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Decentralized bioenergy generation: An option to extend access to electricity in remote areas and curb perennial power outages in Ghana

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Abstract

The article provides an overview of the interventions currently being pursued to extend access to electricity in remote areas, resolve power outages and critique some of these interventions in Ghana. The study is based on the use of secondary data obtained from electronic journals through archival studies. The findings indicate that the expansion of the centralized generation system cannot resolve the problems of frequent outages and extend access to electricity for all by 2020. Decentralized bioenergy generation option will be a medium to long term solution since it has the more promising potential to increase sustainable development in remote areas than the other options in terms of economic activities.

Keywords: Access to electricity, Decentralized generation, Bioenergy

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1. Introduction

With a customer population of more than 2.2 million in 2009, Ghana's demand for electricity has grown at the rate of between 10 per cent and 14 per cent per annum. Out of over 24 million people in Ghana only 60.5% had direct access to electricity by 2009 (IEA, 2009) and it is even unreliable as a result of overloading of the centralized system. This problem of power shortages and unreliability in Ghana has a serious implication for the economy and needs immediate attention.

The total electricity generated in 2010 was 10,232.11 GWh. This comprised 6,994.84 GWh, which was about 68.28% of hydropower; 3,134 GWh, which was about 30.73% of thermal power; and 95 GWh, which was about 0.98% of imports (EC, 2011). The Energy Commission (EC) in 2006 estimated that demand might grow from 7,000 GWh to 13,000 GWh and 3,000 GWh to 10,000 GWh by 2020 for residential and commercial purposes respectively, depending on the rate of economic growth and urbanization.

The general objective of this article is to contribute to the body of knowledge in the area of renewable and sustainable energy. Specifically the article provides an overview of the interventions currently being pursued to extend access to electricity, resolve power shortages in Ghana and critique some of these interventions.

The article is necessary because Ghana's energy capacity is not able to meet its growing energy demand resulting in a perennial shortage of electric power. This is due to the fact that Ghana's Gross Domestic Product (GDP) has been growing since 1985 at a rate between 3.5 per cent and 6 per cent. Despite this growth, the demand for electricity has grown at the rate of between 10 per cent and 14 per cent per annum over the same period (Asante and Clottey, 2006*).* Clearly the electricity supply in many parts of Ghana cannot keep up with the rapid economic growth across the country.

Unfortunately, the expansions being made to meet the growing demand are all based on the centralized systems. For example, since the construction of the Akosombo Hydro Dam, Governments of Ghana (GoGs) have focused mainly on expanding the capacity of the centralized electricity production and grid extension. This has been demonstrated through the addition of the Kpong Hydro Dam and thermal plants. In a quest to expand grid-based electricity, several schemes such as the National Electrification Scheme (NES), Self Help Electrification Projects (SHEP) and the ongoing Ghana Energy Development and Access Project (GEDAP) have been introduced, yet a lot of communities are not connected. Indeed, between 2009 and 2010, the existing installed generation capacity was increased from 1810 MW to 2085.5 MW. Of the additional 275.5 MW within the year, the Tema Thermal 1 Power Plant had a generation capacity of 126 MW, the Tema Thermal 2 Power Plant had 49.5 MW and the Asogli Power Plant had 100 MW (MoE, 2010). Thus an unreliable and insufficient electricity supply to remote parts of Ghana is as a result of this one sided development strategy (ie centralized energy planning employed by GoG). There is, therefore, the need to look for options bearing in mind the environmental implications and this article fills in this literature gap. *The researchers assess the options to extend access to electricity to remote areas for the people of Ghana to meet the growing demand for electricity.*

The article seeks to address two important questions: *(a) What is the main cause of frequent power outages and voltage fluctuations in Ghana? (b) What option is best suitable to extend access to electricity in remote parts of Ghana?*

The article is limited to the use of data gathered from the review of empirical works based on access to electricity and the findings are therefore subject to errors. In addition, errors of omission may not be known by the researchers.

The article does not include the researchers' own empirical works. It is organized as follows: Section 1 briefly presents the introduction; Section 2 establishes the important gaps in the literature; Section 3 presents the findings while Section 4 presents the concluding remarks.

The study employs purposive sampling methods since the researchers aim is to review empirical works on options to expand access to electricity. Therefore, the article is based on secondary sources of data such as text books, journals and conference papers. Data were obtained through archival study of these sources.

