000 hours per year (Ministry of Energy, 2006; Energy Commission, 2007a). A breakdown of the solar intensities in terms of agro-climatic zones is shown in Table 3. The solar radiation data demonstrate some geographical variation with the

highest solar intensities occurring in the savannah zone and the lowest in the middle forest zone. The Solar Map of Ghana which gives a graphical presentation of the relative solar energy resource endowments across the country, is shown in Figure 6.

Table 3: Solar Intensities of Agro-climatic Zones in Ghana

Agro-climatic Zone	Region	Intensity (kWh/m^2-day)[1]
Savannah (close to the Sahel)	Upper East, Upper West , Northern, upper parts of Brong-Ahafo & Volta Regions	4.0 – 6.5 kWh/m^2-day
Middle Forest Zone	Ashanti, Eastern, Western and parts of Central, Brong-Ahafo , Volta Regions	3.1 – 5.8 kWh/m^2-day
Savannah (Coastal belt)	Greater Accra, coastal parts of Central & Volta Regions	4.0 – 6.0 kWh/m^2-day

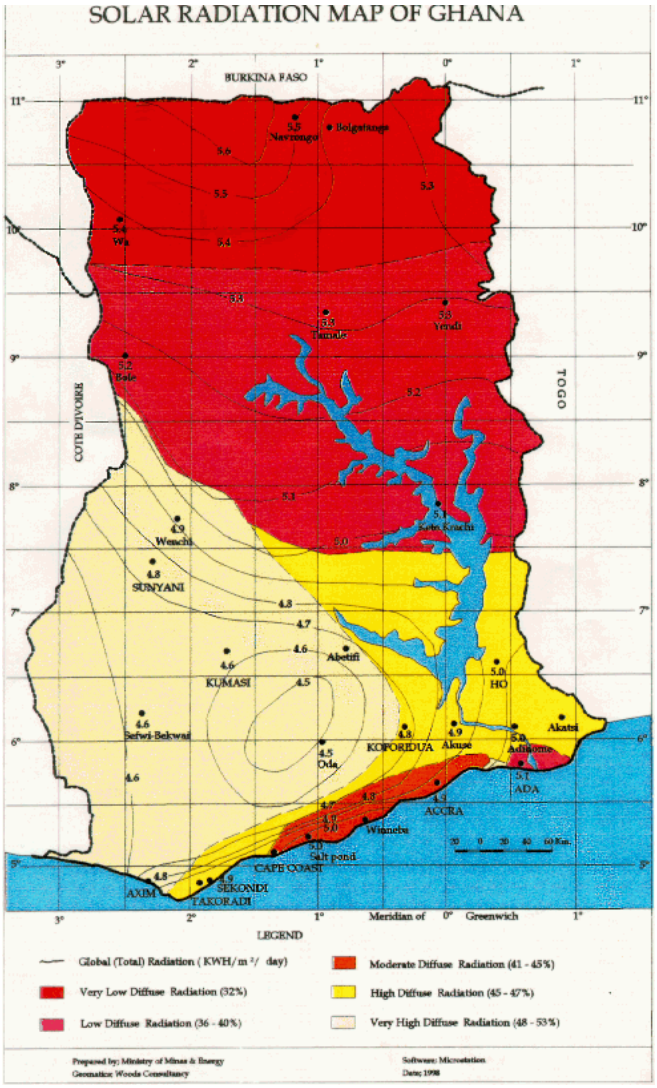
Source: Energy Commission, 2003

Abakah (1995) lamented the fact that solar energy, although abundant in Ghana, was mostly utilized in its raw state through open sun-drying. It is estimated that about 7,000 tonnes of oil equivalent of solar energy was used in drying Ghana's cocoa beans in the year 2004 (Energy Commission, 2006b). An experimental one tonne capacity solar dryer for cereals and pepper was tested at Agona Asafo in the Central Region for two yearsin the 1990s but no progress was made to replicate the technology afterwards.

Solar Water Heaters (SWHs) have been studied and their potential has been tested and demonstrated over the past two decades, nevertheless their market penetration in the country is very low (Energy Commission, 2006b). The main barrier to upscaling and market penetration is the high initial cost as well as high maintenance cost compared to electric water heaters (ibid). According to the Energy Commission (2006b), over the last two decades both natural and forced convection solar dryers have been field tested in the country.

Over the years, solar PV systems have attracted considerable attention and excitement, particularly in situations of energy crisis. In Ghana, solar PV is making contributions to

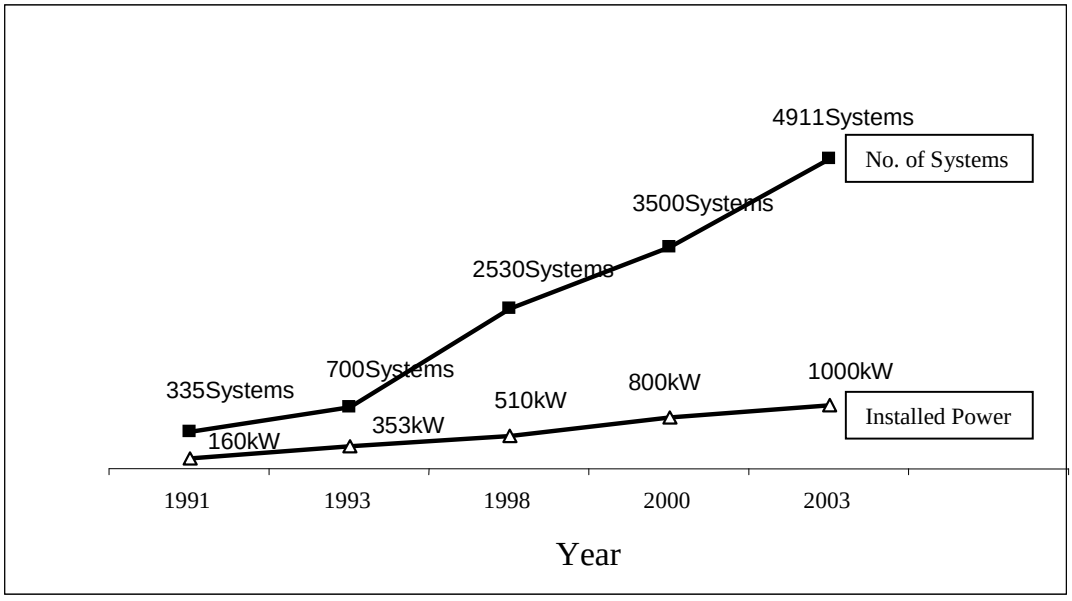
electricity access for household lighting, communication, water pumping, rural vaccine storage etc. Though the evolution of national policies relating to renewable energy can be traced to 1983 when the National Energy Board (NEB) was established (KITE/UCCEE, 1999), public solar PV electrification projects were first implemented in the early 1990's. By 1991 there were about 335 PV installations in Ghana with total estimated power of about 160 peak kilowatts (Essando-Yeddu, 1995; Institute of Economic Affairs, 1999; Obeng, 2008).



Source: Ministry of Energy, Ghana

Figure 6: Solar Map of Ghana

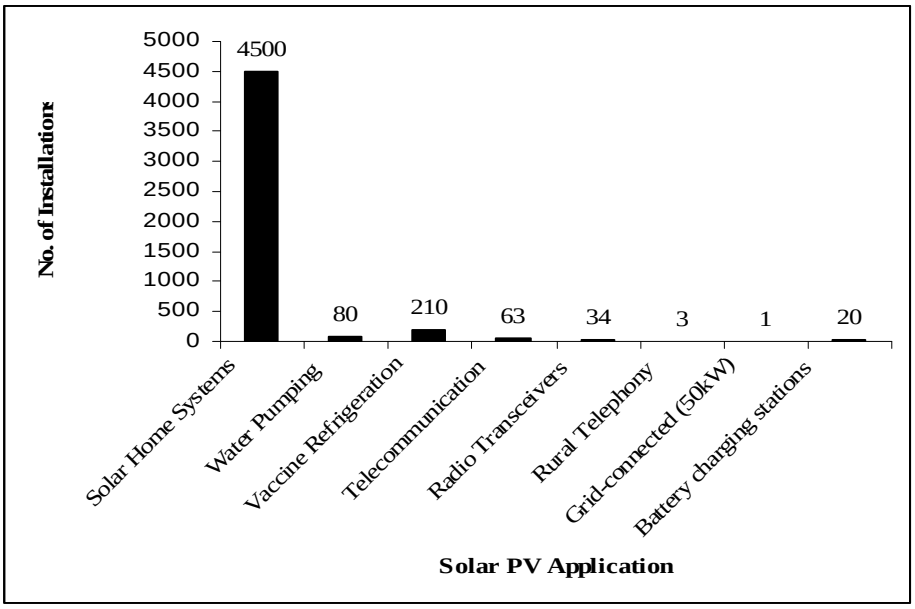
Figure 7 shows an increasing trend from 335 PV systems in 1991 to 4,911 PV systems in the year 2003 (Ministry of Energy, 2003). The early years of 1990's and 2003 are postulated to represent significant turning points of solar PV projects in Ghana. The implementation of the National Electrification Scheme (NES) in 1990 influenced a sharp increase in the number of solar PV systems from 700 in 1993 to 2,530 systems in 1998 (Obeng, 2008). By December 2003 about 4,911 systems were installed with total installed power of 1.0 peak megawatt (MWp) (Ministry of Energy, 2003). Data from the Ministry of Energy and other reliable sources are not available from the years 2004 to date.



Source: Obeng, 2008

Figure 7: Historical Evolution of Solar Photovoltaic Installations in Ghana

Figure 8 provides a more detailed description of the different applications of solar PV systems. The graph shows that out of the total installed systems 4500 were solar home systems.



