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DECENTRALISED OPTIONS FOR ENERGY SUPPLY FOR SUSTAINABLE ECONOMIC DEVELOPMENT IN RURAL GHANA

By

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DECLARATION

I hereby declare that this doctoral dissertation is the result of an independent investigation. Where it is indebted to the work of others, acknowledgements have duly been made.

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DEDICATION

This piece of work is dedicated to Nhyira, Aseda, and Hephzibah-Eliakim

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ABSTRACT

Access to adequate supply of energy is one of the developmental concerns of today that has attracted much international attention. The challenge is even greater with rural communities of developing countries particularly in sub-Saharan Africa. The effect of this is reflected in the low economic development of these rural communities and a persistent poverty cycle. In this study, ten remote rural communities in the Buila, Kassena-Nankana East and Atebubu-Amantin Districts were studied to assess the possibility of engaging decentralised energy system as an alternative to the centralised and conventional energy system which faces hindrances in being extended to these rural communities.

The study employed mixed method in case study approach with household survey, household in-depth interviews, and expert interviews of various levels from international experts to local experts at the District levels. The study found out that the energy needs of cooking, lighting, appliance, and economic activity are unmet or inadequately serviced. Again, the proportion of economic activities identified which depended on energy was insignificant: the agricultural sector was the dominant economic sector and depended more on human power and energy in the non-technicalised state. It was relatively easier for study communities in the Brong Ahafo Region to identify possible enterprise options with improved sources of energy than it was for study communities in the Upper East Region. From the perspective of income earnings of respondents, there was generally extreme inability to pay for decentralised energy alternatives, while the local financial support landscape was unfavourable. At the District Administration level, District Assemblies were found not to have strong mandates over their energy situations.

The study suggests that accessibility, availability and affordability are fundamental to improving energy access, given that there are no socio-cultural hindrances to adopting the decentralised energy option. The hybrid approach to energy provision is recommended. It is also recommended that a regulatory framework that operationalises the Renewable Energy Bill, and dissociates energy production from distribution is instituted to serve as an important leverage for potential investors. An energy committee is proposed to be formed at the District Administration which will ensure the implementation of the District energy development framework, and facilitate the collaboration between the District Administration, the Central Government, private investors, and the beneficiary communities. Productive uses of energy are also recommended to be incorporated into the decentralised energy models to ensure that access to energy promotes economic growth in these communities.

At the conceptual level, the study recommends that preconditions at the household decision making level, the energy environment system, and preconditions from external factors at the national and international levels are acknowledged in planning decentralised energy delivery.

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ABBREVIATIONS

ACGF	Africa Catalytic Growth Fund
AfDB	African Development Bank
AGECC	United Nation's Advisory Group on Energy and Climate
ALFA	Affordable Energy for All
BAR	Brong Ahafo Region
BCF	Billion cubic feet
BOP	Bottom of the Pyramid
BPSD	Barrels per Stream Day
CEESD	Centre for Energy, Environment and Sustainable Development
CH4	Methane
CHPS	Community-based Health Planning and Services
CO2	carbon dioxide
CSIR	Council for Industrial and Scientific Research
DA	District Assembly
DANIDA	Danish Development Agency
DE	Decentralised Energy
DT	Disruptive Technology
EARED	Electricity Access and Renewable Energy Development
EC	Energy Commission of Ghana
EDI	Energy Development Index
EDS	Enterprise Development Services
EIA	Energy Information Administration
EPA	Environmental Protection Agency
ESMAP	Energy Sector Management Assistance Program
EU	European Union
FAO	Food and Agriculture Organisation
FIT	Feed-in-tariff
GCMC	Ghana Cylinder Manufacturing Company
GDP	Gross Domestic Product
GEDAP	Ghana Energy Development Access Project
GEF	Global Environment Facility
GHG	greenhouse gases
GHS	Ghana cedi
GHp	Ghana pesewas
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH
GLSS	Ghana Living Standards Survey
GoG	Government of Ghana
GPOBA	Global Partnership on Output-based Aid
GSS	Ghana Statistical Service
GTZ	Deutsche Gesellschaft für Technische Zusammenarbeit GmbH
GWh	Gigawatt – hour
HDR	Human Development Report
HERA	GIZ Poverty-oriented Basic Energy Services Programme

ICT	Information and Communication Technology
IDA	International Development Agency
IEA	International Energy Agency
IFC	International Financial Corporation
IGF	Internally Generated Funds
IIR	Institute of Industrial Research
KII	Key Informant Interviews
kg/h	kilogramme per hour
km	kilometre
KNE	Kassena-Nankana East
KNUST	Kwame Nkrumah University of Science and Technology
koe	kilogramme of oil-equivalent
kT	kilotonnes
kV	kilovolts
kWh	kilowatt hour
LED	light emitting diode
LI	Legislative Instrument
LPG	Liquefied Petroleum Gas
m	metre
MEPI	Multidimensional Energy Poverty Index
MFI	Microfinance Institution
MFP	multifunctional platform
MoEn	Ministry of Energy
MT	metric tonnes
MTDP	Medium Term Development Plan
MW	Megawatts
NEDCo	Northern Electrification Distribution Company
NEP	National Electrification Programme
NES	National Electrification Scheme
NGO	Non-governmental organisation
No.	number
NPA	National Petroleum Authority
NREL	National Renewable Energy Laboratory of USA
OECD	Organisation for Economic Co-operation and Development
PA	Practical Action
PPEO	Poor People's Energy Outlook
PSIA	Poverty and Social Impact Assessment
PUE	productive uses of energy
PURC	Public Utility and Regulatory Commission
PV	Photovoltaic
RA	Research Assistants
RQ	Research Question
SE4All	Sustainable Energy for All
SEAAF	Sustainable Energy for All Acceleration Framework

SECO	Swiss Agency for Development and Cooperation
SHEP	Self-Help Electrification Programme
SHS	solar home system
SNV	Netherlands Development Organisation
SPSS	Statistical Programme for Social Sciences
SSA	Sub-Saharan Africa
SWERA	Solar and Wind Energy Resources Assessment
TEA	Total Energy Access
TEC	The Energy Centre
toe	tonnes of oil equivalent
TOR	Tema Oil Refinery
TV	Television
UER	Upper East Region
UK	United Kingdom
UN	United Nations
UNDP	United Nations Development Programme
UNESCAP	United Nations Economic and Social Commission for Asia and the Pacific
UNFCCC	United Nation Framework Convention on Climate Change
UNICEF	United Nations Children's Fund
UNIDO	United Nations Industrial Development Organisation
UNSD	United Nations Statistics Division
USA	United States of America
USD	United States dollar
USEIA	US Energy Information Administration
VRA	Volta River Authority
W	Watts
WADE	World Alliance for Decentralised Energy
WB	World Bank
WEO	World Energy Outlook
WWF	World Wildlife Fund

1 INTRODUCTION

1.1 The significance of energy and energy services in development

The significance of energy to development cannot be over-emphasised. Energy has emerged as a top-most discussion for both developed and developing countries in the past few decades so much so that the year 2012 was declared the United Nations' (UN) Year of Sustainable Energy for All. Energy is a critical factor of development. It plays a role in the development process first as a domestic necessity and also as a factor of production (Amigun et al., 2008) and therefore growth (Stern 2004). Toman and Jemelkova (2003) identify energy as a causal factor in economic development. In the World Energy Outlook (WEO) 2013, the International Energy Agency (IEA) calls it a critical enabler (IEA, 2013)[1], that is, access to modern energy underpins the development and growing prosperity of every advanced economy, and fundamental to reducing poverty, improving health, increasing productivity, enhancing competitiveness, improving mobility and promoting economic growth of developing economies. Access to modern energy is also necessary for the achievement of the Millennium Development Goals particularly reducing poverty, improving women and children's health, or broadening the reach of education, and therefore "efforts to alleviate global poverty must not ignore the role of energy" (Martinez and Ebenhack, 2008:1435). In April 2001, the ninth session of the Commission for Sustainable Development (CSD) concluded that "to implement the goal accepted by the international community to halve the proportion of people living on less than USD1 per day by 2015, access to affordable energy services is a prerequisite." (Practical Action, undated: 3). Most of the countries which are currently off-track on the MDGs are those with less energy access (Practical Action, op.cit.).Without appropriate modern energy access people are deprived of basic energy services such as lighting, cooking, water heating, space heating and cooling, and cold storage for food preservation and other perishable products. Again, energy is central to a range of services supporting human development from modern medical care, transportation, information and communications services to mechanical power for agriculture (Human Development Report, 2011).

Discussions on energy access across the globe take different dimensions. While the developed countries seek more alternatives to promote energy efficiency and therefore are consistently innovating technologies that will complement conventional energy sources, the developing world particularly Asia and Africa struggle with fundamental access to energy and energy services. According to the Human Development Report (2011) report and the IEA (2013), about 1.2 billion people worldwide do not have access to electricity, and 2.6 billion still depend on rudimentary energy sources such as wood, charcoal, straw, and dung, for cooking. This consigns the world's poorest to an ongoing cycle of poverty (Practical Action 2010). In addition, the health of the deprived persons are negatively implied: worldwide, about 1.4million people mostly women and children, die each year as a result of inhaling smoke from traditional cooking stoves (ibid.).

[1] [1] http://www.worldenergyoutlook.org/resources/energydevelopment/modernenergyforallwhyitmatters/

At the continental level, although Africa is a continent with abundant and diverse energy resources, yet it is also the continent with the lowest access to modern energy services necessary for socio-economic development (Davidson and Sokona, 2001 quoted in Mahama, 2012). Around 80 percent of people in Sub-Saharan Africa (SSA) consisting about 700million people live without clean cooking facilities; Africa has the lowest electrification rate of all regions (26 percent of households), and as many as 590 million people do not have access to electricity (IEA, 2012:532). Energy demand in the SSA region arises mainly from meeting basic human needs in households including cooking, lighting, space-heating, and the operation of household appliances (African Development Bank (AfDB) Draft Energy Sector Policy, 2011). At the country level, over 80 percent of households in Ghana are without clean cooking facilities (Ghana Statistical Service, 2008); even though Ghana boasts of high electrification rate of 72 percent (Ministry of Energy - Ghana, 2012) in the West African corridor, access is wrought with many technical and distribution issues resulting in frequent power-load shedding programmes that has significant impact on home and industry. Moreover, there are significantly high disparities between urban and rural energy access, as well as access between the various administrative regions of the country.

1.2 The research problem

Sub-Saharan African countries, like other developing countries face two crucial and related challenges in the energy sector. The first is the widespread inefficient production and use of traditional energy sources which pose economic, environmental, and health threats (Barnes and Floor, 1996). The second is the highly uneven distribution and use of modern energy sources, such as electricity, petroleum products, and liquefied or compressed natural gas, which raise important issues of economics, equity, and quality of life (ibid). Although progress is being made on electricity access overall, in the SSA, new connections are failing even to keep up with population growth. The Practical Action (an international non-governmental organisation) Poor People's Energy Outlook (PPEO) 2010 report projected that percentages of people without access to electricity in the sub-region would decline by ten percent between 2000 and 2015 in a business-as-usual scenario (Practical Action, 2010). That means the population without access will decrease from 589 million to about 466million. However, the PPEO 2012 recent analysis of numbers shows a projected increase of 100 million people by 2030 (Practical Action, 2012:1). Following from the 2010 analysis, it has been estimated that without any substantial changes in current policies and practice, the total number of people without access to electricity in sub-Saharan Africa will increase to 691million by 2030 (ibid.).