The findings contribute to a better understanding of decentralized generation systems and provide the Government of Ghana (GoG) with guidance on the needs and alternatives if wider decentralized options to expand access to electricity are to be sought. The results are of direct use to stakeholders, policy makers, managers, researchers, NGOs and energy planners seeking the transformation of local energy systems to expand access to electricity. Finally, the findings provide good material for investors and governments as they give an overview of the interventions made to expand access to electricity in Ghana.

2. Literature review

The literature review addresses issues concerning access to electricity, interventions to expand access to electricity in Ghana, establishes the challenges to expanding access to electricity in Ghana, explains the options to extend electricity to remote areas in Ghana and discusses the ongoing debates on access to electricity globally.

2.1. Access to electricity

Globally, over 1.4 billion people are without access to electricity, with 85% of them living in the rural areas. Africa ranks third on the regional aggregates, with 587 million people without access to electricity by 2009 (IEA/WEO, 2010) as shown in Table 1.

In 2008, the rural electrification rate in developing countries was only 58.4%, while urban electrification rate was significantly higher, reaching 90% (IEA, 2008). According to GSS (2008), 15% of the urban population and 77% of the rural population in Ghana lack access to electricity. This implies that there is a huge gap in providing the populace with access to electricity.

2.2. Interventions to expand access to electricity in Ghana

Several attempts have been made by governments to extend grid based electricity to the citizenry. They include: *National Electrification Scheme (NES), Self Help Electrification Project (SHEP), Power Sector Reform* and *Ghana Energy Development and Access Project (GEDAP)*. The purpose of these interventions by GoG since 1989 is to ensure that all Ghanaians have access to electricity, yet this has not materialized.

The discussion is supported by a research conducted by Appiah (2005) to assess the prospects for the application of low wind speed turbines for rural electrification in Ghana. The research suggests that it is not possible to connect all Ghanaians by 2020 through the grid extension only. This clearly confirms that to achieve 100% electrification in Ghana by 2020, decentralized renewable options must come on line and this is also another gap being filled by this research work.

Table 1. Electricity access in 2009-Regional aggregates

	Population without electricity (million)	Electrification %	Urban electrification %	Rural electrification %
Africa	**587**	**41.8**	**68.8**	**25.0**
North Africa	2	99.0	99.6	98.4
Sub-Saharan Africa	585	30.5	59.9	14.2
Developing Asia	**675**	**81.0**	**94.0**	**73.2**
China & East Asia	182	90.8	96.4	86.4
South Asia	493	68.5	89.5	59.9
Latin America	31	93.2	98.8	73.6
Middle East	21	89.0	98.5	71.8
Developing countries	**1,314**	**74.7**	**90.6**	**63.2**
Transition economies & OECD	**3**	**99.8**	**100.0**	**99.5**
World	**1,317**	**80.5**	**93.7**	**68.0**

Source: WEO-2011

2.3. Challenges to expand access to electricity in Ghana

It is the aim of GoG to ensure that all communities have access to electricity by 2020. However, some challenges exist and must be addressed. Clearly not all electrification policies target poor rural communities in Ghana (IEA, 2010). This is because the report of the Ministry of Energy's Sector Strategy and Development Plan (2010) indicates the following policy responses to inadequate access to electricity under the power sub-sector strategy issue 2:

i. To increase the momentum of the National Electrification Scheme to provide access to electricity progressively to all communities.

ii. To upgrade and reinforce transmission and distribution network capacity, and

iii. To open up the sub-sector to private sector participation in power distribution and sale.

This policy shows that the general focus is geared toward expanding the national grid to all these communities. At the moment no key programme has been drawn to develop and use decentralized generation options for communities remote from the national electricity grid.

Another point worth discussing is the fact that most rural communities in Ghana are often characterized by low population density and low demand for electricity (IEA, 2010). These communities are mostly dispersed in nature, making it economically unviable to extend the grid-based electricity to such places. Unfortunately, this policy is being pursued and after connecting these areas, the government then hands over the extension and these customers to Electricity Company of Ghana (ECG) and Northern Electricity Distribution Company (NEDCo) to manage. Technically the extension of the grid to remote communities and few customers (low density) is not the best option and it brings about losses and financial burdens to the utility companies. This is because in order for these communities to enjoy reliable service, the utility companies are forced to employ technicians to handle these stations and sometimes the monthly salaries of these technicians are even more than the revenue generated from these communities. This is certainly not an economically viable venture but it is being done.