Source: Obeng, 2008

Figure 8: PV Applications in Ghana as of December 2003

Despite this achievement, Ghana Statistical Service (2005) reported 0.2 percent for the contribution of solar energy to the total energy supply in terms of the population using solar for lighting. Over the last couple of decades the Ministry of Energy has implemented several rural solar electrification projects using stand-alone off-grid systems, often with support from development partners like UNDP and the Spanish Government. Im more recent times Ghana has seen three (3) grid-connected solar PV systems installed for demonstration purposes, one at the Ministry of Energy (50 kWp), Energy Commission (4 kWp) and KNUST College of Engineering (4 kWp). A National Renewable Energy Law, currently under discussion, could pave the way for many more of such gid-connected solar PV systems.

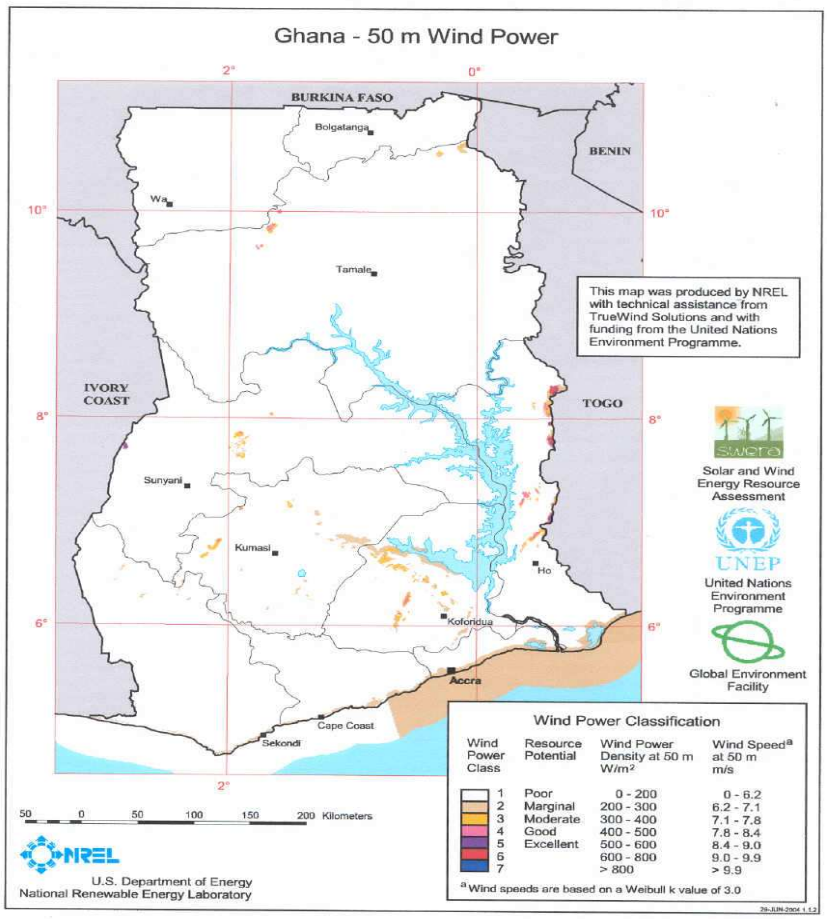
Though solar PV systems are cost-effective alternatives for low voltage applications in remote areas, high installed system cost, lack of local market, lack of sustainable financing among others impede access widening in poor developing countries like Ghana (Basnyat, 2004; Johansson et al, 2004; Sawin, 2004; WCRE, 2004). The cost of PV module is declining worldwide with growing market volume and it is expected that, if wide-scale electrification programmes associated with bulk purchase of PV and economies of scale in production and sales go ahead, the costs of P**V** systems would decline further (Plastow and Goldsmith, 2001; WGBU, 2004).

Data available from First Solar, Inc., USA indicate current PV module manufacturing cost of $1.12/Wp and a wholesale PV module price of about $2/Wp (Fthenakis et al. 2009). However, in Ghana the costs of PV installations can be as high as US$ 10-20/Wp, depending on the type of system (solar home system or grid-connected systems (Energy Commission, 2006). Through a fee-for-service approach adopted in Ghana, project beneficiaries could overcome the barrier of high PV system costs and paid only fixed monthly service fees of GH¢1.5 (US$1.63) for a 50Wp and GH¢2.5 (US$ 2.72) for a 100Wp PV system (Amous et al, 2002; Obeng, 2008). In the wake of current energy challenges in several African countries such as Ghana, there is the need for cost-benefit analysis to provide information for investments required to increase access to energy services, particularly for rural communities far removed from the national grid.

2.3.4 Wind Energy

Over the past 20 years extensive assessment of wind energy potential in Ghana has been carried out and reliable data on wind is available at the website of the Energy Commission of Ghana. Indications are that the coastal belt of Ghana has good wind energy potential(Antonio et al. 2003; Energy Commission, 2004). Wind measurements taken at 12 metre height along the coast revealed wind speeds varying from 3.33 m/s in Oshieyie, Greater Accra Region to about 6.08 m/s in Mankoadze, Central Region. However, practically, the most economic exploitation based on current technology is at 50 metre-heightwith annual average wind speed between 7.1 and 9.0 m/s, classified as “Moderate” to Excellent in Figure 9.

The lower wind speeds nearer ground level are suitable for energy conversion devices like wind-powered water pumping systems. Though some wind energy systems have been spotted in the country, there is no data on energy supply from such wind systems in Ghana and little research has been done on the potential contribution of wind energy, especially in distributed non-grid systems, to the goal of increasing energy access for all by the year 2020.

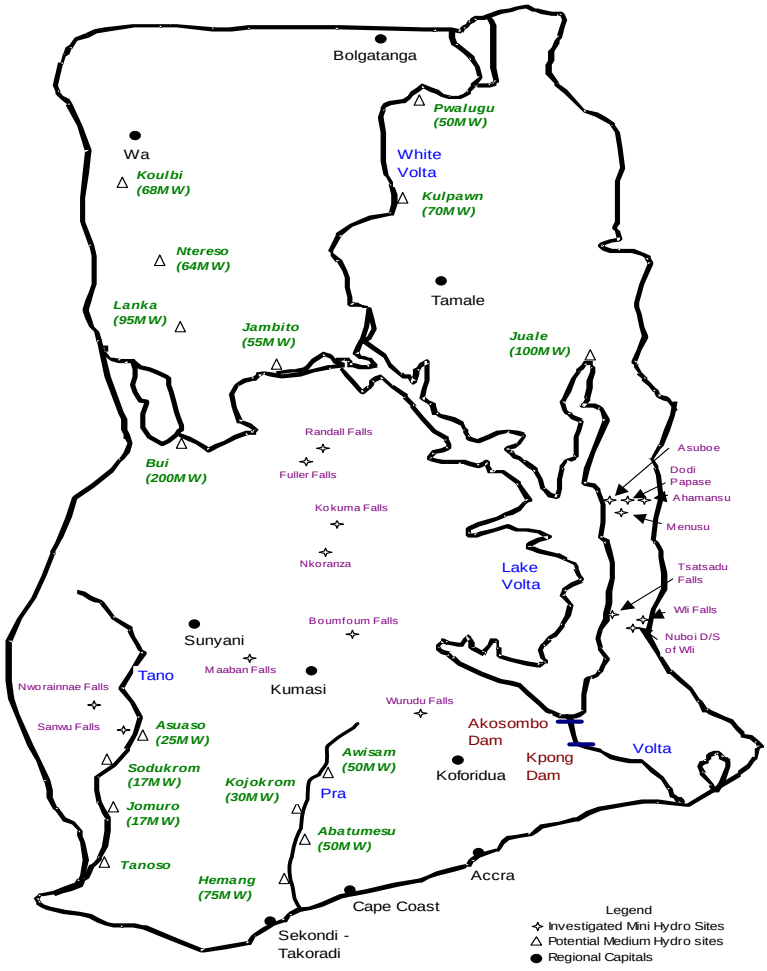


Source: NREL, US Department of Energy

Figure 9: Wind Power Map of Ghana

2.3.5 Small Hydro

Over seventy (70) small hydro sites have been identified in Ghana but none of these has been developed so far (Edjekumhene et al. 2001). In the early 1980s one pilot project commenced at Likpe-Kukurantumi on the Dayi River but it was abandoned from 1983 onwards and subsequent attempts to revive this project did not succeed. UNIDO is currently supporting the Ministry of Energy to implement another pilot project but that too seems to have stalled. A map showing some of the identified small and medium hydro sites in Ghana is presented in Figure 10.



Source: KITE

Figure 10: Map Showing Small and Medium Hydro Sites in Ghana

Edjekumhene et al. (2001) concluded that Ghana's small hydro potential could be put at 1.2 – 4 MW if the potenatial sites are developed as simple run-of-river projects, sized to provide power to rural communities not connected to the national grid, and at 4 – 14 MW if the plants are connected to the national electrical grid to absorb the excess energy output. Dernedde and Ofosu-Ahenkorah (2002) revealed that many of the sites that were found suitable for development to electrify adjoining rural communities had not been built and with the advancement of Ghana's national electrification scheme a greater proportion of the villages such plants could have served had been connected to the national grid; gid-connected plants would therefore make the most sense in any future small hydro development programme. Dernedde and Ofosu-Ahenkorah (2002) also noticed that flows had considerably decreased in the decade

leading up to their study to the extent that some of the rivers completely dry out for up to 7 months a year as a result of massive deforestation in the catchment areas of the rivers, resulting in considerabe reductions in the technically feasible size of small hydro plants that can now be developed in the country. Dernedde and Ofosu-Ahenkorah (2002) further recommended that, especially for the low height sites in the Volta Region, serious consideration should be given in future to the development of integrated power and irrigation infrastructure to include small hydro plant providing power to pump the water to farms and supply the excess energy to the national grid.