The situation is worse for cooking fuel. Population growth through new births exceeds access to modern fuels, i.e. liquid or gas cooking fuels. The energy estimations show that about 200million more people will be without access to modern cooking fuels (Practical Action, 2012). Even though the utilisation of traditional biomass is in itself not an energy poverty issue in the PPEO definition of Total Energy Access (even currently in Europe, there is a gradual shift back to the use of woodfuels as combined heat and power and even for earthen heaths) the unsustainable exploitation of these resources and the unhealthy combustion in homes constitute a problem that requires the development and use of improved appliances and improved ventilation if the human and environmental impact of this practice is to be positive (ibid.). Furthermore for billions of the world's poorest people, the ability to earn a living depends heavily on access to energy. It is recognised that there is a link between energy and economic activities. As earlier stated (particularly in the rural areas), there seem to be an overlap between energy for the domestic, livelihoods and even the community activities. Consequently, there seem to be a vicious cycle between poor access to energy and the high dependence on traditional biomass, and socio-economic development. Moreover, these traditional energy resources are becoming increasingly scarce. Attempts at meeting these energy needs through the expansion of conventional energy are long term and costly.

Barnes and Floor (1996) assert that the idea of simply expanding supplies of modern energy will not solve the problems in practice, because even under the most optimistic growth scenarios, many rural areas in the developing world are likely to depend on traditional fuels for the next 20-30 years. Meanwhile, within the short term or the immediate future, income levels of these rural areas are not likely to improve significantly to be able to embrace conventional energy or will supply prices go down sufficiently. In recent years, there has been the search and the edge to find the suitable ways of providing energy such that it is accessible to all and affordable to all. Khennas, an Independent Energy Expert sited in Practical Action's PPEO (2012), iterates this concern. He observes that even though energy initiatives in the SSA are large scale (through the creation of power pools) and mainly focused on electricity, there are tens of thousands of villages within the SSA far from the grid for which *decentralised options*[2] are the least-cost options. Even more, these large hydro-schemes have significant environmental and social impacts, in particular displacements of people, which must be fairly addressed.

Decentralised energy options are mainly derived from renewable energy resources. Fortunately, rural Africa and for that matter, rural Ghana, has been recorded to have abundant renewable energy potentials (AfDB Draft Energy Sector Policy, 2011) which could be tapped to supply energy at a local level in the form of decentralised energy systems. Decentralised energy systems are not only close to the point of utility and save wastage in transmission and distribution associated with centralised conventional energy, but for communities economic growth purposes, they reduce the unproductive periods of waiting for the conventional and centralised energy supply. Ghana has gradually and consistently been making progress with grid electrification from more of a social perspective than an economic perspective. The problem is that national figures are more likely to present 'inflated' figures obscuring the actual access picture. While the current national electrification access is pegged at 72 percent, the rural electrification rate is 49 percent; the rates in the three Northern Regions (which are also the poorest regions of the country) stand at 50 percent, 44 percent and 40 percent for Northern, Upper East and Upper West Regions respectively, and their corresponding rural electrification access rates are 43 percent, 30 percent and 32 percent respectively. The Brong Ahafo Region has an access rate of 67 percent and a rural access of 45 percent (The Energy Centre, 2011; Quandzie, 2011). In Ghana, the desire to achieve universal access to energy has been

[2] Author's own emphasis

expressed in targets even more ambitious than the UN Sustainable Energy for All target: to reach universal (100 percent) access to electricity by 2020 and 50 percent access to LPG by 2015 (Ministry of Energy 2010; Energy Commission 2012). As the Practical Action (2010) expresses it, whereas aggregated national and supranational estimations are increasingly produced in an attempt to drive policy urgency, there remains a massive lack of reliable information on energy issues which might be useful at community, project or enterprise levels. Further, the people who have the least access to energy are least reflected in the limited data that are collected.

Again, the issue with promoting energy access at the decentralised basic scale however does not come easily with the simplicity of the forces of market demand and supply. In spite of the fact that several attempts have been made to implement the 'basic' forms of decentralised options, particularly solar, there still exists an energy access-supply gap. The market forces of demand and supply seem to be defined by other issues often contextual, that themselves shape and define the rural market environment which practitioners sometimes fail to foresee. Marshall (2006) defines demand as the amount a customer is willing to buy or the intensity of his eagerness to buy a certain amount. Klerkx et al. (2006:198), in explaining the concept of demand point to its substantive meaning – this meaning focuses on the interests of people in certain products or services and in the content of them. Within the context of the study, would rural households without any coercion demand the decentralised energy options, and what options will meet their needs? Furthermore, discussions on energy options have not considered understanding the social system that defines how the rural environment within which these decentralised options (which are technological innovations) should operate.

1.3 Decentralised energy options

There is a global debate that establishes a link between climate change, loss of biodiversity and desertification. Energy supply pathway that is dependent on fossil fuels and unsustainable exploitation of woodfuel resources has implications for climate change and biodiversity. In a statement by executive secretary of the UN Framework Convention on Climate Change (UNFCCC), climate change has already had a major impact of desertification with significant results such as changes in rainfall pattern which leads to even more desertification3. Developing countries are at a higher risk in terms of mitigation. Greenhouse gas emission, as well as local and regional pollutants, could be reduced through more efficient use of energy and increasing the share of lower carbon-emitting fossil fuels and renewable energy technologies such as solar, wind, hydropower and environmentally sound biofuels4. In a similar way, through sustainable woodfuel development such as afforestation and reforestation such as the development of woodlots may improve biodiversity, as well as food production, land and water resources. An energy development pathway such as decentralised energy pathway that is less dependent on fossil fuels and more on renewable energy may be advantageous.

[3] http://www.worldpreservationfoundation.org/blog/climate/un-says-desertification-loss-of-biodiversity-and-climate-change-are-inextricably-linked/#.VLsoLY05DIU. Accessed 28/12/2014
[4] http://www.ipcc.ch/ipccreports/tar/vol4/014.htm. Accessed 28/12/2014

Decentralised energy (DE) options or solutions are promoted where the grid is not able to reach or likely to reach in the near future. The World Bank-ESMAP (2001) in Subhes (2013) defines them as an 'alternative approach to production of electricity and the undertaking and management of the electrification project that may be grid connected or not'. It is characterised by locating energy production facilities closer to the site of energy consumption. Kaundinya et al. (2009) quoted in Subhes (2013), indicates that decentralised systems can exist at different levels – (i) the village level where the focus is on providing electricity to meet the rural needs, and (ii) the industry level where the demand of the industry is the main focus and any excess power is fed into the grid. Thus, decentralised energy options can be grid-connected or off-grid (stand-alone). The small scale characteristic of DE also favours the active involvement of local stakeholders and may be custom-designed according to the community or region. Using micro-grid as an example, Philipp & Schäfer (2009) quoted in Schäfer & Laufer (2011) describe decentralised energy solutions as strengthening the social structures of a community and tending to decrease the gap between the rich and the poor members of a community. Decentralised options can also be grouped into two categories – individual solutions and collective solutions. Individual solutions normally include small ready-to-use kit-based systems such as solar home systems (SHS), solar lamps, and battery-operated systems, among others. Collective systems come in two modes of operation: stand-alone systems and local grid systems (ESMAP 2001, quoted in Subhes, 2013). Even though discussions on decentralised energy are mostly tuned towards the production of electrical energy, the same concept nonetheless can be applicable in identifying cooking energy options (heat) and mechanical energy.

1.4 Research goal and questions

Based on the forgone discussion, this study is based on the assumption that local energy resources have spatial locational advantages and therefore are easy to access, cheaper to produce and may provide the opportunity for 'technological leapfrogging' to address the energy poverty problem in the short to medium term.

Research goal

The goal of the study was to examine which appropriate, implementable and sustainable decentralised energy options can address rural energy needs and the underlying issues that that affect their promotion and implementation.

Research questions

From the research goal, the following specific questions were addressed:

1. What are the socio-economic energy needs of the rural household?
2. How are these being met?
3. What are the available options for decentralised energy? What potentials exist for energy development?
4. What are the preconditions necessary for the implementation and sustainability of decentralised energy systems?
    a. What are the preconditions affecting household decision making on decentralised systems?

b. What are the preconditions emanating from the energy system environment?
c. What are the external factors that affect the implementation and sustainability?
d. What financial and investment capacities are available for the development of decentralised energy options?

5. What mechanisms should be instituted towards a sustainable energy supply which will in turn ensure sustainability of economic development?
6. What recommendations are necessary for both private and public energy providers, energy support institutions and executors, and to make policy more effective?

1.5 Significance of the study

A study into possible decentralised energy options that address energy access in the rural areas could not be more appropriate than within this period when the UN General Assembly due to the critical nature of energy access declared the year 2012 as a Year of Sustainable Energy for All. The first key objective of the UN initiative is to ensure universal access to modern energy services which relates to the objectives of this research. This objective is based on the acknowledgment that though energy is not explicitly indicated in the outline of the Millennium Development Goals (MDGs), access to reliable, better and sustainable energy services for all would be essential for the achievement of several MDGs, namely in the area of incomes, food security, education, and health. Consequently, the Sustainable Energy for All Acceleration Framework (SEAAF) aims to assist countries address commonly observed challenges in energy policy, planning and programming, such as advancing demand-driven prioritisation of energy services based on development needs among others. Among the objectives of the acceleration framework adopted by Ghana are to identify gaps in existing polices and interventions, and to develop cost-effective solutions that can accelerate progress towards the attainment of sustainable energy for all. It is part of the objectives of this study to examine government policies and interventions and propose recommendations to address the gaps identified.

Furthermore, at the country level, even though rural development is an important development theme in Ghana, poor energy access is a key feature of the rural communities and has been an impediment to growth and development. Energy is identified a critical enabler. About 80 percent of rural households in Ghana rely on traditional biomass (fuel wood and charcoal) as the primary fuel for domestic cooking and other productive activities (Energy Commission of Ghana, 2012). The rural electrification access stands at 49 percent. As development practitioners attempt to find energy solutions, an investigation into 'smaller groups' who will otherwise be overshadowed by national averages is necessary. Identifying critical issues contextually provides appropriate data and information that will help both policy makers and implementers to make 'near-best' policy decisions. The study therefore advances the voice of the poor people for whom energy interventions are being planned. It also fits into the international data collection process to provide a database for referencing.