Finally, the financial constraint on VRA and ECG is also another challenge. The main causes of this financial burden on the utilities are inefficiency, inability to collect bills and lower tariff charges (Ibig pg 36), making it difficult for these utility companies to extend the grid to remote areas.

2.4. Options to extend electricity to remote areas in Ghana

Basically three options have been found in literature to extend electricity to remote areas. They include (IEA, 2002):

i. Grid Extension,

ii. Stand-Alone Systems, and

iii. Decentralized Renewable Energy Systems

2.4.1. Grid extension

Grid extension simply means extending the national grid to connect communities that are not yet connected to the grid. This is the most common option used by developing countries, including Ghana. Most of the interventions provided by GoG to increase access to electricity are all towards expanding the national grid. However, empirical studies have shown that it is not economically good to employ this method if the community is far away from the national grid, if the community is characterized by low power demand, and if customers in this community are scattered.

Unfortunately, most of the policies in developing countries, including Ghana, are in support of this option. Today, the planning of electricity emphasizes centralized electricity generation, long distance, and high-voltage transmission from centralized sources such as hydro and thermal power plants in Ghana as indicated in the 2009 budget. No wonder between 2009 and 2010, the existing installed generation capacity was increased from 1810 MW to 2085.5 MW (MoE, 2010). This shows that the general outlook and focus are on consolidating and expanding centralized generation first and only later making way for decentralized generation.

The study critiques the centralized planning of electricity generation and expansion as the main option of making electricity accessible to all because of the following reasons:

- The aging centralized energy infrastructure is being overstretched and it is becoming more unreliable as evidenced by the increased outages we experience often as demand grows in Ghana.
- The importation of crude oil for the thermal plants has financial implications for the economy because of its price fluctuations in the international market. The increase in oil prices since 2002 has increased pressure on Ghana's balance of payments (GhanaWeb.com, 2009). This has always been the reason why Ghana has unequal development in all the sectors.
- Currently natural gas has come on board to relieve VRA from such financial burden, and energy planners and policy makers seem to build hope on it. This study is partially in support of this because oil and natural gas are non-renewable energy sources and despite their abundance they will be depleted one day. It is evident that natural gas burns much cleaner than crude oil; however, it still discharges carbon dioxide and nitrogen oxides as well as methane if it is burnt in an incomplete manner (EERE, 2009). The heavy use of crude oil and natural gas causes air pollution and climate change.

It is obvious that Ghanaians will no longer tolerate frequent outages and low voltage supply as a result of over-reliance on the centralized generation system. Government should therefore, consider decentralized renewable generation options.

2.4.2. Stand–alone systems

This system is normally employed when the load involved is very small, such as only a few lighting points. Often a stand-alone system involves the use of renewable energy technologies such as photovoltaics (PV), solar water heater (SWH), small wind generators, etc., and because of its smaller power rating, it is mostly suitable for remote households. In Ghana, over 4,000 stand-alone photovoltaic systems were installed nationwide in 2001 with a total capacity of about 1MW (EC, 2002).

2.4.3. Decentralized renewable energy systems

Decentralized renewable energy systems supply power to isolated groups of households, communities or even larger groupings and involve a local grid-network for the supply of power (IEA, 2002). In this type of system, the power is usually generated and distributed to the local community in which it is installed. It does

not require transmitting power from the source to a distant load or community, hence its transmission losses are minimal.

Some experts have criticized the decentralized renewable generation option for being initially expensive. This study disregards this assertion because compared to the cost of grid extension to remote areas and its maintenance, decentralized renewable generation will be the best option for Ghana. Moreover, considering the losses incurred on a centralized system as a result of frequent power outages and voltage fluctuations as well as continual fossil fuel price increases and its environmental implications, Ghana must take a second look at decentralized renewable generation options.