3.0 Policy Framework for Increasing Energy Access

3.1 Policies, Plans and Programmes up to 2000

Over the period up to the end of the 20th Century, the colonial administration of the Gold Coast and successive governments of Ghana formulated and developed various energy policies, plans and programmes to ensure the long-term reliability and security of energy supply for sustainable social and economic development of the country. The various energy policies, plans and programmes during this period include the following:

- Electricity Supply Ordinance (1920);
- Volta River Scheme (1915-1961);
- Rural Electrification Programme (1972);
- National Charcoal, Woodfuel, and LPG Promotion Programmes (1988-1990);
- National Electrification Scheme – NES (1989) with two main components:
    (1) District Capitals Electrification Programme –DCEP (2000), and
    (2) Self-Help Electrification Programme- SHEP (2001).

The first attempt to develop a modern legal framework for the energy industry in Ghana was in 1920, when the Electricity Supply Ordinance was passed (Botchway, 2000). The ordinance provided for private generation, regulation of diesel-based power and the inspection of generation activities by government officials. Under the Ordinance the Electricity Department was established as the state regulatory agency, but due to the lack of private sector participation in the industry, it became the sole power utility responsible for the generation, transmission and distribution of power (ibid). On the basis of the assessment by Botchway (2000), taking into consideration the stage of economic development of the country at the time, the Ordinance had very limited ambition and this was not surprising because it regulated the mainly diesel based power. According to Kay, cited in Botchway (2000), in 1923 a 10 year colonial development plan was launched in which about 75 percent of the projected £24 million was earmarked for transport and the rest for water supply, drainage, electricity etc. Unfortunately this plan, which was seen as the most ambitious colonial development programme was abandoned in 1927 following the departure of Governor Guggisberg.

Though the idea of the Volta River Scheme originated as far back as 1915, it was the government of the first President of Ghana that initiated the Volta River Project and saw to its completion (Botchway, 2000). The scheme had two grand ambitions – (1) a fully integrated and nationally owned aluminium industry processing Ghana's own bauxite with Ghana's own power and Ghana's own labour into a full range of finished aluminium products; and (2) abundant and cheap power, which would in turn make possible the modernization through industrialization of the Ghanaian society. According to Faber (1990: 66) "much of the disillusion of Ghanaian intellectuals with the Volta River scheme should perhaps be seen in the context of the continuing frustration of the two grand ambitions".

Given the focus of this review, the success of the ambition of providing abundant and cheap power to industrialize the Ghanaian society cannot be denied in view of its positive impacts on Ghanaians. Ghana's electricity access widening has been primarily based on hydroelectric grid extension. Since its implementation in the 1960's successive governments have increased the installed capacity, and there have been some technological advances by way of retrofitting to enhance efficiency. Furthermore, electricity supply to industries and enterprises have tremendously contributed to job creation and improvement in quality of life of Ghanaians.

The Rural Electrification Programme (1972) was an ambitious programme, which had the objective of increasing electricity access for the rural population. It was pursued within what is understood from some authors as a comprehensive rural development policy (Botchway, 2000; Aryeetey and Goldstein (n.d.) Rimmer (1978) cited in Botchway (2000) took a different stance on the broad rural development policy and commented that during that period rural farmers were still deprived of the benefits of their productivity. However, in terms of extension of feeder roads, water supply and energy in the form of electricity, successful access widening was reported by Aryeetey and Goldstein (n.d.) However, the authors did not provide any quantitative data on the proportion of the population who gained access to electricity during the period.

Under the National Electrification Scheme (NES) introduced in 1989 the Government of Ghana committed the country to increase electricity access to all communities with population above 500 by the year 2020 (Energy Commission, 2004, 2005). The NES was planned to proceed in six five-year phases over the period 1990 - 2020. The electrification of the several thousand un-electrified villages in the country has been assumed to be by grid extension, with community participation under the Self-Help Electrification Program (SHEP). Challenges envisaged within this programme include: low density of potential consumers of rural areas; low income levels in rural communities; significant distances required for medium-voltage lines; the costs of medium-voltage; and low-voltage lines, transformers, and service drops.

In the 1990s concerns arising out of the escalating consumption of woodfuels in the form of firewood and charcoal resulted in several bio-energy programmes including the Improved Charcoal Cookstove Project, Improved Charcoal Making Project, Biogas Project, and National LPG Promotion Programme. These programmes and projects were, *inter alia*, aimed at reversing the rapid deteriorating environment and ecological damage, as evidenced by perceptibly high rates of deforestation and desertification as well as the worsening effects of global warming and other atmospheric pollutants from the inefficient production and use of woodfuel (Abakah, 1993). The immediate objective of the national policy on woodfuel production and utilisation was to ensure sustainable production, marketing and consumption of woodfuels. A key recommendation of the policy was that government should support the promotion and development of sustainable management of the country's natural forests and woodlands for sustainable supply of wood including woodfuels (Energy Commission, 2006b).

In 1990, the Government of Ghana launched a National LPG Programme under which the Tema Oil Refinery was to be modernized and a massive LPG campaign implemented. This offered the opportunity to promote LPG as an alternative energy to charcoal and firewood. The promotion targeted urban households, public institutions requiring mass catering facilities and the informal commercial sector including small-scale food sellers (UNDP Ghana, 2004). Extensive promotional and educational campaigns were also carried out to ensure that environmental, health and safety regulations were observed and the benefits of switching to LPG communicated to the public.

3.2 Policies, Plans and Programmes after 2000

Between 2000 and 2005, government adopted a formal energy policy, which recognizes the provision of adequate energy supply for meeting development objectives of poverty reduction and economic growth. It emphasised private sector participation to overcome funding constraints. The overall Government policy aimed to facilitate a “Golden Age of Business” and stressed on improved availability, accessibility and affordability, with special focus on rural areas (African Development Bank, 2005, NDPC, 2007). The Ghana Poverty Reduction Strategy (GPRS) documentation also emphasised reliable supply of high quality energy to boost industrial development and cost recovery pricing while protecting the poor, continuation of rural electrification, promotion of energy efficiency and renewable energy (African Development Bank, 2005). The introduction of the GPRS brought new policy directions aimed at expanding the use of renewable energy in rural electrification programmes in Ghana (World Bank, 2003).

The Strategic National Energy Plan (SNEP) completed by the Energy Commission in 2006 is a comprehensive way of looking at the available energy resources of the country and how to tap them economically and timely to ensure a secured and adequate energy supply for sustainable economic growth now up to 2020 (Energy Commission, 2006). The goal of SNEP is to contribute to the development of a sound energy market that would provide sufficient, viable and efficient energy services for Ghana's economic development through the formulation of a comprehensive plan that will identify the optimal path for the development, utilisation and efficient management of energy resources available to the country.

The SNEP identified key energy sources for long-term development and sustainability of electricity supply to include hydro-power, gas-powered thermal plant, renewables (such as wind, solar energy and biomass) and nuclear energy technologies.

The ten (10) broad objectives of the SNEP are as follows (Energy Commission, 2004):

- Objective 1: Stimulate economic development by ensuring that energy plays a catalytic role in Ghana's economic development.
- Objective 2: Consolidate, improve and expand existing energy infrastructure.
- Objective 3: Increase access to modern energy services for poverty reduction in off-grid areas.
- Objective 4: Secure and increase future energy security by diversifying sources of energy supply.
- Objective 5: Accelerate the development and utilization of renewable energy and energy efficiency technologies.
- Objective 6: Enhance private sector participation in energy infrastructure development and service delivery.
- Objective 7: Minimize environmental impacts of energy production, supply and utilization.
- Objective 8: Strengthen institutional and human resource capacity and R & D in energy development.
- Objective 9: Improve governance of the Energy Sector.
- Objective 10: Sustain and promote commitment to energy integration as part of economic integration of West African states.

Unfortunately the SNEP was not adopted formally by the Government and one of the challenges for the energy sector today is how to redress this situation and make the SNEP a binding policy document.

The Energy for Poverty Reduction Action Plan (EPRAP) is another policy document which was not formally adopted by the Government.

The broad objectives of the Plan of Action proposed in EPRAP are as follows:

1. Facilitate the provision of reliable electricity to support and enhance the delivery of essential social services such as education, health care and potable water as well as the deployment of ICTs in rural areas

2. Facilitate the provision and use of modern energy services (in the form of mechanical and/or electrical power) at the community level for **all** rural communities for productive applications
3. Facilitate the provision and use of affordable modern cooking fuels and devices to **at least 50%** of households currently using traditional biomass for cooking

EPRAP recommended a number of priority projects including the following:

- Grid Extension to Fish Landing and Freezing Facilities
- Establishment of Woodlots and Transfer of Improved Technology for Charcoal Production
- Promotion of Access to LPG in Rural and Poor Peri Urban/Urban Communities
- Promotion of Improved Cookstoves in Households
- Windpumps for irrigation, Multi-functional Platforms for Agroprocessing, etc

EPRAP was developed on behalf of the Ministry of Energy by the NGO, KITE, working with the aid of a National Multi-Sectoral Group comprising representatives from the key sector ministries and selected agencies whose activities were seen to be crucial to the attainment of the MDGs Agriculture, Health, Education, Small And Medium Scale Enterprises, Water And Sanitation, Communications and Households.

The one major programme that has taken off since 2000, as far as access to energy services is concerned, is the Ghana Energy Development and Access Project (GEDAP). GEDAP is a multi-donor funded project involving the World Bank, International Development Agency (IDA), Global Environment Facility (GEF), African Development Bank (AfDB), Global Parternship on Output-based Aid (GPOBA), Africa Catalytic Growth Fund (ACGF) and the Swiss Agency for Development and Cooperation (SECO). The Development objective of GEDAP is to improve the operational efficiency of the power distribution system and increase the population's access to electricity and help transition Ghana to a low-carbon economy through the reduction of greenhouse gas emissions.