Finance and investment are factors that have considerable impact on the promotion of energy. Financial and investment constraints are challenges for the conventional energy utility investment and therefore a disincentive for investment in remote rural communities which are also widely scattered. In the alternative energy sector for rural energy development, finance and investment have again been constraining factors due to the fact that the private sector which is the main driver in the sector is profit-oriented. A research into financial and investment capacities particularly within the local communities and administrative districts informs the modelling of a finance and implementation approach which should help in providing a win-win solution for both the investors and the consumers. Again, implementation of decentralised energy initiatives also has over the years suffered non-sustainability. The study provides information on rural expectations. It also informs government and implementation agencies on which preconditions from both the regulatory and the private sector dimensions need to be satisfied, and which of these need immediate attention to serve as leverage in the total implementation model. In addition, the study also provides information on emerging phenomenon in the household energy use patterns which will also inform energy planning for rural areas in Ghana and also inform the supply chain.

1.6 Organisation of the report

The report is organised into nine chapters. Chapter one is the introduction to the research. It presents a general background on the phenomenon under discussion from an international perspective, zooming in gradually to the local issue which is the core of the study. The chapter presents the research goal and the key research questions, and a justification for the research within international and national contexts are provided. Chapter two presents the theoretical and conceptual context within which the study is carried out. It traces critical energy issues from the international level to the local level, draws relationships between the key issues the study attempts to address at all these levels and establishes a framework within which this study is carried out. In Chapter three, the research process is presented. The analysis and findings from the field study which measures the key variables of the study are presented in chapters four to seven. Chapter eight discusses and synthesises findings within the tenets of the theoretical framework and the conceptual framework. The work is concluded and recommendations are made for theory, policy and practice in chapter nine.

2 ENERGY ACCESS IN DEVELOPING ECONOMIES – A THEORETICAL AND CONCEPTUAL FRAMEWORK

2.1 Purpose of literature review

The purpose of literature reviews is not to provide answers about what is known on a topic but rather to develop sharper and more insightful questions about the topic (Yin, 2009:14). This chapter examines literature on the issues and concepts under investigation, and also reviews theories that support these concepts. The aim is to fit the study in an appropriate theoretical and conceptual framework, identify departures and/ or conformities to previous studies and also to be able to lift the research from the normative to the theoretical level as a necessary contribution to academia. Within this same discussion, limits are set for the study and its analyses to ensure a certain appreciable degree of sharpness and convergence as against a broad incoherent discussion that is not able to reach a valid conclusion. This chapter is in three parts: a discourse on the energy situation at the Sub-Saharan African regional level, situating it in the global context; a discussion of the energy situation at the country level with highlights on energy development at the rural level; and an exposition on the concepts and theories that apply to and delimit the study. The chapter ends with a conceptual framework.

2.2 Energy and development in Africa

2.2.1 Energy demand, access, and projections in Africa

Discussions on energy and its relation to development emphasise the fact that energy in all its forms is a prerequisite to development. About 1.3billion people worldwide are till date without access to electricity and more than a quarter of the world's population – 2.6 billion people – does not have access to clean and affordable energy service to meet their daily basic energy needs (IEA-WEO, 2012). The IEA reports that among the developing regions, only 26 percent of the population in Africa has electricity (IEA, 2012), and about 25 percent of the 2.6 billion people cooking with biomass live in Africa (Practical Action, undated: 2). It is estimated that without any drastic action, nearly one billion people will still be without electricity and 2.6 billion people will still be without clean cooking facilities by 2030 (idem.). Considering energy consumption in general, it is estimated that in the business-as-usual scenario, Africa's energy consumption will experience an accumulated growth of 68 percent from 2007 to 2035, rising annually by 1.8 percent which is above the expected global average of 1.4 percent (AfDB, 2011). There is a concern that even though the annual increase in consumption of fuels is above the world average, the percentage of Africa's consumption remains relatively low within the global consumption (ADB, 2011). The Sub-Saharan African sub-region compares even more poorly with the others with the level of energy development. At least 625 million people do not have access to modern energy and energy services in the sub-region, relying exclusively on traditional biomass for cooking, heating and lighting (AfDB, 2011:37; UNDP, 2009:1, 10; IFC, undated). The IEA developed an Energy Development Index (EDI) to assist policy makers in tracking progress towards providing modern energy access and make a more informed assessment. The

Sub-Saharan African region scored the least, dominating the lower half of indices of 80 countries (IEA, 2012). The severity of energy access issues in Sub-Saharan Africa is also depicted when the Multidimensional Energy Poverty Index[5] (MEPI) for the countries within the sub-region are considered. An AfDB (2011) report indicates that with the exception of Angola, Namibia and Senegal which reports of MEPI of less than 0.6, depicting average energy poverty, all other 21 countries within the sub-region under investigation have indications of severe energy poverty with Ethiopian showing MEPI of 0.9, depicting acute energy poverty. Energy demand in the sub-region arises mainly from meeting basic human needs in households, including cooking, lighting, space-heating, and the operation of household appliances (AfDB, 2011).

2.2.2 Cooking and heating in Sub-Saharan Africa

A number of energy profile studies indicate that averagely almost 80 percent of the population in Sub-Saharan Africa rely on traditional bio-energy for cooking and water heating (Brew-Hammond 2010:2292; Karekezi and Kithyoma, 2002:1071; IEA, 2010: 251). In the rural areas, the average is close to 100 percent, while the urban is just a little below 60 percent (ibid.). At the country level, many countries like Liberia, Burkina Faso and Tanzania have more than 95 percent of their population relying on traditional biomass for cooking and heating (ibid.). The number of people relying on traditional biomass for cooking is projected to increase over the next 25 years: it is estimated that this will rise from the current 600 million to over 700 million in 2030 (Brew-Hammond, 2010). A study by Kuygusuz (2011) (quoted in AfDB, 2011), shows further that cooking constitutes about 80 percent of the share of household energy demand in the sub-region. Such high numbers may suggest that even seemingly better-off households either lack access to financial resources for modern fuels and energy services as asserted by Kaygusuz (2011) or lack the physical access to them. More significantly, it goes to show that greater part of energy demand especially within the poor segments of the sub-region, is only to meet basic living need – cooking – and not any extraordinary high consumption industrial or commercial need. Averagely, only 17 percent of the people have access to modern fuels: for instance, less than ten percent of the people have access to liquefied petroleum gas (LPG) (UNDP, 2009:13). Even Kerosene which is considered unsustainable and 'not clean' (but 'modern') and normally at the lower part of the energy ladder is available to only seven percent of the Sub-Saharan African region (UNDP, 2009:14). Ghana is indicated to have a modern energy access rate of about twelve percent (ibid.). Moreover, within the sub-region, the rural-urban disparity is significantly high with a rural-urban ratio of five percent to forty-two percent.

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[5] The *Multidimensional Energy Poverty Index (MEPI)* provides information on the impacts of a lack of energy access on individual deprivation and quality of life issues. The index takes into account both the incidence of energy poverty as well as quantifications of its intensity. Taking this enhanced perspective on energy access means going beyond the fact of whether an individual is connected to a commercial energy provider or not. The index weighs three typical dimensions of energy poverty (two indicators for cooking – depending on the type of fuel and stove or open fire usage, lighting indicating access to electricity as well as the possession of household appliances, i.e. a refrigerator), but also includes two additional dimensions measuring access to communication (telecommunication means) and entertainment/education (ownership of a television or radio) to account for the multiple dimensions of an individual's energy poverty. The MEPI values range from 0 to 1 in which energy poverty increases from 1. The MEPI rises towards 1 depending on the non-availability of the defined indicators and the number of people who are excluded.

2.2.3 Electricity in Sub-Saharan Africa

In terms of power, access to electricity is about 31 percent for the Sub-Saharan African region (IEA, 2010:239). In 2012, the IEA-WEO reported the electrification access falls between 31.8 percent and 43 percent showing a slight increase from 2010. When South Africa is excluded, the IEA (2006) estimates that the total installed capacity of electricity in Sub-Saharan Africa is 28 gigawatts – less than half of the installed capacity of Spain [the installed capacity of Spain alone is about 70 gigawatts]. The low level of electricity generation, in addition to the limited distribution and transmission infrastructure, results in a current per capita electricity consumption of only 124 kilowatt hours. With the rapidly growing population, the per capita electricity consumption in Sub-Saharan Africa is expected to keep declining if the current trends continue (AfDB, 2011). Moreover, the rate of generation falls below the rate of economic growth. Whereas economic growth in the region showed rates of up to 4.5 percent between 2000 and 2005, electricity generation in the region increased by only 1.2 percent annually (Foster and Briceño-Garmendia, 2010 quoted in AfDB, 2011). According to the AfDB (2011), it is estimated that the demand for electricity in Africa will grow at a rate of 2.6 percent between now and 2035. Within this same period, electricity generation is expected to increase by less than four percent annually, raising supply to 1,210 billion kilowatt hours by 2035. The AfDB estimates further that although electricity generation in Africa will more than double until 2035, the absolute amount of kilowatt hours produced will remain comparatively low because most of the increment will again be accounted for by coal-fired generation in South Africa. For Sub-Saharan Africa, the rise in electricity generation will remain relatively low and unable to meet a greater proportion of electricity demand within the sub-region. From another angle, the Practical Action's (PPEO) report reinforces the point that while percentages of people without access to electricity in Sub-Saharan Africa were projected to decline by ten percent between 2000 and 2015 in a business-as-usual scenario, the absolute numbers show there will be an increase of 100 million people in the period to 2030 (Practical Action, 2010). By implication, without substantial changes in current policies and practices, the total number of people without access to electricity in sub-Saharan Africa will increase to 691 million by 2030 (Practical Action, 2012:1). In contrast, North Africa has electrification rate as high as 99 percent (Practical Action, 2010: 55; IEA, 2012). In the West African corridor, Ghana seems to be doing well and toping electricity access with 54 percent access as at 2008 (UNDP, 2009), 61 percent as at 2010 (IEA, 2012) and 72 percent as at 2012 (Ministry of Energy, Ghana 2012).

2.2.4 Livelihood development in Sub-Saharan Africa

With regards to livelihood development, the main sectors of need in the rural economy are agriculture and rural industries. Increased agricultural productivity is a key driver for food security, income generation, development of rural areas, and ultimately global poverty reduction (Practical Action, 2012: x). Agricultural activities - land preparation, cultivation, irrigation, harvesting, processing, storage, and transportation of agro-products - have direct energy needs. For smallholder farmers, the increased use of modern energy services can contribute to increasing incomes through a wide range of energy services at each step of the agricultural value chain from production, through post-harvest processing and storage, to marketing (Practical Action, ibid.). Rural industrial activities make use of traditional biomass for heat generation in activities such as bakeries, blacksmithing, brick manufacturing, and food preparation and vending. Mechanical energy needed for these livelihood activities is substituted by human power in the absence of a grid power connection (AfDB, 2011).