Decentralized renewable generation options available to Ghana are solar energy, wind energy, small-scale hydro energy, and bioenergy. Some research works are being done to explore these options in Ghana. However, the researchers zero in on biomass technology to extend electricity to remote areas due to the following reasons:

- During logging activities it is estimated that only 50% of wood is properly extracted and the rest is considered as logging waste (Edjekumhene et al., 2001). In 2008, an estimated 720,000 m^3 of residue, equivalent to 360,000 tonnes of residue, was generated from logging activities alone, according to the 2008 production data for industrial round wood at RPR of 0.6 (Duku et al., 2011). It can be used to generate electricity.
- Biomass is available in all rural communities throughout the country. Therefore using it to generate electricity will facilitate decentralized power generation, boost economic activities in those areas and thereby raise the standard of living of the rural folk (Bürgi, 2003).
- Biomass plantation-based power production has a higher job creation capacity than all the other options since labour will be needed for the plantation and its maintenance (EC, 2008).
- Finally, biomass supplied almost six times the combined energy generated by geothermal, solar and wind energy sources globally (IEA, 2009).

2.5. Ongoing debates on access to electricity globally

Access to electricity by all is the concern of governments, scientists and international bodies. This is because to achieve the MDGs, access to electricity has a pivotal role to play. Most of the urban centers have access to electricity but the hurdle is the areas remote from the grid. A lot of debate is going on with regard to options to expand access to electricity to remote areas.

Globally, experts say that the centralized grid system is being stretched to its limits making this infrastructure unreliable, brittle and inefficient and so much attention should be given to decentralized generation (CanREA, 2006).

Pepermans et al. (2005) further assert that a number of factors combine to commend renewable decentralized generation (DG) to electricity producers and consumers. These include novelties and improvements in decentralized generation (DG) technologies, free markets, and limitations imposed on the

extension of transmission from a centralized grid to remote areas by social and environmental considerations.

In support of this debate IEA & WEO (2010) also propose a target of 70% mini-grid or 75% off-grid rural electrification for 2030 through the formation of Universal Modern Energy Access Case (Table 2).

Table 2. Targets in the Universal Modern Energy Access Case

	2015		2030	
	Rural	Urban	Rural	Urban
Access to electricity	Provide 257 million people with electricity access	100% access to grid	100% access, of which 30% connected to the grid and 70% either mini-grid (75%) or off-grid (25%)	100% access to grid
Access to clean cooking facilities	Provide 800 million people with access to LPG stoves (30%), biogas systems (15%) or advanced biomass cookstoves (55%)	Provide 200 million people with access to LPG stoves	100% access to LPG stoves (30%), biogas systems (15%) or advanced biomass cookstoves (55%)	100% access to LPG stoves

Source: WEO, 2010

Grid extension will contribute part of the solution (access to electricity) but decentralized options have an invaluable role to play where grid extension is too expensive. Hence it is obvious that attention and resources are globally shifting to the use of decentralized generation systems to provide electricity to areas already far from the national grid. This study is in support of this ongoing debate and there is the need to do an assessment on decentralized generation options with a view to expanding access to electricity in Ghana.

3. Research findings

The following findings were deduced from the literature review:

- The analysis of electricity supply and demand shows that there is a gap in electricity demand that needs to be filled. The 2010 report of the Energy Commission confirms that Ghana requires a capacity addition of about 200MW per annum to catch up with the increasing demand in the medium to long term. This simply means that if nothing is done Ghana will experience another power crisis by the year 2014 with adverse impacts on its economy as happened in 1982, 1997, 2002, 2006 and 2007.

a. The literature confirms that it is not possible to connect all Ghanaians by 2020 through the grid extension only.

- It is clear from the study that the unreliable and insufficient electricity supply is the consequence of the one-sided development strategy employed in Ghana (centralized energy planning).
- The ongoing debate presented above clearly suggests that decentralized generation options will be a medium to long term solution to the frequent outages Ghana has been experiencing and can extend access to electricity to the remote parts of the country.
- Research done by experts (Duku et al., 2011; EC, 2008; Edjekumhene et al., 2001) confirms that Ghana has biomass resources which can be used to generate electricity in the remote areas.

b. Finally, policies targeting rural electrification in Ghana also need to be comprehensively looked at.

4. Conclusions

It is obvious that the demand for power in Ghana is far outpacing supply, resulting in a perennial shortage of electric power. However, access to reliable electricity is central to the attainment of sustainable development. The article has argued that the expansion of the centralized generation system cannot resolve the problem of frequent outages and extend access to electricity for all by 2020. It is suggested that the decentralized bioenergy generation option should be considered as a medium to long term solution for Ghana as compared to other options. It is recommended that a techno-economic assessment be done on biomass-based projects suitable for power generation in Ghana.

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