Electricity Access Expansion and Renewable Energy Development constitutes Component C of GEDAP with a project cost of US$101.5 million. This component has three (3) sub-components: (1) the multifaceted approach, (2) grid extension and (3) isolated grids. The first sub- component is designed to support a new and multifaceted approach to expanding electricity access in Ghana tailored to geographical location, potential level of electricity demand, and distance from the existing grid, with financing for investments plus technical assistance and training in support of the following:

- intensifying the use of the existing ECG and NED distribution networks, and extending these networks where economically viable;
- developing new, isolated mini-grids serving towns and clusters of consumers far from existing networks;
- development of mini grids using renewable energy for population clusters far from the grid where grid connection would be less efficient and more costly;
- the establishment of a program for disseminating solar systems in remote, sparsely populated rural areas that can only afford electricity for lighting; and
- introduction of new financing systems and institutions to encourage the development of small private energy businesses,

Grid Extension, the second sub-component under Component C has US$50.4 in financing costs associated with connection of un-electrified towns and villages to the national grid through the construction of 33 kV network, 11 kV and Low Voltage distribution networks, transformers, poles, connection services (drop lines, meters, etc.) and associated equipment. The third sub-component, Isolated Grids, has an estimated total amount of US$9.1 M to support grid-connected renewable energy such as small hydro, wind, and biomass, as well as isolated grid systems such as village hydro with the Rural Electrification Fund (REF) providing partial capital subsidies to 2-3 small-scale grid-connected renewable energy projects (1-10 MW) from micro-hydro, biomass, or wind, and 5-7 mini-grids or village hydro systems to private sector or cooperatives.

3.3 Policy Mechanisms and Institutions

Over the years, successive governments of Ghana have used a number of policy mechanisms to improve access to energy services for the population. Efforts have been made to restructure the power sector to provide adequate and reliable electricity as well as promote clean energy services based on energy efficient and renewable energy technologies. Energy sector restructuring has been initiated as a recommendation to address major challenges including inadequate funding, weak institutional framework, poor implementation and management. In the case of the power sector, growing demand for energy and constraint in supply as well as inadequate financing were the key factors that triggered reforms (Edjekumhene et. al, 2001). Relevant policy mechanisms adopted to address energy sector challenges in Ghana include regulation of electricity tariff, deregulation of petroleum pricing, setting industrial standards and permitting, education and information dissemination and stakeholder involvement (see Aryeetey and Ahene, 2005; Energy Commission, 2006a, 2006b, 2006c; World Bank, 2008).

With respect to financing, direct or indirect government subsidy and grants from donor agencies are undoubtedly the most highly used mechanism covering capital-related subsidies to the utilities and the oil refinery and price-related subsidies on electricity and petroleum products. Several policy mechanisms have also been employed including establishment of the Energy Fund (funded through levies on petroleum products) and the REF (funded by both donors and government). In a few instances customs duty waivers have been employed as in the case of solar panels.

To ensure the proper functioning of all players in the energy sector and to create the requisite conducive environment for the protection and enhancement of private investment in the sector, a number of regulatory agencies have been established by Acts of Parliament. These institutions are the Energy Commission, Public Utilities Regulatory Commission (PURC) and the National Petroleum Authority (NPA). The Energy Commission advises government on energy policy and strategy; and is also involved in indicative planning of energy and electricity system expansion, and licensing of energy sector operators (Energy commission, 2006c). The PURC established in 1997, is a prime body for setting tariffs and framing customer service regulations. The National Petroleum Authority is an independent regulator, which reviews world market price

developments, the prices of imported finished products, and the operations of Ghana's Tema Oil Refinery.

In earlier times, electricity regulation was under the mandate of the then Ministry of Mines and Energy (MME). The Ministry was the policy making body for electricity and petroleum with a primary responsibility of ensuring policy development and coordination of the power sector, assisted by Volta River Authority (VRA) and Electricity Company of Ghana (ECG). The Ministry also had the responsibilities of setting tariffs for electricity consumption prior to reforms in the power sector (Edjekumhene et. al, 2001).

At present, the energy system in Ghana is essentially managed by the public sector. The Ministry of Energy (MOE) is responsible for formulating and implementing fuels and electricity policies. The Volta River Authority (VRA), a state owned entity, was created under the Volta River Development Act 1961 (Act 46) for the generation and transmission of power in Ghana. VRA supplies electricity to large industrial and mining units and to two electricity distribution companies- Electricity Company of Ghana (ECG) and Northern Electricity Department (NED) of VRA. The Electricity Corporation of Ghana (ECG) was established by a decree (NLC Decree No.125) in 1967. It replaced the Electricity Department of the Ministry of Works and Housing. However, under the provisions of the Statutory Corporations Act 1993 (Act 461), ECG has since 1997 been converted into a limited liability company known as the Electricity Company of Ghana (Aryeetey and Ahene, 2005).

Under an on-going Power Sector Reform, a merger of ECG and NED to form one distribution company is being considered. The transmission function has been separated from the generation and other responsibilities of the VRA and a new company, Ghana Grid Company (GRIDCo), has been established for this function. A new Government agency, the Bui Development Authority, has also been established to oversee construction of the 400 MW hydro plant on the Bui River. One independent power producer, Takoradi International Company (TICO), is already in operation and there are several others at various stages of project development (Osono, Cenpower and Asogli). A new Rural Electrification Agency (REA) is proposed to be established under the current World Bank funded GEDAP (World Bank, 2007). The REA will manage the REF.

With respect to petroleum products, apart from the Ghana National Petroleum Corporation (GNPC) and Tema Oil Refinery (TOR), there is the Ghana Oil Company (GOIL) and many privately-owned oil marketing companies including the multinationals like Shell. The LPG industry has seen many private distributors and retailers and, as discussed earlier, there is still unsatisfied demand for support to establish new and more SMEs in LPG distribution and retailing. The energy sector has taken the initial steps required to show commitment to the rural population and to ensure that the rural areas are not neglected. The Unified Petroleum Price Fund (UPPF) scheme initiated by the Government was meant to motivate transporters who travel to rural and distant locations, outside a radius of 200 km from the refinery (UNDP Ghana, 2004). In spite of the UPPF Scheme, penetration of LPG in the rural areas is still not encouraging as rural consumption is less than 2 percent of the national consumption (Ghana Statistical Service, 2005).

The woodfuels sector represents a grey area with mostly small informal and unregulated operators. A few SMEs and some NGOs have been involved in the improved cookstoves market but traditional stoves are very much a thing for the informal sector. The biofuels industry is still at its infancy but as indicated earlier there are promising signs of rapid growth, especially in the number of large, foreign-owned firms investing in the business of growing the feedstock and processing it for export.

The Energy Foundation is a public-private sector partnership that promotes energy efficiency and conservation in Ghana. The sector also has several active NGOs, like KITE and NewEnergy, involved in a range of activities from energy efficiency enterprise development to rural multi-functional platforms (MFPs).

3.4 Main Challenges

According to Energy Commission (2006), the main challenges facing the energy sector of Ghana are the following:

1. Rapidly growing demand for energy by all sectors due to the expanding economy and growing population.
2. Risk of significant imbalance between energy production and indigenous sources of supply.
3. Inadequate investments to match the growing energy demand due to lack of capital.
4. Risk of over reliance on imports to meet local shortfalls of conventional fuels, which could threaten the country's supply security, making it vulnerable to external pressures.
5. High levels of end-use inefficiency culminating in waste of final energy forms.
6. Inefficient pricing of energy services resulting in poor financial positions of the energy providers, but also high cost of tariff, which would not encourage maximum use of energy for wealth creation and could threaten the country's growth in prosperity and modern way of life.
7. Operational inefficiencies of the utilities leading to high energy losses and consequently increasing cost of supply and distribution.
8. Over reliance on woodfuels which could threaten the country's forest cover.
9. Solar energy, which is relatively abundant, but barely exploited to supplement the commercial energy requirements of the country.

As far as this review is concerned, the challenges listed above have not gone away and will need to be addressed more broadly within the framework of energy policy and insitutions in Ghana as a whole.

4.0 Key Issues and Options for Increasing Energy Access

This section contains preliminary thoughts of the authors and will be expanded upon and refined in subsequent phases of the GIS-based energy access project. In particular, this Zero-Order Draft will be reviewed jointly with personnel of the Ministry of Energy and the Energy Commission over the next three months following which a First-Order Draft will be prepared for presentation at a forum to be organised for key stakeholders in the last quarter of 2009. A similar process will follow the stakeholders forum (or meeting of an expanded National Multisectoral Group) to allow specific comments and suggestions from key stakeholders to be incorporated in the document and a Second-Order Draft prepared within three months of the forum. The first meeting of the Steering Committee in 2010, roughly a year from now, will then undertake a final review of the Second-Order Draft and approve a final draft for distribution to the general public.

The section is organised around three broad themes as follows:

a) Electricity for all by 2020;
b) LPG / Improved Cooking Systems for all by 2015; and
c) More productive uses of rural/renewable energy all the way.

A second volume or supporting document to this review of policies and programmes, will focus on the assessment of sectoral energy needs, identification of gaps and comparison with national and regional targets. It is intended that this volume becomes a living document to be reviewed once a year as one of the instruments for monitoring and evaluating the performance of the energy sector with respect to respect to the achievement of energy access targets within the economy as a whole and the sectors directly relevant to the MDGs and poverty reduction in particular. The problem of lack of data to determine whether targets will be achieved will be addressed within this context.

4.1 Electricity for all by 2020

Ghana currently ranks third highest in sub-Saharan Africa, after Mauritius and South Africa, as far as access to electricity is concerned. Mauritius has already achieved universal electrification and South Africa is aiming to do so by 2012, as shown in Figure 10 below. Akuffo (2009) has

already indicated for Ghana that current rates of electrification would not lead to full electrification by 2020, the target set originally in the NES and reaffirmed by the current Government. Figure 11 shows that a major shift in the current electrification trajectory to something somewhat similar to South Africa's will be required if Ghana is to meet the 2020 target. Whether or not Ghana will be able achieve this 2020 universal electrification target, and what it would take to do so, is a key issue for this review.