2.3 Africa's alternative energy potential: a brief discussion on barriers affecting the development of alternative energy in Sub-Saharan Africa

2.3.1 Alternative energy potential

Discussions on alternative energy for Africa underscore the substantial renewable energy resources that could be harnessed for the continent's energy development. Renewables are suitable for power generation and the production of heat and liquid fuels on either large or small scale and can be installed as on- or off-grid solutions. Their advantage as standalone technologies could in some cases make renewable energy technologies superior to conventional technologies for serving the energy needs of rural Africa (AfDB, 2011). Out of the top 35 developing countries that exhibit high renewable energy potential, 17 are in Sub-Saharan Africa. Karikezi (2007:5) assents that while it is asserted by many analysts that renewable cannot solve all of Africa's energy problems, they are still perceived as having significant potential to meet growing energy requirements in the region. The region has significant hydro, solar and wind potentials (as well as an estimated 9000 megawatts of geothermal potentials occurring within the East African region, prominent along the Rift Valley region) (Karikezi, 2007). Twelve percent of the world's hydro potential is in Africa and mostly in Sub-Saharan Africa but only five percent is being exploited (Kölling et al., 2011:56; AfDB, 2011). Solar has large potentials for electricity, heating and drying. The least potential generation is estimated to be as much as 33 terawatt-hour (TWh) per annum recorded in the Gambia (ibid.). The share of renewable energy in electricity generation in Africa is expected to increase from 16 percent in 2008 to 39 percent in 2035. It is estimated that hydro, solar, and wind could secure the energy supply at many times the current level of consumption; wind potentials are the least though, as they mostly found along the coast. Apart from geothermal and hydropower projects which are normally large scale, the use of the other renewable energy have often been in the form of small scale decentralised energy systems as a more feasible alternative to tackling the poor energy access issues. As Practical Action puts it, energy needs of the poor are small but small amounts of energy can make a significant difference to their lives (Practical Action, undated).

2.3.2 Factors affecting the adoption and dissemination of alternative (renewable) energy systems

In spite of the competitive advantages and potentials discussed above, the exploitation and deployment of renewable energy (RE) as decentralised systems is below optimum. The sub-section highlights barriers identified by energy researchers and practitioners as hindering the promotion of RE in Africa.

Political and legal barriers: National policy initiatives and the enabling environment are key factors necessary for RE development. However, renewable energy resources have not attracted the level of investment or policy commitment they deserve (Karikezi, 2007). It is recalled that most non-oil producing African countries started engaging RE in their energy policy packages during the 1970's oil crisis. However, with subsequent decline in oil prices, support for these policies shrank and became in some instances solely rhetorical (AfDB, 2011). Practical Action's PPEO report (2012) emphasises that the multiple sources of energy and the variety of value chains involved in delivering energy services mean that the required policies should not be confined to the energy sector, which has conventionally been the remit of energy policy. However, the policy direction must come from an overall strategy or national goal for energy and must be articulated in terms of specific national targets and minimum standards. These targets need to be reflected through the range of regulations, institutions, and budgets that affect action. Political will and the commitment of governments are identified as necessary to prioritise investment in energy as critical for development of the poorest sectors.

Technical barriers: The adoption and deployment of new technologies is a long term process of learning and practices which is in most cases not factored into implementation models and patterns. Karekezi and Kithyoma (2003) stress that trained manpower capable of developing and manufacturing RE technologies is a prerequisite for their successful dissemination. Low technical knowledge of the different categories of stakeholders involved in delivery and implementation, and even in policy making, retards the transfer of knowledge and local absorption. Subsequently, projects suffer non-sustainability when technical experts leave.

Lack of sustainable models: Closely related to the technical barriers is the issue of sustainable models. It is a matter of concern that policy frameworks and national energy policies in developing countries in most cases do not respond to the needs and capacities of the poor (Practical Action, undated). In a similar vein, energy technology research, development, and transfer do not address the energy needs and capacities of the poor (ibid.). The issue of poor sustainability of energy access initiatives long after the initial programmes are ended is one that has resulted in disillusionment among intended beneficiaries as well as among planners, policy and decision-makers, hindering the wider uptake of options that could improve access to energy for the poor. For instance, in rural areas, small energy generation systems installed to provide electricity to small villages or communities frequently last a few months before being abandoned. Similarly, large numbers of projects for the dissemination of efficient stoves have not changed the use of three stones from being a common practice. Practical Action observes that such situations are caused by the original programme implementation model not addressing the underlying problems associated with poverty and household cash flow, lack of technical capacity, and institutional support.

Financial barriers: Insufficient financing is one of critical barriers to energy access in general for the poor and also to the large uptake of renewable energy technologies (RET).

Globally, compared to current energy sector spending, the cost of delivering energy to meet the needs of poor people is only about 2.85 percent of total global energy investment depicting a meagre investment requirement. While most African countries, especially non-oil producing countries have limited budgetary means, RET require high initial investment cost as well as low-cost and long-term financing for the intended beneficiaries most of whom have low ability to pay (AfDB, 2011; Brew-Hammond, 2010; Practical Action, undated). Two main issues have been identified to be the causes of insufficient financing: (i) the overall amount of invested capital is too low; and (ii) investments focus mainly on large-scale projects and less on the expansion of decentralised and off-grid energy supply solutions (ibid.). Karekezi (2007) in his review of energy intervention in Africa mentions that, most African policy makers are keen on large power projects and electrification programmes as a way of tackling the energy access challenge. Moreover, the production of RET require countries to import foreign technologies due to limited local production capacities. Again, both internal and external private investors are profit-oriented and would not be attracted to the idea of promoting energy access to the poor unless subsidies or other financial incentives are in place, and unless clear policies on tariffs and risks are set in advance (Practical Action, undated). In addition, there is low availability of credit schemes for low-income households. However, it is in the area of finance that some of the most effective and innovative ways to reduce the costs of modern energy services for low-income households can be modelled (Practical Action, 2012: 82). The AfDB (2011) suggests that there is no conventional rule to addressing affordability issues; however, each country needs customised, adapted solutions that fit the local context.

In addition to the above, other factors including poor institutional framework and infrastructure, inadequate planning, lack of coordination and linkage in national renewable energy programmes, pricing distortions that place renewable energy at a disadvantage, weak dissemination strategies, poor baseline information and low maintenance capacity have been identified as having significant retrogressive impact on the development and dissemination of RE systems (Karekezi, 2007).

2.4 Energy use and supply in Ghana with emphasis on rural context

2.4.1 Traditional fuels – biomass

The situation described in Sub-Saharan Africa replicates itself in the national context of study. The greater proportion of energy supply in Ghana is met from woodfuels, i.e. firewood and charcoal. Woodfuels account for over 70 percent of total primary energy supply and about 60 percent of the final energy demand; in 2009, the total supply of primary woodfuel was estimated to be 20 million tonnes (Energy Commission (EC), 2012). Between 2004 and 2008, the consumption of woodfuel increased by 58 percent, while the consumption of charcoal also increased by about 50 percent during the same period (Kemausour et al., 2012). About 90 percent of woodfuels is obtained directly from the natural forest. The remaining ten percent is from wood waste i.e. logging and sawmill residue, and planted forests. Districts in the transitional and savannah ecological zones of Ghana particularly the Kintampo, Nkoranza, Wenchi, Afram Plains, and Damongo Districts provide the bulk of dense wood resources for woodfuels. The rate of woodfuel supply from the natural forest is nonetheless unsustainable due to the unsustainable practices adopted in logging. The Ministry of Lands and Natural Resources of Ghana estimates the rate of deforestation in Ghana to be two percent per annum (Ministry of Lands and Natural Resources, 2012: iv). Communities in the transitional zone which are the main charcoal producers are showing signs of forest depletion causing producers to travel further to find the resources for the same production quantity. The use of woodfuels split itself between urban and rural users: firewood is used mainly used in the rural areas, and charcoal even though produced in the rural hinterlands, is mainly produced for urban consumption. The biomass business is purely informal and unregulated (Amaka-Otchere, 2006; UNDP, 2006). The rural communities simply collect fuelwood from farms for their domestic and productive energy uses. It is projected that under these supply conditions, woodfuel will remain a dominant and an important source of energy for next few years just as pertains in other Sub-Saharan African countries (UNDP, 2006; UNDP, 2009; Practical Action, 2012; IEA, 2010:253). According to Ghana Living Standards Survey Five (GLSS 5), about 80 percent of rural households depend on firewood as the main source of cooking fuel (Ghana Statistical Service (GSS), 2007). In the rural Savannah areas, 6.5 percent of households use crop residue or sawdust as cooking fuel. It is estimated that if this consumption rate is maintained, the country is likely to consume more than 25million tonnes of woodfuel by the year 2020 (EC, 2012).

2.4.2 Modern fuels – LPG and Kerosene

With regards to access to modern cooking fuels, out of the six percent and nine percent of user households using LPG as their primary source of fuel for cooking recorded in 2004 and 2005 respectively, 70 percent resided in the administrative regions of national capital and the second largest city, i.e. the Greater Accra and Ashanti Regions. 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 (Kemausuor et al., 2012). A recent study found that only about 19 percent of households in the upper income quintile in Ghana have access to LPG, reducing to about two percent in the lowest income quintile group (ibid.). Even though the country has tried an LPG improvement programme running since 1990, the programme targeted the urban consumers. Therefore, in 2004 the LPG programme was re-launched as the LPG Rural Challenge programme with the aim of encouraging the switch from usage of charcoal and firewood as source of cooking fuel to LPG (National Petroleum Authority/Ministry of Energy, undated). The GLSS 5 shows that two percent, 1.9 percent, and 0.6 percent of rural areas in the coastal, forest and Savannah ecological zones use LPG (GSS, 2007). LPG is produced by the nation's single oil refinery, the Tema Oil Refinery, together with other petroleum products such as gasoline and kerosene. The production levels have fluctuated over the years, falling from 75,300 tonnes in 2005 to 31,600 tonnes in 2010 (EC, 2012). The gap in supply is compensated for through imports. It is anticipated that the recent discovery of natural gas will expand the LPG production options in Ghana (EC, 2011).

Kerosene, even though not applauded as clean energy (but classified with modern energy) with its associated pollutants that often cause respiratory and eye ailments, was also considered in the energy mix of the country. In 2001, the Ministry of Energy instituted as part of the energy policy framework, the Rural Kerosene Distribution Improvement Project (Abavana, 2004; Ministry of Energy, 2006; Budget Statement - Government of Ghana, 2009) to provide an alternative modern form of energy for lighting to the rural segment. The aim of the project was to ensure that kerosene is made available at all times in rural areas and at the officially approved prices. The project targeted the establishment of over 2,400 kerosene retailer outlets in rural areas all over the country by the year 2010. A total 1200 surface tanks have been fabricated and distributed. There is very little information on the progress and success of this programme with the exception of the number of surface tanks that were fabricated. There is no information on the success of the actual supply of fuel to these retailers.