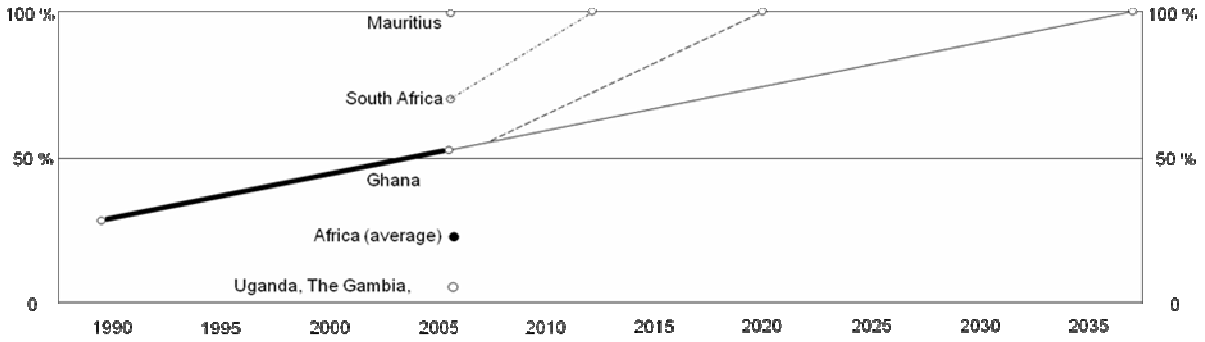


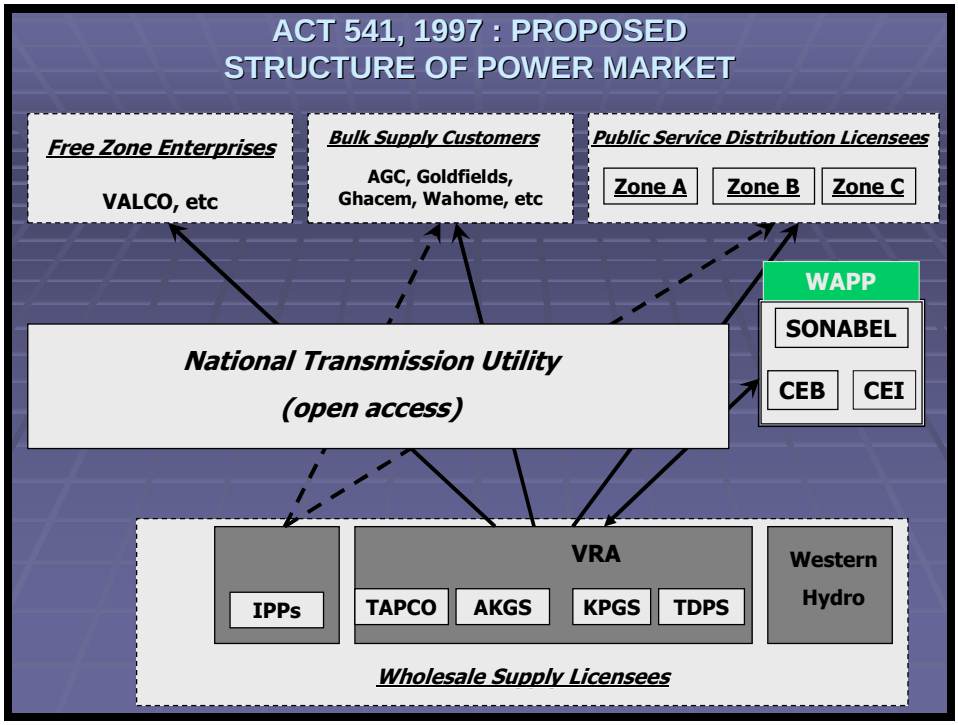
Figure 11: Electrification Status and Trajectories for Ghana and Selected African Countries.

Alternative Energy Africa (2009) estimates Ghana's rate of increase in demand for electricity at 10 to 15% per annum over the last two decades. Thus an important consideration is to match the growth rate of electricity demand with adequate supply at reasonable prices. Though progress has been made towards achieving the goal of securing reliable and adequate supply of electricity at reasonable prices, much effort is needed to improve existing installed capacity, manage generation and distribution losses as well as reduce costs and prices to reasonable levels. This raises major questions on both the supply and demand sides of the electricity supply chain.

On the supply side, as discussed already in the section on policy mechanisms and institutions, growing demand for energy and constraint in supply as well as inadequate financing were the key factors that triggered reforms in the energy sector. In the case of the power sector, the ongoing reform/restructuring programme has proceeded in fits and bursts over the last decade and a half or so. If the sector is to succeed in playing its role towards the meeting the 2020

universal access target then a renewed impetus will be required in the implementation of the reform/restructuring programme and more dynamism will be needed in the distribution as well as generation sides of the industry.

Mahama (2008) affirmed his support for zoning the country to enable several distribution companies participate in the supply of power to households and industries, as shown in the schematic diagram for Ghana's power sector presented in Figure 12. In line with this affirmation it may therefore be more appropriate to hold ECG and NED as separate companies, with some transparent cross-subsidy mechanisms to address the higher incidence of poverty in the northern regions of Ghana, as a first step towards the establishment of a few more dynamic distribution companies.



Source: Mahama (2008)

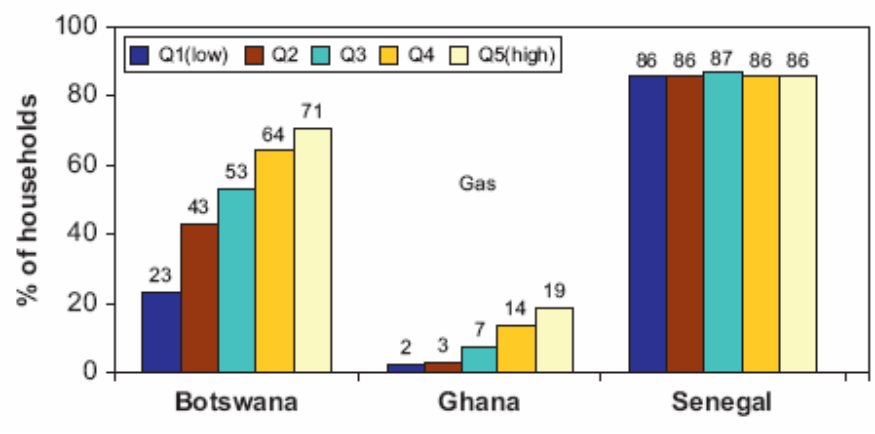
Figure 12: Proposed Structure of the Electricity Supply Industry in Ghana Post-Reform

The generation side of the industry could also benefit from the introduction of more dynamism to ensure that adequate electricity supply is guaranteed. One suggestion that might help in this direction would be to go beyond the proposed structure presented in Figure 11 such that TAPCO (Takoradi Power Company), the thermal side of VRA, is separated from the hydro side of VRA to ensure greater transparency in the cross-subsidy mechanisms and provide more opportunities for local Ghanaian shareholder participation as has been done successfully in Kenya.

The ambition of Ghana's founding fathers to produce cheap electricity has not been sustained due to several challenges including the lack of a combination of coherent policies among others to consolidate, improve and diversify sources of electricity supply in Ghana (Energy Commission, 2006). Contrary to this ambition, electricity prices have been rising and several mechanisms, including regional power pooling, are being put in place to reduce electricity costs and improve reliability. Taking the power sector reform bull by the horns and driving more dynamism into the industry with a good eye on the ECOWAS regional electricity market could well be the approach that might deliver the much sought-for local benefits as far as affordable access is concerned.

4.2 LPG / Improved Cooking Systems for all by 2015

As a member state of ECOWAS and a leader within the region, Ghana is expected to lead the way towards achievement of the ECOWAS target of 100% of the total population having access to improved domestic cooking services by 2015, with close to 10% using LPG. As discussed in previous sections of this review, about 9% of Ghana's population in 2005 used LPG as their main energy source for cooking and the corresponding LPG access rates for rural areas, urban areas and Accra are 2%, 17% and 30%, respectively. With Ghana's urban population predicted to approach 60% by 2030 it should be possible to take advantage of the relative ease of LPG uptake in urban areas to exceed the ECOWAS target and Ghana's true leadership fashion go for a doubling of LPG access from the 2005 rate of 9% to something much closer to 20%, with the rest of population using improved woodfuel-based cooking services, by 2015.



Source: Prasad (2008)

Figure 13: Proportion of households using gas for cooking by income quintile

Senegal has been a pioneer in the ECOWAS region in terms of her efforts to increase access to LPG for cooking. As shown in Figure 13, percentage rates for LPG access in Senegal have been reported in the 80s across all five income quintiles[2]. Figure 12 also shows Botswana, another country in sub-Saharan Africa, to have much higher LPG access rates than Ghana. It may therefore be argued that if these two African countries have done it, Ghana should be able to do it too, and again questions relating to how this can be done should be of central concern to this review.

Abavana and Mahama (2006) have proposed a strategy focused on "promoting the growth of a commercial market for clean energy services, with an active role for government as a regulator and civil society as a facilitator." The top five interventions which were employed in their UNDP-supported project on LPG Substitution for Wood Fuel, and could possibly be scaled up in an intensified nation-wide LPG program, are as follows:

1) Creating awareness for LPG as a cost-effective, safe, convenient, and reliable energy alternative.

2) Building community capacity and networks as an integral part of the supply chain.

3) Establishing a sustainable supply chain for LPG products and services.

4) Introduction of appropriate LPG appliances (cookers and mini cylinders).

2 This data may only refer to the capital, Dakar, as other sources report lower figures around 40% for the country as a whole.

5) Initiating a national dialogue on the development of a Standards and Safety Regulations and LPG Code of Practice for Filling and Handling.