2.4.3 Modern fuels – grid electricity

Ghana's strategy for improving energy access has mainly focused on electrification even though electricity is "just one component of energy access" (Practical Action, 2012). The country has since 1989 implemented a National Electrification Agenda that is expected to have the whole country connected to the grid by the year 2020. Over the last two decades, the National Electrification Programme (NEP) has electrified over 4,000 communities and raised the national access rate from under 35 percent to over 72 percent. This current electrification rate of 72 percent splits into a ratio of 100%:49% between the urban and the rural areas (The Energy Centre (TEC) of KNUST, 2011). As at December 2009, the installed power capacity of the country was about 1,860 Megawatt (MW) capable of producing 9,800 Gigawatt-hour (GWh) of electricity (EC, 2010). In addition, it was expected that in 2010, the capacity will be increased by 600MW with a corresponding 4000GWh of power. In 2010, the total generation capacity was 1930MW with approximately 50 percent of this energy coming from hydro-power and the remainder from thermal generation sources. Power supply is intermittent, barely able to support itself with frequent load-shedding programmes. It is currently estimated that the cost of electrification per household is USD2000 (Amadu, 2012). Given that over 90 percent of rural customers are "lifeline customers" whose electricity consumption is subsidised, the state-owned distribution utilities are struggling to maintain this customer base (ibid.). In order to reach the remaining 30 percent of the population in a sustainable manner with clean energy, technological innovation and new business models will be crucial, as the costs of grid connections keep rising due to reducing customer density and longer transmission and distribution lines (Amadu, 2012), leading to higher fixed costs per consumer in rural areas (World Bank, 2010). Large regional disparities also exist. While the rural segments of the first three more developed administrative Regions – Greater Accra, Central and Ashanti Regions – are boasting of electrification of between 68 percent and 75 percent, the three Northern Regions – Northern, Upper West and Upper East Regions – have electrification rates between 22 percent and 31 percent. The rural segments of the Brong Ahafo Region record the 5th lowest access to electricity with 45 percent. It is interesting to note that the Brong Ahafo Region is located in the transitional ecological zone whose physical characteristics transits from the forest semi-deciduous ecological zone towards northern savannah zone. These characteristics seem to exhibit itself in the development of the Region. There are only three urban Districts in this extensive Region and these are the most electrified. Interestingly, these lie within the southern forest zones of the Region[6]; the Districts in the northern part of the Region fall within the northern savannah zones and are mainly rural Districts and the least electrified. The TEC report shows that, more than 50 percent of the “unconnected” population live in settlements of population smaller than 500 (see Figure 2-1 below). In the Savannah zones, when national figures are disaggregated, the rural areas of the Savannah ecological zone are recorded to have the highest dependence on fuelwood as primary cooking energy of 71 percent (EC, 2012). The GLSS 5 report (GSS, 2007) shows that rural segment of this same ecological zone exhibit greater dependency on kerosene as a primary source of lighting with 81 percent. Interestingly, even with the low penetration of solar in the total energy mix of the country, when the energy mix per ecological zone for both the urban and rural segments is considered, rural Savannah records the highest portion of solar energy use with 0.3 percent access rate. The rural Savannah also records the least electrification in the country with 16.6 percent access, and significantly, the highest use of candles and torchlight. In the absence of electricity, unconnected rural areas are dependent on kerosene as the main fuel for lighting for 82 percent and 22 percent of households in the rural and urban areas respectively (GSS, 2005; EC, 2006), and improving to 72 percent and 20 percent for rural and urban areas respectively from 2005 to 2008.

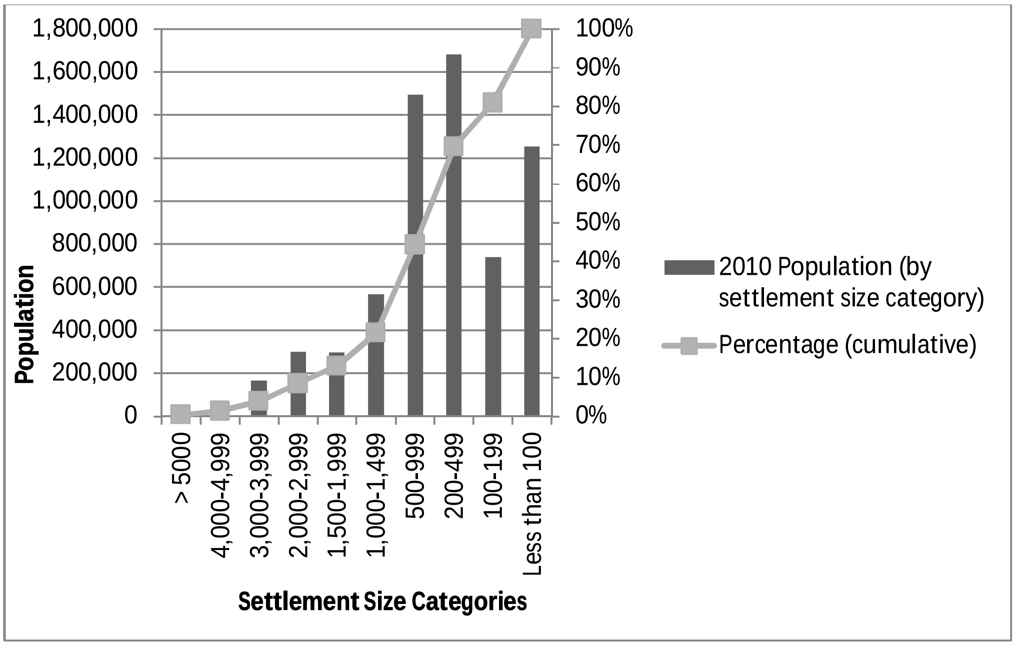
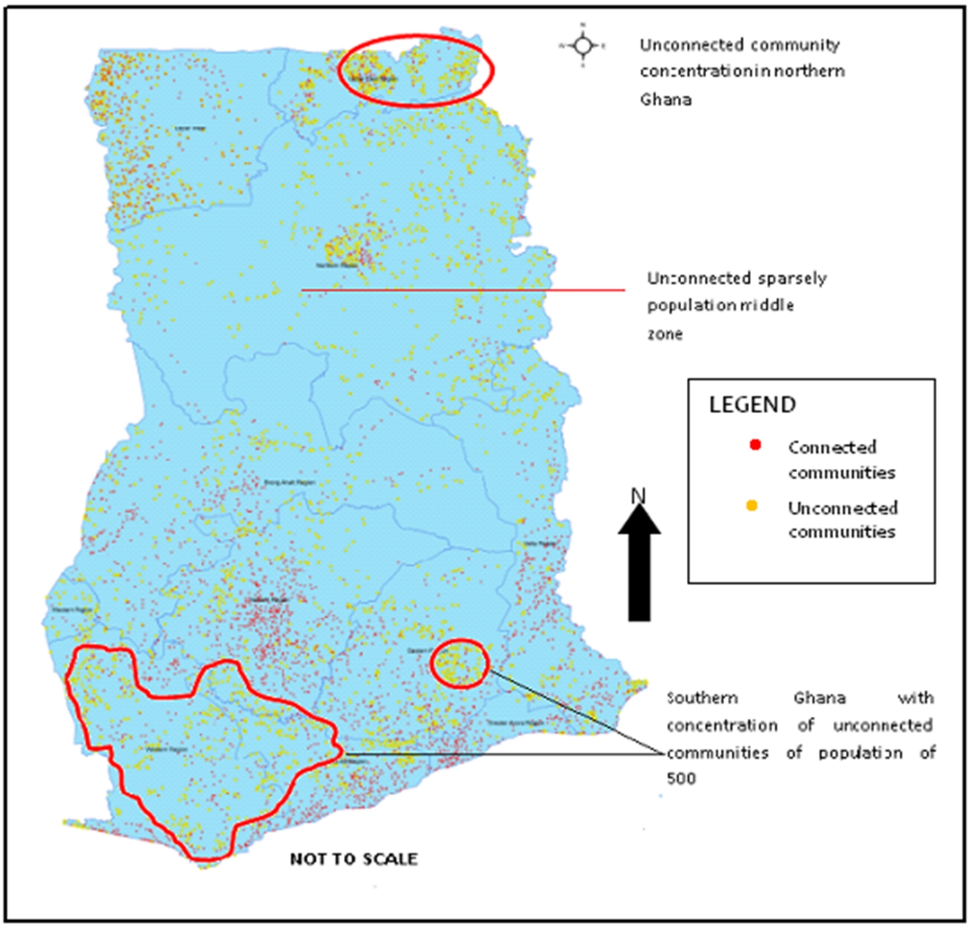


Figure 2-1: Rates of electrification according to settlement sizes in Ghana
Source: The Energy Centre (TEC), 2011

6
http://www.modernghana.com/GhanaHome/regions/brongahafo.asp?menu_id=6&sub_menu_id=134&gender= (Accessed 24.05.2013)



Map 2-1: Grid electricity connection distribution in Ghana
Source: Based on The Energy Centre (TEC), 2011

2.4.4 Modern fuels - Petroleum

Ghana basically imports crude oil and processes it. Ghana's oil industry featured more prominently in the downstream sector until the offshore discovery of crude oil in commercial quantities in July 2007, which launched both the upstream and downstream sectors. By 2012, the country had identified seven major oil fields offshore; this is believed to contain reserves of over 1.8 billion barrels of oil and gas deposit within two deep water blocks, i.e. the Tano Deep-Water Basin, and the west Cape Three Points Deep-water basin which is offshore the Western Region of the country, popularly called the Jubilee Fields. Another oil field, the Tweneboa field is known to contain about 1.4 billion barrels of oil and gas deposits[7]. Recently another oil field has been discovered in the Volta Region[8] but it is yet to be validated. One intended use of the resources from the oil fields is the processing of Liquefied Petroleum Gas (LPG) to supplement household LPG demand

[7] http://www.ghanabusinessnews.com/2010/07/01/tullow-oil-says-tweneboa-jubilee-have-total-of-2-9-billion-barrels-of-oil/ Accessed 24/05/2013
[8] http://www.ghanaweb.com/GhanaHomePage/NewsArchive/artikel.php?ID=264617 - General News of Sunday, 10 February 2013 (Accessed 02/05/2013)

due to the increase in transport demand of the fuel. Currently, the country's oil refinery, TOR, operates at 45,000 barrels per stream day (BPSD) capacity refinery with a maximum LPG production capacity of about 52,000 tonnes per year (EC, 2011). The percentage of consumption supplied by the national TOR rose steadily between 2000 to 2005 from 21.6 percent to 106.8 percent and has been falling steadily from 2005 from as high as 106.8 percent to 17.7 percent in 2010 (idem.) due to technical capacity problems of the refinery. Appraisal work on the Jubilee Fields has estimated that with an oil-to-gas ratio of about 1,000 standard cubic feet per barrel, the field has substantial associated natural gas reserves estimated at over 500BCF. It is estimated that about 300,000 tonnes per year of LPG would be produced from processing natural gas from the Jubilee Field compared to the 2009 consumption of 220,600 tonnes (idem., p.16).

2.4.5 Renewable energy

Renewable energy sources play a limited role in energy supply in Ghana notwithstanding the government policy to increase the proportion of renewable in the total energy mix. With the passing of the Renewable Energy Bill, it is a policy goal to achieve ten percent as the proportion of renewable energy in the total energy mix of the country. In the case of solar energy, Ghana receives averagely 4.0 – 6.5kWh/m2/day of solar radiation and sunshine duration 1800-3000 hours per year (Kemausuor et al., 2012). However, solar has not been fully developed and contributes only 0.2 percent to total energy supply for lighting. The total installed power as at 2003 was 1000kW (ibid.; SWERA Report, undated). In much the same way, a 20-year assessment of wind potentials in the country indicates wind resources along the coast. Wind measurements taken at twelve meter height along the coast revealed wind speeds varying from 3.33 m/s to about 6.08 m/s which is not suitable for economic exploitation (Kemausuor et al., 2012).

The country is again endowed with numerous water bodies which have the potential of being harnessed into small hydro resources. Over 70 of such resources have been identified but none has been developed. It is estimated that the small hydro potential could be harnessed at 1.2-4 MW if they 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 (Kemausuor et al., 2012). The cost of connecting new communities to the national grid has become extremely expensive and difficult to justify on a benefit criteria. Concerns about regional inequity in the electrification investments are putting even more pressure on government to extend the grid to uneconomic locations from the utilities' perspective. Analysis of data from a review of the status of the National Electrification Program indicates that the cost of grid electrification per household is currently over USD 2000 (Ministry of Energy, 2010). Amadu (2012) argues that In order to reach the remaining 30 percent of the population in a sustainable manner with clean energy, technological innovation and new business models will be crucial, as the costs of grid connections continue to rise.

In summary, the discussion from Chapter 2.2 till 2.4 depicts that energy access in the Sub-Saharan African sub-region compares poorly with other developing continents even though there seem to be improvement in energy access over the past few decades.

The rural segment of the sub-region is the worst affected by this energy poverty which in turn affects their socio-economic development. Low access to modern energy results in a high dependency on biomass for domestic activities and rural enterprise activities but in an unsustainable manner which raises concern for population increases and consequently the increase dependence on the same stock of biomass resources. For lighting, high dependency on kerosene is recorded. Even though kerosene is referred to as a modern fuel, the pollution associated with its use of kerosene lamps and the effect on health cannot be ignored. Even though in Ghana the National Electrification Programme boasts currently of electrification rate of 72 percent, high disparities exist at the regional levels, and between ecological zones with significant urban-rural dichotomies. The Savannah regions record the lowest electrification and even lower electrification rates within their rural areas. In addition, the power producing companies are barely able to maintain constant supply resulting in frequent power outages and load-shedding programmes. Meanwhile, renewable energy and its accompanying alternative energy technologies play a minimal role in energy supply in the country even though the country is richly endowed with it. It cannot be over-stated that the country has attempted a number of alternative energy approaches in an attempt to address this issue. At the Sub-Saharan African regional level, a number of factors have been identified as affecting the adoption and dissemination of renewable energy by governments. Further document review in Chapter four will bring to fore what persists in the Ghanaian context with regards to specific government initiatives and regulatory framework that attempted to address the issue. From the forgone discussion, the accessibility, affordability, and availability emerge as fundamental to addressing the objectives of the study. These concepts are further discussed within selected theories in an attempt to draw out a conceptual framework in the following section.

2.5 Emerging concepts

2.5.1 Accessibility

Energy access has been widely discussed and various schools of thoughts have attempted to find a definition that will provide useful meaning and capture the important issues concerning access to energy and its related services as a basic human need for subsistence and protection. Brew-Hammond defines it as the ability to use energy sources, namely electricity, liquefied petroleum gas (LPG) or charcoal, and energy services such as lighting, cooking, heating, water pumping, and grinding (Brew-Hammond, 2010: 2291).The World Energy Outlook[9] defines it as a household having reliable and affordable access to clean cooking facilities[10], a first connection to electricity, and an increasing level of electricity consumption over time (IEA, 2012). The definition of access includes consumption of a specified minimum level of electricity, and the amount varies based on whether the household is in a rural or an urban area. The definition also includes provision of cooking facilities which can be used without harm to the health of the household and which are

[9] http://www.worldenergyoutlook.org/resources/energydevelopment/definingandmodellingenergyaccess/

[10] This definition refers primarily to biogas systems, liquefied petroleum gas (LPG) stoves and advanced biomass cookstoves that have considerably lower emissions and higher efficiencies than traditional three-stone fires for cooking.

more environmentally sustainable and energy efficient than the average biomass cookstove currently used in developing countries. The Practical Action's Poor People's Energy Outlook (2012), provides a valuable complement to the IEA's World Energy Outlook's definition by capturing community energy needs in their definition, i.e. "the increased use of modern energy services for production and income generation by poor people and not just consumption (light and cooking), and even energy for community service". The UN Secretary General's Advisory Group on Energy and Climate (AGECC)(2010) cited in the International Energy Agency-WEO (2012) defines energy access as "access to a basic minimum threshold of modern energy services for both consumption and productive uses which is reliable and affordable, sustainable and where feasible, from low-GHG emitting energy sources".

The lack of access to modern energy and energy services is most severe in rural areas of Sub-Saharan African region which accommodates about 68 percent of the region's population (Karekezi and Kithyoma, 2002: 1071). A daunting 90 percent of rural households in Sub-Saharan Africa rely on wood or other inefficient forms of biomass to meet their energy demand for cooking and space heating (Karekezi and Kithyoma, op.cit). Wood or crop residues account for 94 percent of the primary source of energy for rural households (and 4 percent for urban households). In proportionate terms, energy for cooking takes up about 80 percent of household energy demand (Kaygusuz ,2011 quoted in AfDB, 2011), indicating a significantly low consumption of energy for other needs. Economic activity is the worst affected. In 2000, households in Sub-Saharan Africa consumed nearly 470 million tonnes of wood fuels (0.72 tonnes per capita) in the form of wood and charcoal. There appears to be a correlation between poverty levels and traditional biomass use in many developing countries (Karekezi, 2004). As a rule, the poorer a country is, the greater its reliance on the traditional biomass resources (IEA, 1998 quoted in Karekezi, 2004). Energy poverty and the over-reliance on biomass have daunting implications on the well-being of users: it is reported that smoke-related deaths account for four million deaths each year worldwide (http://practicalaction.org/smoke-indoor-air-pollution[11]).

Beyond the domestic needs, the development of the rural economy also suffers the inadequate and constrained access to energy, with the areas most affected being agriculture and industry. Agriculture and agro-based businesses have direct energy needs for land preparation, cultivation, irrigation, harvest, processing, storage and transport (and indirect energy needs stemming from the production of fertilisers and the like which is not within the scope of the context of this discussion) (Food and Agriculture Organisation [FAO], 2000). In rural industries, traditional biomass is used for heat generation. In absence of a grid connection, mechanical power is substituted by human power in both rural industry and agriculture (AfDB Draft Energy Sector Policy, 2011). Biomass based industries are also a significant source of enterprise development, job creation and income generation in rural areas (Karekezi, 2004). At the community level, poor access to energy is reflected in the non-availability of community facilities such as clinics, schools, public lighting, and water pumping (AfDB Draft Energy Sector Policy,

[11] Assessed 27/01/2013

2011). Those without adequate access find themselves in a vicious circle of energy poverty (Chineyemba, 2008 quoted in AfDB, 2011). In addition, negative environmental externalities such as deforestation and its eventual effects on the micro-climate for farming, drying of water bodies, and in the global sense, climate change, which works in a cycle to further deteriorate the poverty situation and development progress.

Improving energy access to all has become a key development concern as projections show that unless particular measures are taken there will be more people without access to energy by the year 2030 than today: the Practical Action projects that without a concerted effort, by 2030, three billion people will still cook with traditional fuels. That means, 1 in every 2.5 persons will still rely on traditional fuels for cooking. In the case of access to electricity, every 1 in 7 people will not have access to electricity amounting to almost 900 million people without access to electricity, and many hundreds of millions will be confined to poverty as their incomes are constrained by lack of energy access (Practical Action, 2012)[12]. Defining energy access is important to identifying solutions to address it. As Practical Action puts it, "*how we define energy access is critical in determining how we tackle energy poverty",* (Practical Action, 2012:41). From the various definitions, contributions, and discussions on the concept, this study adopted the following working definition for energy access:

> *The fundamental energy requirement for any group of persons forming a household and eventually living in a living space referred to as their community, and which include sufficient energy for lighting, cooking and some form of livelihood*.

In the following discussion, various measures of energy access were examined. The essence was to expose the study to some standard requirements considered in assessing energy access even though the study did not focus on measuring these indices. The discussion was tailored towards the rural dimension.

Measures of accessibility

i. ***The Energy Development Index - Energy as a domestic consumable and for community service***

The International Energy Agency (IEA) in an attempt to model[13] energy access discusses it under household and under community service (See Figure 2-2). The Energy Development Index (EDI) is a multi-dimensional indicator that tracks energy development at the country level and between countries, distinguishing between developments at the household level and at the community level. This development indicator has been improved over the time and now includes a component on productive use which is fundamental to improving livelihoods and also serves as a sustainability measure for the rural areas. It sets certain minimum energy requirements that can be used as a proxy to an acceptable minimum

[12] http://cdn1.practicalaction.org/p/p/4f1ea5d5-024c-42a1-b88d-026b0ae4f5bb.pdf ; Assessed 27/01/2013
[13] http://www.worldenergyoutlook.org/resources/energydevelopment/definingandmodellingenergyaccess/ - World Energy Outlook- Methodology for Energy Access Analysis. Accessed 11/02/2013

energy access. At the household level, the two energy categories considered are energy for lighting and for cooking. Both access to electricity and access to cooking facilities are considered. Household access to electricity is defined as the consumption of a specified minimum level of electricity. For rural households, the initial threshold level of electricity consumption is assumed at 250 kilowatt-hours (kWh) per year. This is calculated on the assumption of five persons per household. It is hypothesised that, at the rural level, this level of consumption could provide the minimum requirement for a floor fan, a mobile telephone, and two compact fluorescent light bulbs for about five hours per day [the estimated urban minimum consumption is twice the rural consumption.] In terms of cooking, energy access involves the provision of cooking facilities which can be used without harm to the health of those in the household and which are more environmentally sustainable and energy efficient than the average biomass cookstove. In this sense, the IEA primarily refers to biogas systems, liquefied petroleum gas (LPG) stoves and advance biomass stoves that have considerably lower emission and higher efficiencies than the traditional three-stone stoves for cooking.

At the community level, the categories are public facilities and productive uses. Public facilities category includes the use of modern energy in schools, health facilities, water and sanitation, street lighting and other communal facilities. In the case of productive use, the focus is often on modern energy use for activities such as agriculture (ploughing, irrigation and food processing), and micro-small enterprises such as milling, and textiles production. Even though the EDI measures energy access for countries as holistic entities and therefore takes both the urban and the rural component into consideration, this discussion will only consider the rural component.