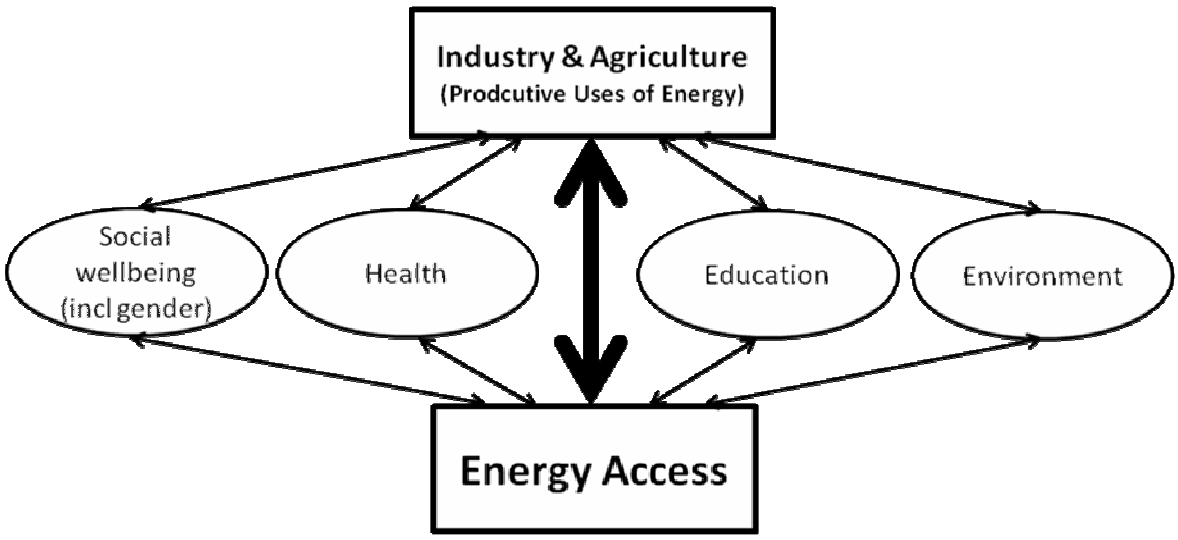
Abavana and Mahama (2006) call for "more emphasis on engaging the local authorities (municipalities) and the private sector more effectively, and using the Public Private Partnership (PPP) business model for service delivery." Active implementation of their fundamental strategy based on government as a regulator and civil society as a facilitator, coupled with the continued provision of business development services, such as the AREED package successfully developed by KITE and others to promote private entrepreneurship in the clean energy sector, could go a long way in helping to reach and possibly exceed the ECOWAS White Paper target for LPG access in West Africa.

Togobo (2006) has pointed out that, based on previous studies, there is a strong correlation between the level of household income and the type of fuel used, with low income households preferring traditional fuels like charcoal, firewood and agricultural residues and higher income households relying on more conventional fuels like LPG and electricity. Togobo (2006) has also pointed out the immense role of kerosene for lighting and the fact that the retailing of kerosene is done in small shops, in houses and by head loaders, usually in mineral and beer bottles or in small gallon tanks. He points out further that between kerosene and LPG the fuel of choice is the latter and therefore Government may choose to continue providing support within its kerosene pricing policies/distribution setup to ease the price changes resulting from transportation, while expanding and intensifying policy measures for the promotion of LPG use by those who can afford this throughout the country.

As indicated above, a doubling of LPG access to about 20% by 2015 would leave some 80% of the Ghana's population to be served with other forms of improved cooking services. Togobo (2006) argued for conscious and sustained efforts at improving efficiency and sustainable continuity in the woodfuel trade given the fact that woodfuels happen to be the main fuels used for cooking in Ghana and furthermore, the regulatory mechanisms in place to ensure sustainability are few. Togobo (2006) therefore calls for effective programmes aimed at promoting efficient production and use of cooking fuels especially charcoal and firewood.

4.3 More productive uses of rural/renewable energy all the way

It has been argued elsewhere that efforts which succeed in integrating productive uses and income generation activities into energy access initiatives, whether based on conventional fuels or renewable energy, may well turn out to be the deciding factor if the dream of energy for all in sub-Saharan Africa is to become a reality in the foreseeable future (Brew-Hammond and Kemausuor, forthcoming). In line with this argument, Figure 14 has been drawn to drive home the importance of coupling energy access initiatives with productive uses of energy, essentially in industry and agriculture, and how close coupling between energy access initiatives and productive uses of energy may be important in and of itself, as well as important for the main socio-economic sectors addressed in the MDGs, namely, Social wellbeing (including gender), Health, Education and Environment (SHEE).



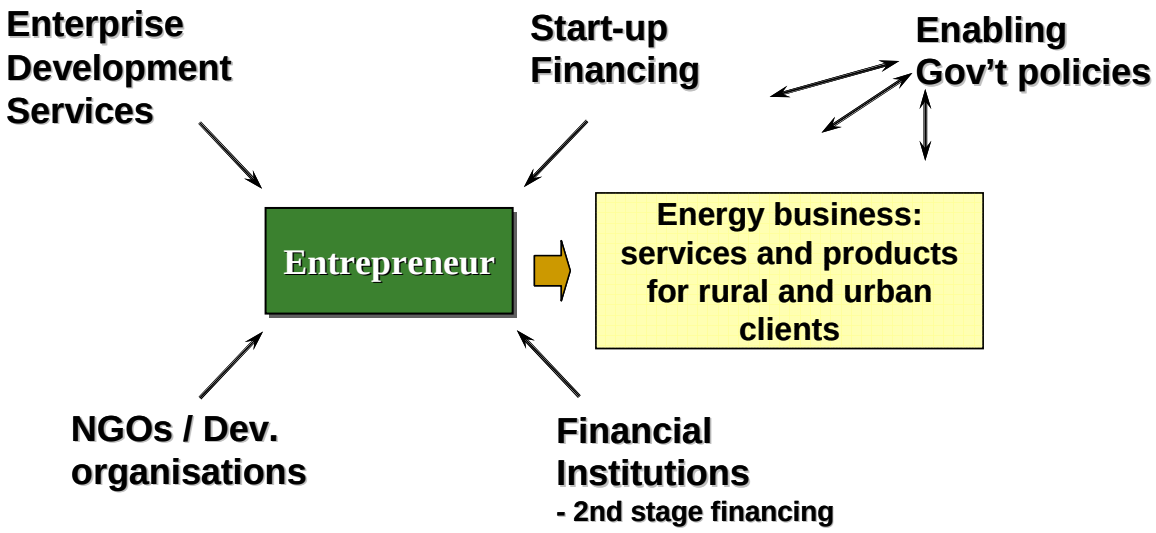
Source: Brew-Hammond and Kemausuor (forthcoming)

Figure 14: A framework for co-benefits from energy access and productive uses of energy

The extent to which Ghana is able to successfully pioneer energy access initiatives with embedded linkages to productive uses/income generation may therefore help to make the difference, whether or not universal access to modern energy services will be achieve by 2020. Previous sections of this report discussed in particular the availability of renewable energy resources that could be used, in

addition to the conventional energy sources, to stimulate the rural economies, increase household incomes and hence improve affordability for modern energy services.

Akuffo (2008) acknowledges the fact that it has been very difficult in Ghana to actually establish enterprises that will focus on the rural areas and also on renewable energy. He therefore suggests that in rural areas, the focus should be on the social aspect and there should be policy to lift the rural folks up from their current status through social programmes. Akuffo and Obeng (2008) go further in their study of energy SMEs in Africa and the constraints and challenges they face including lack of relevant policies and institutional framework to provide sufficient leverage for SMEs to tap into new energy business; lack of capacity building in energy system development and commercialization; limited rural energy market; inherently high initial cost of renewables and energy efficient products; and poor access to clean energy financing.



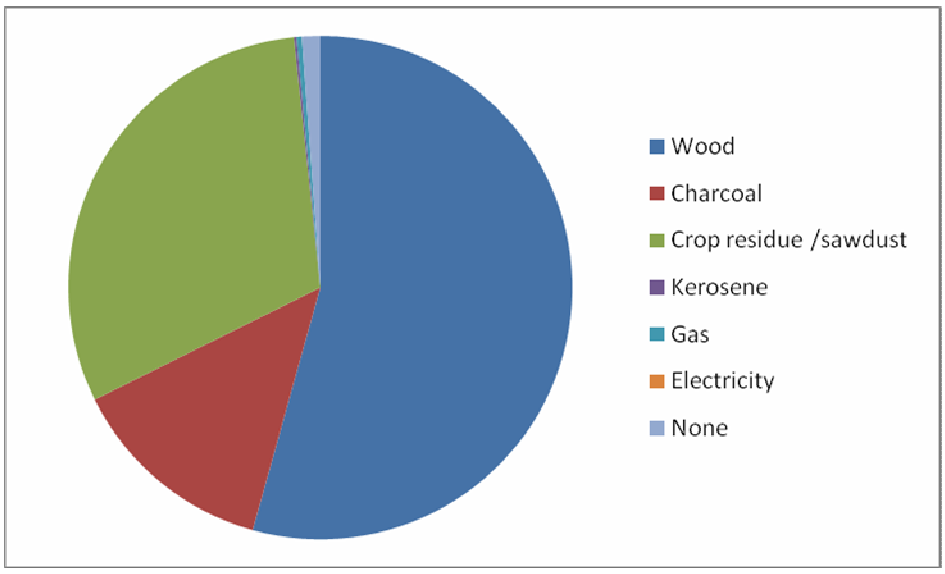
Source: Agbemabiese (2009)

Figure 15: A framework for co-benefits from energy access and productive uses of energy

In the light of their findings Akuffo and Obeng (2008) concluded that the REED approach (shown schematically in Figure 15) has high potential to contribute to the overall national development priorities, particularly the goal of widening access to energy services for under-served communities. Akuffo and Obeng (2008) go on to propose several policy-related interventions including the

building of human and institutional capacity in energy system management. This need to build human and institutional capacity is being taken up in various programmes like GEDAP and the Renewable Energy Education Project (REEP) implemented through an international partnership let by The Energy Center, KNUST with funding from the European Union's EDULink Programme of the Africa, Caribbean and Pacific (ACP) Secretariat. Ghana should do well to scale up such enterprise-centered capacity development programmes, with a strong emphasis on productive uses especially in rural areas.