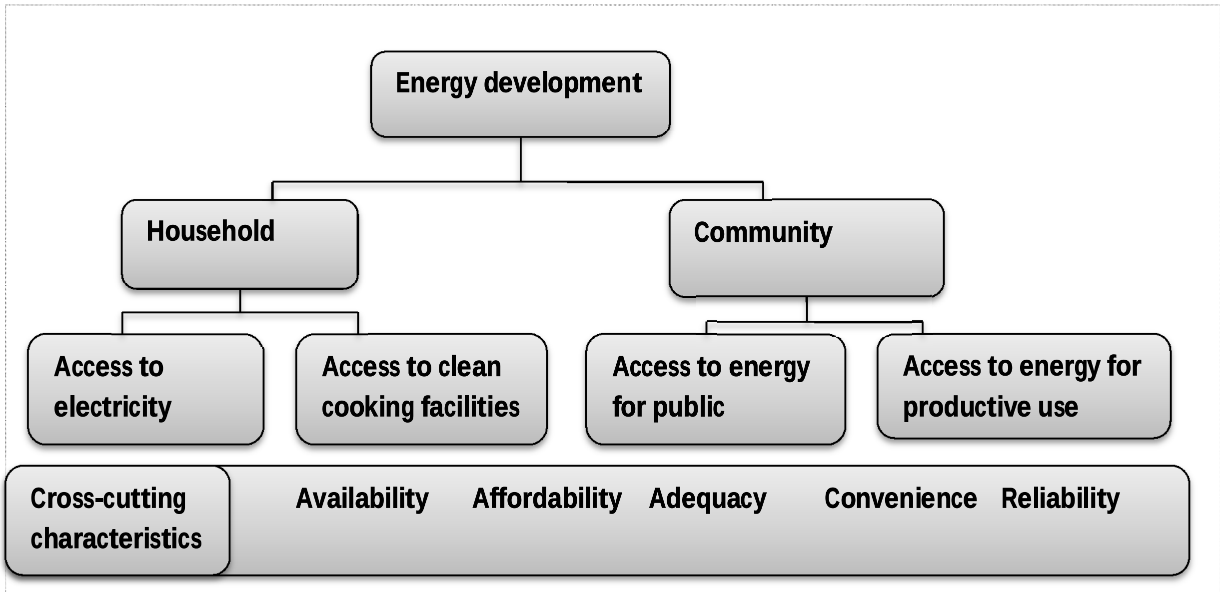


Figure 2-2: Energy Development Framework
Source: Adapted from IEA-WEO, 2012

The IEA notes that households do not distinguish between household energy use and micro-enterprise energy use for enterprises conducted within the home, an observation which is very true especially of rural households where micro-enterprises such as food vending are normally undertaken also on subsistence level to provide supplementary income for other household needs and in the process, also provide the household dietary needs. The energy needs of the two activities are not differentiated.

The discussion within the broad categories of household and community considers both access to modern fuel and appliances as dependent on each other, that is, a person has adequate access only if they have access to both. It is further acknowledged that in respect to both access to energy and access to appliances, there is also progression. In the case of access to energy, an energy ladder is presented –e.g. in the case of electricity, the first move might be from candle and batteries to solar lanterns, solar home systems or possibly, a mini-grid. Likewise in the case of access to appliances, first access could involve a small number of appliances with greater diversity coming later. Furthermore, there are important issues that are considered to make the model holistic sometimes referred to generically as “quality of supply”. For any energy supply to provide a genuine opportunity to use modern energy services there needs to be a technical possibility to use it (availability), a price that is not prohibitive (affordability), sufficient supply (adequacy) and a supply that is easy to use (and pay for), including being located nearby, available at desired hours of the day and safe to use (convenience). Importantly, the supply must be of the right quality (e.g. voltage level) and be usable for most of the time (reliability) (IEA, 2012). Following from the above, four indicators are considered in the calculation of the EDI. These are access to electricity, access to clean cooking facilities, access to energy for public services, and access to energy for productive use. The data required to calculate these indicators are taken from the macro country level and from international sources, which are beyond the context of this research. Table 2-1 provides more insight into the dimension of energy access, with their potential indicators, as well as the strengths and the weaknesses of the indicators. These provide a useful measure and reference points for considering what pertains in the research communities.

An observation of the EDI and its use shows significantly that its application in the rural segment is almost not-applicable or rather it can rarely be used for rural areas where there is no electrification as most of the variables are based on electricity consumption. Rural power is derived in most cases from dry cells, car batteries, and diesel engines, and sometimes solar. While the detail calculation of the EDI could not be applied in the context of this research, it was significant to note the indicators used and applied in discussing the energy situation at the micro rural level of the study. The minimum indicators at the household and community levels could be applied at the level of the study.

ii. ***Total Energy Access - Proposed Minimum requirements***

The Practical Action PPEO (2012) proposes the minimum requirements set in Table 2-2 for Total Energy Access (TEA) based on studies on people’s experiences and collated data at household, project, national and international levels. Total Energy Access[14] is energy access defined at point of use and in all its dimensions. It is hailed as a practical tool for measuring the status and progress of energy access at the household level. In the recent review of the TEA, it is acknowledged that each household however also has to earn income and whether that takes place in the household, in a field, or in an office or workshop – that enterprise activity also needs energy. Finally, both households and enterprises exist within a community, which requires energy for shared services used by all, including schools, health centres, telecommunication networks, and street lighting. The proposal admits that the criteria in its application will be contextual but they will serve as good guidelines to access the status of households and communities, identify gaps, and track improvements. The schematic below - Figure 2-3 - illustrates the overlapping energy access units between the household, the enterprise and shared community services.

Table 2-1: Dimensions of Energy Access

Dimension	Potential Indicator	Strengths	Weaknesses
clean cooking	Percentage of households having an efficient stove that meets minimum requirements for indoor air quality	Directly measures the main issue relating to clean cooking facilities – indoor air quality	Data improving but still not sufficient. Requires regular surveys adopting common standard for minimum acceptable air quality.
	Percentage of households that cooks with modern fuels	Close to a direct measurement. Does not require an inventory of stove types.	Data improving but still not sufficient. Does not reflect use of improved cookstoves with traditional fuels.
	Percentage of income or expenditure spent on cooking fuels	It captures affordability and is an indication for how price changes will affect access	It does not capture gathering fuel wood. Requires regular expenditure surveying
electricity access	Percentage of households with access that meets minimum quality requirements	Measures multiple aspects of household electricity access situation	Data severely lacking and a common standard required for minimum quality
	Number of household electricity connections	Numbers can be updated annually, and help illustrate availability	Several cases were reported where connections do not equal effective electricity access. Also excludes illegal connections

Source: Adapted from IEA (2012:10) – World Energy Outlook: Energy Access Methodology

[14] The Poor People's Energy Outlook 2010 defines Total Energy Access through a series of minimum standards for access to the key energy services, which all people need, want, and have a right to (Practical Action, 2010; 2012)

Table 2-1: Dimensions of Energy Access (continued)

Dimension	Potential Indicator	Strengths	Weaknesses
energy for public services	Percentage of hospitals and schools with minimum level of electricity supply and percentage of villages with street lighting	Data could be gathered by relevant government ministries	Data not commonly collected at present. No common definition of minimum levels.
productive use	Percentage of businesses with equipment common for their sector that consumes modern energy	Ownership of modern equipment is a sign of using modern energy services	Such detailed data is uncommon, as is it normally only collected in business surveys
	Percentage of businesses with minimum quality of electricity supply	Potentially available from utilities or electricity regulator	Minimum requirements differ between businesses and not reported at present
	Percentage of farms with minimum availability of advanced mechanical power	Measures productive use of modern energy in an important sector	Not commonly reported at present and would need a definition for minimum availability
reliability of electricity supply	Average number of power outages per year and their average duration.	Potentially available from utilities or electricity regulator	Not commonly reported at present
	Expenditure (as percentage of household or company income) on back-up electricity generation	This will have a strong correlation with the reliability of electricity supply	It requires regular household expenditure and enterprise surveys, also rurally and in slums

Source: Adapted from IEA (2012:10) – World Energy Outlook: Energy Access Methodology

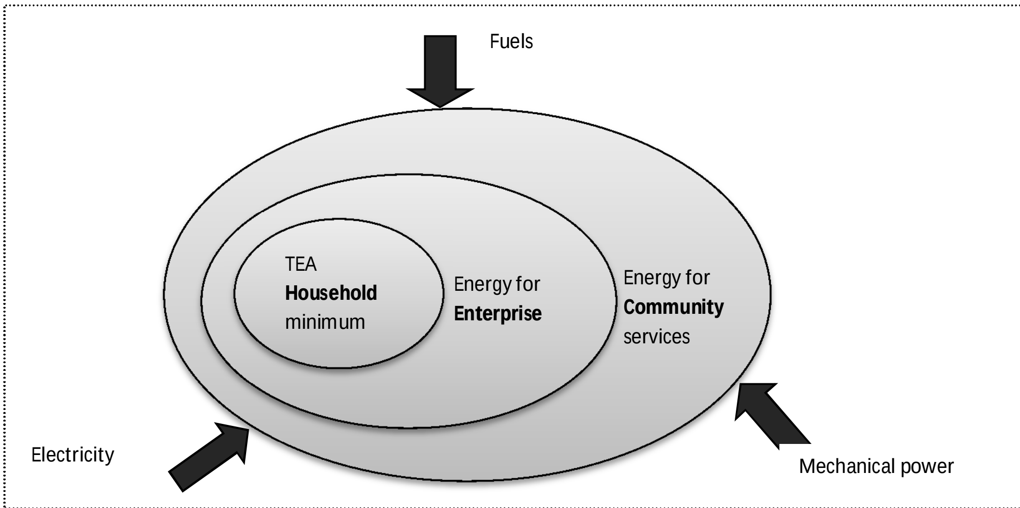


Figure 2-3: Total Energy Access
Source: Adapted from Practical Action, 2012

Table 2-2: Minimum standards for energy service

Energy service	Minimum standard
Lighting	• 300 lumens at household level • For electricity consumption, worldwide, a lifeline tariff of 50kWh is normally accepted**
Cooking and water heating	• 1kg woodfuel or 0.3kg charcoal or 0.04kg LPG or 0.2litres of kerosene or ethanol per person per day, taking less than 30 minutes per household per day to obtain • Minimum efficiency of improved wood and charcoal stoves to be 40 percent greater than a three-stone fire in terms of fuel use • Annual mean concentrations of particulate matter (PM2.5) < 10 µg/m3 in households, with interim goals of 15 µg/m3, 25 µg/m3 and 35 µg/m3
Space heating	• Minimum daytime indoor air temperature of 12 degrees
Cooling	• Food processors, retailers and households have facilities to extend life of perishable products by minimum of 50 percent over that allowed by ambient storage. • All health facilities have refrigeration adequate for the blood, vaccine and medicinal needs of local populations • Maximum indoor air temperature of 30 degrees
Information and communications	• People can communicate electronic information beyond the locality in which they live • People can access electronic media relevant to their lives and livelihoods
Earning a living	• Access to energy is sufficient for the start-up of any enterprise • The proportion of operating costs for energy consumption in energy-efficient enterprises is financially sustainable.