The challenge of incorporating strong productive use elements in energy access inititiaves in general, and renewable energy schemes in particular, cannot be underestimated but there is evidence to suggest that with some careful thinking and innovative programme design, this should be feasible with tangible results for all to see. For instance, an important feature of the woodfuels consumption pattern in Ghana is the use of agricultural residues in the poorer regions of the country constituting some 2% of the total population of the nation. As shown in Figure 16 for the Upper East Region, the population depending on agricultural residues for cooking is as high as 30% pointing to the scarcity of wood in parts of the region and the endemic poverty levels that put even charcoal or other commercial fuels out of reach.



Source: Data from GLSS (2005)

Figure 16: Types of Cooking fuels used in the Upper East Region of Ghana

Table 4: Distribution of cattle population in the Three Most Cattle-Rich Regions of Ghana

Region	Cattle population	No. of cattle owning households	No. of cattle owning agric. households	Average cattle per agric. household
Northern	982,847	98,090	85,142	11.5
Upper West	787,681	28,250	23,645	33.3
Upper East	454,112	47,577	39,441	11.5
TOTAL	**2,224,640**	**173,917**	**148,228**	**15.0**

Source: Bensah (2009) citing GSS (2008) and KITE (2008)

Interestingly enough, the Upper East and Northern Regions have the same number of cattle per agricultural household, second only to that in the Upper West Region (see Table 4). The potential for household level biogas plants designed to produce fertilizer for improving agricultural yields, in addition to energy for cooking and lighting, is therefore considerable. It is unclear why such a programme has not seen the light of day, to date, but the numbers suggest that this could open the door for not only increasing access to modern energy services but also generating the incomes necessary for improving their social welfare of poor rural families. The viability of this and similar productive use-oriented energy access programmes will be investigated in subsequent phases of the GIS-based energy access project.

5.0 Conclusions and Recommendations

5.1 Conclusions

The following broad conclusions can be drawn from the review:

1. Since the passage of the Electricity Supply Ordinance of 1920, there have been several plans, policies and programmes aimed at increasing access to energy. These have generally failed to achieve the aims with which they were begun or they were not able to meet their targets within the specified periods due to one problem or the other. Several problems have been identified, ranging from funding to poor organisation and lack of participation from the private sector.
2. Despite the intentions of several past governments to increase access to energy services, particularly to the underserved areas, existing policies and plans have not delivered effective results.
3. Even though the aim of Ghana's electrification policy is to make available cheap electricity for all, this could not be sustained due to several challenges including the lack of a combination of coherent policies among others to consolidate, improve and diversify sources of electricity supply in Ghana. Contrary to this ambition, electricity prices have been rising.
4. From modest beginnings since the commissioning of the Akosombo hydro-power generation plant, access to electricity in Ghana has been increasing. There has been a phenomenal growth from the late 1980s buoyed by the NES and later SHEP (under the NES). This has raised electricity access rate to about 55 percent in 2008, a feat only rivalled by South Africa in sub-Saharan Africa. Nevertheless, some 44% or so of households in Ghana are still without electricity and this is a source of concern.
5. There is lack of data to determine whether current energy policies and plans will achieve the targets and goals for energy access as set in the governments' policy documents, ECOWAS White paper, and the MDGs. Already, Ghana face several challenges which frustrate efforts to achieve national energy access targets and goals. These challenges include growing demand for energy but with inadequate investment to match the demand, high levels of end-use inefficiency culminating in waste of final energy forms, inefficient

pricing of energy services resulting in poor financial positions of the energy providers, operational inefficiencies of the utilities leading to high energy losses, under-exploitation of renewable energy sources, e.g. solar, and over reliance on woodfuels which could threaten the country's forest cover.

6. Several policy mechanisms and institutions have come on board over the years, all in the aim of delivering a better energy access to Ghanaians. On the generation side have been VRA while ECG and NED have been responsible for distribution. Efforts at policy formulation and regulation have been handled by the Energy commission and the PURC.
7. Biomass in the form of woodfuel, remain the most prominent fuel in Ghana for cooking and heating. That firewood and charcoal contribute about 63 percent to the total energy consumed in the country is a source of worry if Ghana is to reduce deforestation and the associated health problems associated with indoor pollution from the use of biomass for cooking and heating.
8. Even though some strides have been made in LPG consumption in urban areas, especially in the Ashanti and Greater Accra Regions, access to LPG is still lower than expected and even worse so in the rural areas. Penetration of LPG in the rural areas is still not encouraging as rural consumption is less than 2 percent of the national consumption.
9. Renewable energy has not made much contribution the energy mix in Ghana. Gains in solar PV have been modest when compared to the country's potential. Even though the costs of acquiring solar PVs are currently high, it is believed that costs could go down if wide-scale electrification programmes associated with bulk purchase of PV and economies of scale in production and sales go ahead.
10. Wind energy and small hydro resources have not been exploited much and biofuel programmes are still in the feedstock stage with little to show in terms of the production of commercial fuels.

5.2 Recommendations

The main recommendations arising out of this review may be summarized as follows:

1. There is the need for a coherent national energy policy with inputs from a wider section of the public that has precise targets and clearly laid down strategies to achieve the targets. Such strategies should involve funding mechanisms.

2. Efforts must be made towards achieving 100% access to electricity by 2020, and around 20% of the population having access to LPG with the rest of population using improved woodfuel-based cooking services, by 2015.
3. Efforts at promoting and making available renewable energy technologies at cost effective prices must be stepped up. Perhaps this calls for the passage of the renewable energy law which hopefully should establish incentives for the renewable energy industry.
4. Energy access initiatives should be coupled with productive uses of energy, especially in rural areas, and enterprise-centered approaches should also be promoted vigorously.
5. Government must support academic and research institutions in the country to build capacity for more R&D into energy technology and policy so that they can complement government efforts at achieving ‘sustainable’ energy for all in Ghana in the near term.

References

Abakah, E. (1993). A Review of Economic Growth and Energy Consumption in a Developing Country: Ghana. OPEC Review, Oxford 17(1993) 1, 47-61.

Abakah, E. M. (1995). Technological Innovation and Development in Ghana's Renewable Energy Sector: An Appraisal. OPEC Review, Oxford 19(1995) 2, 169-179.

Abavana, C. and A. Mahama, (2006). LPG Substitution for Wood Fuel Project. Project Completion Report. UNDP Ghana Country Office, Accra.

Agbemabiese, L. (2008). Renewable Energy Enterprise Development. In: Brew-Hammond, A. and F. Kemausuor (Eds). Renewable Energy for Rural Areas in Africa - The Enterprise Development Approach. University Press, KNUST – Kumasi, Ghana.

Akuffo, F. O., 1992. Strengthening National Energy Policy and Operations Management Capabilities - Energy Policy in Ghana. UNDP Project GHA/89/003 Phase 1 – Final Report, May.

Akuffo, F. O. (2008). AREED: Challenges and Opportunities. In Brew-Hammond, A. and F. Kemausuor (Eds). Renewable Energy for Rural Areas in Africa - The Enterprise Development Approach. University Press, KNUST – Kumasi, Ghana.

Akuffo, F. O. and G.Y. Obeng (2008). Policy Recommendations For Energy Sme Development In Africa - A Policy Makers' Paper. Energy Programme, United Nations Environment Programme (UNEP), Paris.

Akuffo, F. O. (2009). Electricity for All in Ghana: When and How? John Turkson Memorial Lectures on Energy, Kumasi, Ghana.

Alternative Energy Africa (2009). Ghana Gets a Taste of India. [http://ae-africa.com/read_article.php?NID=792], (Accessed March 30, 2009)

Alternative Energy Africa (2009). Ghana Receives Smart Grid from BPL Global. [Available at www. AE-Africa.com], (Accessed January 2009).

Amissah-Arthur, H. (2008). AREED Experience in Ghana. In Brew-Hammond, A. and F. Kemausuor (Eds). Renewable Energy for Rural Areas in Africa - The Enterprise Development Approach. University Press, KNUST – Kumasi, Ghana.

Amous, S., Asiegbu, J. and Mahama, A. (2002) Energy-based Electrification for Social and Economic Development. Final Evaluation Report. Accra: UNDP/GEF RESPRO GHA/96/G31.

Antonio, J., F. Akwensivie, I. A. Edwin, A. Brew-Hammond and F. O. Akuffo (2003). Wind Energy Resource Assessment in Ghana. Paper presented by F. K. Appiah (on behalf of authors), World Wind Energy Conference, Cape Town, South Africa.

Aryeetey, E., Harrigan, J. and Nissanke, M. (n.d). Economic Reforms in Ghana. The Miracle and the Miracle. [Available at www. Amazon.de].

Aryeetey, E. and Ahene, A. A. (2005). Utilities Regulation in Ghana. Centre on Regulation and Competition. Working Paper Series No. 111. Institute of Statistical, Social and Economic Research (ISSER), University of Ghana, Accra, Ghana. ISBN: 978-1-905381-10-7.

Bensah, E. C. (2009). Technical Evaluation and Standardization of Biogas Plants in Ghana. Draft MSc Thesis, Department of Mechanical Engineering, Kwame Nkrumah University of Science and Technology (KNUST), Kumasi, Ghana.

Botchway, F. N. (2000). The State, Government and the Energy Industry in Ghana, in Verfassung und Recht in Ubersee. Baden-Baden. 33(2000) 2. Pp 135-211

Brew-Hammond, A. (1996). The Electricity Supply Industry in Ghana: Issues and Priorities. Africa Development, Dakar 21 (1996) 1. Pp 81-98.

Brew-Hammond, A. (1998). Technological Accumulation and Electric Power Generation in Sub-Saharan Africa - The Case of Volta River Authority, Ghana. DPhil thesis submitted to the Science Policy Research Unit, University of Sussex, Brighton, UK.

Brew-Hammond, A., 2007, Challenges to Increasing Access to Modern Energy Services in Africa. Background Paper prepared for the Forum of Energy Ministers of Africa (FEMA) Conference on Energy Security and Sustainability, 28 – 30 March 2007, Maputo, Mozambique.

Cecelski, E. (2003). Energy, Poverty and Gender Enabling Equitable Access to Rural Electrification: Current Thinking on Energy, Poverty and Gender. World Bank: Washington.

Denton, F (2006). Analysis of Policies and Institutions and Linkages with Energy SME Development: Ghana, Mali, Senegal, Tanzania and Zambia. AREED Policy Review: UNEP Risoe Centre, Denmark

Dernedde, S. and A. K. Ofosu-Ahenkorah (2002). Mini Hydro Power in Ghana - Prospects and Challenges. Energy Foundation, Accra.

DFID (2002). Energy for the Poor: Underpinning the Millennium Development Goals. London: Department for International Development (DFID) Publication.
[http//www.dfidkarenergy.org.uk/assets/energyforthepoor.pdf], (accessed 2006 December 19)

ECOWAS (2005). White Paper for a Regional Policy. Geared Towards Increasing Access to Energy Services for Rural and Periurban Populations in Order to Achieve the Millenium Development Goals. UNDP and French Ministry of Foreign Affairs.

Edjekumhene, I, S-B Atakora, R. Atta-Konadu and A Brew-Hammond (2001). Implementation of Renewable Energy Technologies- Opportunities and Barriers: Ghana Country Study. UNEP Collaborating Centre on Energy and Environment, Roskilde, Denmark.

Edjekumhene, I., M. B. Amadu and A. Brew-Hammond (2003). Power Sector Reform In Ghana In The 1990s: The Untold Story Of A Divided Country Versus A Divided Bank. Kumasi Institute of Technology and Environment (KITE), Kumasi, Ghana.

Edjekumhene, I. (2007). Tariffs and the Poor. In: Brew-Hammond, A. and F. Kemausuor (Eds), Energy Crisis in Ghana: Drought, Technology or Policy? Kwame Nkrumah University of Science and Technology (KNUST) College of Engineering, University Press, Kumasi, Ghana.

Energy Commission (2004). Energy Review. Official Journal of the Energy Commission of Ghana. November/December. Issue 02-2004. ISSN 0855-6083

Energy Commission (2005). Off-grid Rural Electrification Programme OEP Phase 1. Renewable Energy Division Document, Accra, Ghana.

Energy Commission (2006a). Strategic National Energy Plan 2006-2020. Energy Supply to the Economy. Annex II of IV. Electricity. Energy Commission, Accra, Ghana

Energy Commission (2006b). Strategic National Energy Plan 2006-2020. Energy Supply to the Economy. Annex IV of IV. Woodfuels and Renewables. Energy Commission, Accra, Ghana

Energy Commission (2006c). Strategic National Energy Plan 2006-2010. Main Report. Energy Commission, Accra, Ghana.

Energy Commission (2007a). National Energy Statistics 2005. Energy Commission, Accra, Ghana.

Energy Commission (2007b). Energy Statistics 2007. Energy Commission, Accra, Ghana

Energy Commission (2009). Securing Ghana's Future Energy Today. Energy Commission of Ghana, Accra. Available at [www.energycom.gov.gh] (Accessed February 20, 2009).

Energy Foundation (2002). Final Report on Pre-feasibility Studies on the Establishment of a Plant for the Production of Photovoltaic Modules and Balance of Systems in Ghana, Accra.

EnterpriseWorks/Vita (2009). Clean Energy for Household Cooking in Ghana. EnterpriseWorks/Vita.[http://www.enterpriseworks.org/display.cfm?id=3&sub=15&cont=7], (Accessed June 2, 2009).

Essandoh-Yeddu, J. (1993) Monitoring the Performance of Solar Photovoltaic Installations in Ghana. Accra: Ministry of Energy.

Faber, M. (1990). The Volta River Project: For Whom the Smelter Tolled, in Pickett, J and Singer, H (Eds), 'Towards Economic recovery in Sub-Saharan Africa'. London: Routledge, pp 65-91.

Hart, D., 1980. The Volta River Project - A case study in politics and technology. Edinburgh University Press, Edinburgh.

Ghana Statistical Service (2005). Ghana 2003 Core Welfare Indicators Questionnaire (CWIQ II) Survey Report. Statistical Abstract. Ghana Statistical Service, Accra, Ghana.

Ghana Statistical Service (2007). Pattern and Trends of Poverty in Ghana (1991-2006). Ghana Statistical Service, Accra, Ghana.

Institute of Economic Affairs (1999). Stand Alone PV Systems. IEA-PVPS Task III. Accra, Ghana.

IEA (2002). World Energy Outlook. Organisation for Economic Cooperation and Development/ International Energy Agency (OECD/IEA), Paris.

IEA (2006). World Energy Outlook. Paris: International Energy Agency (IEA).

Kay, G.B. (1972). The Political Economy of Colonialism in Ghana: A Collection of Documents and Statistics 1900-1960, Ghana.

KITE/UCCEE (1999). Renewable Energy Technologies Project. Interim Report. Kumasi Institute of Technology and Environment (KITE) in collaboration with UNEP Collaborating Centre on Energy and Environment (UCCEE), Kumasi, Ghana.

Lenin, W.I. (1920). All Russian Soviet Congress. 22. December 1920.

Mahama, J. (2008). Energy – My Vision: Presentation on behalf of NDC Flagbearer, Professor John Evans Atta Mills. In: The Energy Centre, KNUST. Flagbearers on Energy in Ghana.

Ministry of Energy (2005). Enhancing Energy Security and Access. Meet the Press. Ministry of Energy, Accra, Ghana

Ministry of Energy (2006). Energy for Poverty Reduction Action Plan for Ghana. A Targeted Approach to Delivery of Modern Energy Services to the Poor. Accra: Ministry of Energy, Ghana. ISBN: 9988-643-64-0.

Moxon, J., 1984. Volta, Man's Greatest Lake. Andre Deutsch, London (First published 1969).

NDPC (2007). Implementation of the growth and Poverty Reduction Strategy 2006-2009. Annual Progress Report. National Development Planning Commission (NDPC), Accra, Ghana.

Nketiah, K. S., Atakora, S-B. and Brew-Hammond, A. (2001). Sawmill Energy Efficiency in Ghana. KITE Publication, Kumasi, Ghana.

Nkrumah, K., 1961. The Volta River Project. A Statement of the President to the National Assembly on February 21, Ghana Information Services, Government Printer, Accra, Ghana.

Obeng, G.Y. (2008). Solar Photovoltaic Rural Electrification: Assessing Energy-Poverty and Impacts on Quality of Life in Ghana. A PhD Thesis Submitted to the Department of Planning, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana.

Prasad, G. (2008). Energy Sector Reform, Energy Transitions and the Poor in Africa. Energy Policy, 36(8), pp 2785-2790.

Quaye, E.C. (1992). Biomass Energy in Rural Households: Consumption Patterns and Perceptions of Women. African Arid Lands, Working Paper Series, Nordiska Afrikainstitutet, Uppsala, Sweden. ISSN 1102-4488.

Rimmer, D. (1992). Staying Poor. Ghana's Political Economy 1950-1990 p. 18.

Sackey, T. (2007), Why the Power Shortage? In: Brew-Hammond, A. and F. Kemausuor (Eds), Energy Crisis in Ghana: Drought, Technology or Policy? Kwame Nkrumah University of Science and Technology (KNUST) College of Engineering, University Press, Kumasi, Ghana.

Sawin, J.L. (2004). National Policy Instruments. Policy Lessons for the Advancement and Diffusion of Renewable Energy Technologies around the World. Thematic Background Paper. International Renewable Energy Conference, Bonn, Germany.

TCC (2008). The New Insulated Ahibenso Charcoal Stove. An Energy Saving Charcoal Stove for the Household. Technology Consultancy Centre (TCC), KUNST, Kumasi.

Togobo, W. A. (2006). Comparative Cost of Cooking Fuels in the 3 Northern Regions of Ghana. Household Energy Programme for Cooking (GHA/UNDP/00051634), Energy Commission, UNDP and Green Energy Consult.

Turkson, J.K. (1990). Planning for the Energy Sector of Ghana: Emerging Trends and Experiences. Energy Policy (18) 702-710.

UNDP Ghana (2004). Liquefied Petroleum Gas (LPG) Substitution for Wood Fuel in Ghana – Opportunities and Challenges, Accra: UNDP Ghana Publication.

UNDP (2004). World Energy Assessment. Overview 2004 Update. Goldemberg, J. and Johansson, T.B (Eds.), Vienna: United Nations Development Programme (UNDP) Publication.

VRA-Volta River Authority (1985). Ghana Generation Planning Study: Executive Summary for the Republic of Ghana, Accra.

Warwick, H. and A. Doig (2004). Smoke – the Killer in the Kitchen: Indoor Air Pollution in Developing Countries. ITDG Publishing, London, UK.

WEHAB (2002). A Framework for Action on Energy. World Summit on Sustainable Development. WEHAB Working Group, Johannesburg.

World Bank (1989). Structural Adjustment Programme in Ghana. Report No. P-4915-GH.

World Bank, (2007). Ghana Energy Development and Access Project. Project Appraisal Document. Energy Unit. Sustainable development department, Africa Region, World Bank.

World Bank (2008). Ghana Accelerating Growth to Halve Poverty.
[Available at http://www.worldbank.org/ida], (Accessed March 2009)

Yankah, E.N. (1999). What is the Volta River Authority? Volta River Authority (VRA), Ghana.
[http://members.tripod.com/ericyankah/vrabinfo.html], (Accessed March 25, 2009)

Yankey, V. (2008). E+Co's Experience in Ghana. In Brew-Hammond, A. and F. Kemausuor (Eds). Renewable Energy for Rural Areas in Africa - The Enterprise Development Approach. University Press, KNUST – Kumasi, Ghana.