Source: Adapted from Practical Action, 2010; 2012/ ** Source: Government of Ghana and World Bank, 2004; AfDB, 2011

2.5.2 Affordability and Availability

Availability

Energy is considered to be *available* if the household is within the economic connection and supply range of the energy network or supplier (Brew-Hammond, 2010:2292) and when there is a technical possibility to use it (IEA, 2012).

Affordability

Very often, affordability is a critical issue for the rural populace regarding modern energy and energy services. Even when the first cost is overcome, the ability to maintain the service has financial implications which rural households often find difficult to overcome. Energy is *affordable* when the household is able to pay the up-front connection cost or the first cost, and the energy usage cost (Brew-Hammond, 2010:2292; IEA, 2012). Estache et al. (2002) quoted in Abdullah (2009:18), defines it as the actual ability of a household to pay for energy and related services, and is differentiated among affordability of access and affordability of consumption. Komives et al. (2005) quoted in AfDB (2011), suggests one measure: a threshold of five percent of total expenditure is often applied in determining the affordability of basic electricity services for poor households.

There is an interplay between accessibility, affordability and availability. In addition to the discussion on access, Ranjit and O'Sullivan (2002) quoted in Brew-Hammond (2010:2292) suggests that 'access' refers to a household's ability to obtain a modern energy service should it decide to do so. Following from this, Brew-Hammond (idem.) proposes that access is a function of availability and affordability (or rather from the other side of the equation, availability and affordability are integrals of access). There is a strong correlation between affordability and demand. Effective demand is defined as need backed by the ability to pay. Affordability in the generic terms is ability to pay. It can be inferred therefore in a simple equation that:

Need + Affordability = Demand

This can be translated to Marshall's (1890) law of demand which says that "the amount demanded increases with a fall in price, and diminishes with a rise in price". In the earlier discussion on decentralised options, Kaundinya et al., (2009) asserted that off-grid systems are demand-driven._This would be generalised for all range of DE options across the divergent energy needs that this research considers. The concept of demand-driven has its roots in the familiar economic concept of market *demand*. There is no clear cut definition for the 'demand-driven' phenomenon. However, a number of authors have attempted to define it according to the intended target, the purpose of *demand* and also according to the agent that is satisfying *demand*. Marshall (2006) defines demand as the amount a customer is willing to buy or the 'intensity of his eagerness to buy a certain amount'. Demand in this economic sense measures the strength of the desire and becomes efficient when the price a person is willing to offer reaches the level that others are willing to sell at (Franken, 2012). Klerkx et al. (2006:198) adds to the concept of demand by pointing to a second more substantive meaning. This meaning focuses on the interests of people in certain products or services and in the content of them. It also focuses on needs as an endogenous concept (Franken 2012). It can be expressed by preferences or priorities, which is basically about making a trade-off between different options by the demander (ibid.). For the purposes of this research, the Author relates more to 'demand' which is *substantive* and expressed as a *preference*, which does not simply follow the simple economic relationship between demand and supply. Following from that, Davis (2004) and Krohwinkel-Karlsson et al. (2008) both quoted in Franken (2012), relate demand-driven to community or user preferences respectively, where preferences are the expressed needs that are endogenous. Demand-driven means there is a need which is causing this demand. There must be a demand before an intervention can be demand-driven. This is iterated by Franken (2012, draft paper). Demand-driven will therefore be inferred as the demand and the preferences of target beneficiaries affecting an intervention.

2.5.3 The interplay of availability, affordability and access in energy supply in sub-Saharan Africa

In an AfDB (2011) cross-country analysis of energy access and income, the results showed a high correlation between access to modern energy and income quintiles in Africa, particularly within the Sub-Saharan Africa region. Almost 100 percent of the highest income quintile in Côte d'Ivoire, Namibia, South Africa, Ghana, Cameroon, Nigeria and Zimbabwe had access to electricity, whereas the two lowest quintiles had no access at all or only very limited access. A significant limited access of lower income groups in urban area led the study to conclude that affordability rather than physical access is an obstacle for this group. However, in the determination of energy development as proposed by the IEA, all these indicators are taken into consideration because there is an interaction between these factors. They are not considered exclusive but as components of a whole to determine energy development. This emphasises the case made by Abdullah (2009) and Estche et al. (2002) that affordability needs to be examined as a function of both access (physical) and of consumption. Physical access is clearly understood as the physical proximity of the energy: no specific minimum physical thresholds have been set or suggested by the various measures of accessibility reviewed with the exception of electricity standards set under the IEA-EDI which suggested a generic 'located nearby'. In Ghana, during an implementation of the so-called multifunctional platform (under the auspices of the United Nations Development Programme (UNDP)), the project set minimum distance to access grid electricity at eight kilometre. On the consumption hind sight, the important question will be the minimum threshold of prices that makes it accessible to all classes. Accessibility of consumption is therefore equivalent to affordability.

2.5.4 How these concepts apply in energy supply and demand in the Africa and Sub-Saharan African sub-region

Even when the infrastructure is in place and energy is available nearby, low income households are faced with pressing questions of affordability (Practical Action, 2012:81). The availability of an energy supply system either as grid electricity, LPG or kerosene distribution network, for example, does not guarantee universal access to energy services (ibid). In some countries, the proportion of communities electrified is much higher than the proportion of households connected (World Bank, 2010 quoted in Practical Action, 2012). A United Nations Industrial Development Organisation (UNIDO) study on electrification concluded that, 'it is not proximity to the power line but cost that constitutes the main factor excluding poor people from grid connection.' (UNIDO, 2010, quoted in Practical Action, 2012). In a Poverty and Social Impact Assessment (PSIA) study in Ghana by the World Bank and Government of Ghana (2004), similar conclusions were drawn where the rural electrification programme - the Self Help Electrification Programme (SHEP) - was as effective as electrifying communities but not households. In another World Bank Energy Sector Management Assistance Programme (ESMAP) study in Ghana (ESMAP, 2006; KITE 2005), almost 50 percent of respondents of the survey indicated that they are not using electricity even though the grid distributions lines are available to them because of the high cost associated with its use. Similarly, even though 65 percent of respondents preferred LPG as cooking energy, 50 percent of all respondents will not use it because it is too expensive. As Practical Action (2012) puts it, poverty remains the main barrier to energy access for the billions who currently lack adequate access; yet, lack of access to energy services is a barrier to poverty reduction.

In the Sub-Saharan African region, the phenomenon persists. Studies show that affordability and access are predominantly low among groups that are already disadvantaged. On the average, low-income households spend a higher share of their income to satisfy their energy needs than high income groups, while at the other end of the income continuum, high income groups tend to have a higher rate of access to modern energy and related services. Thus according to an AfDB (2011) report, people relying on traditional energy sources pay a higher share of their income to fulfil their energy needs than people relying on modern energy. If non-monetary activities in the fuelwood gathering process such as the time spent and the physical effort were monetised, the cost for traditional fuels will even be higher. Although lower income groups do have a certain willingness to pay, the actual price of modern energy including fixed costs often exceeds their ability to pay (AfDB, 2011). Brew-Hammond (2010) adds that the increasing numbers of people relying on traditional biomass for cooking is linked directly to their per-capita incomes which are not expected to increase high enough for them to switch away from traditional biomass use. Modi et al., (2005) sited in AfDB (2011) reports that the unit cost of modern energy is almost the same as per unit cost of traditional fuels such as charcoal and wood. This further iterates a report by Edjekumhene, Amaka-Otchere, and Amissah-Arthur (2005) which showed that as traditional fuels are bought piecemeal-wise, the eventual cumulative cost per month is over and above the monthly cost of modern fuels such as liquefied petroleum gas (LPG). The difficulty for poor households however remains that they are unable to cover the first cost; then again, they earn subsistent incomes sometimes on a day-to-day basis and therefore will purchase energy as and when they need it. Again, in certain instances where modern energy services and access to modern energy especially in the electricity sector are subsidised, the subsidies often tend to fail to improve access for the poor and rather benefit higher income groups and those who already have access to electricity. The PSIA electricity sector report on Ghana showed that approximately half of those benefiting from the lifeline tariff bracket (i.e. consumption less than or equal to 50kWh) would not fall under the poverty line (Government of Ghana-World Bank, 2004). It was further observed that in the case of compound[15] houses, individual households which would have consumed less than or equal to 50KWh per month rather fell within higher tariff band and paid higher tariff rates. This is because compound houses used shared meters. On shared meters, the cumulative consumption exceeded the 50KWh lifeline tariff band. On the other hand, individual households up the income ladder who were able to manage their consumption well ended up benefiting from this subsidy. Another angle to the discussion is that since availability and affordability are interrelated, if a government decided to maintain energy prices below costs with a view to making energy more affordable to the poorest households, it might actually reduce the availability of energy as the utility providers might consider it unprofitable to extend coverage to areas where the poor reside (Brew-Hammond, 2010).

In summary, accessibility, availability and affordability - the 3As, as the Author likes to term these - are phenomenal in identifying alternatives to improve energy. Various measures of accessibility are identified even though the research does not seek out to

[15] 'Compound house' is a typical housing phenomenon in the high-density urban areas in Ghana, where different households or families live in different sections of the same house. The phenomenon is similar to apartments but in this case there are many shared facilities particularly with regards to utility areas. Compound houses typically share electric meters. As rural areas grow, the same phenomenon is gradually infiltrating the originally communal household system.

measures these indices because they were designed to be applied at the country level. However, the indicators and variables provide a basis for examining the situation within the study context and to make appropriate recommendations where necessary. In the discussion on accessibility, an energy and appliance ladder was indicated. Contrary to previous assertion on kerosene as a form of modern energy, there seem to be a significant omission of kerosene in this discussion of the energy ladder. With regards to affordability, a paradox seems to be at play. Despite the generally agreed assertion that energy poverty affects socio-economic development of energy poor rural areas, poverty also affects the accessibility to energy even when the options are available. There is a cyclical process here that needs to be intervened at a certain point.

2.5.5 Possible scenarios for improving affordability

In spite of the affordability challenge, it is evident that as Practical Action puts it, even though poverty remains the main barrier to energy access for the billions who currently lack adequate access, lack of access to energy services is a barrier to poverty reduction. It may be necessary therefore to go beyond numbers, that is, the cost involved, to anticipating the potential economic returns that are possible when the financial barrier is removed. The following are suggested scenarios that could improve financial resources available to the rural poor and improve affordability. These consist of both internal initiatives that could be taken by the rural households themselves, and external interventions by the state and/or investor.

i. Through government interventions in the form of subsidies,
ii. Through local initiatives such as the formation of farmer cooperatives, and applying for financial assistant based on the stronger front and the leverage created with that front,
iii. As initiative of local financial institutions and investors while adopting business models that combines pro-poverty with financial profitability, and
iv. Ensuring that energy interventions are linked to the economic structure of the localities so that the economic activities of households are vibrantly engaged to sustain demand for energy.

2.6 Theoretical discourse

2.6.1 Bottom of the pyramid

The theory of the Bottom of the Pyramid (BOP) propounded by C.K. Prahalad (2005) attempts to help solve the puzzle of identifying and understanding the type of 'market' the rural consumers are. This theoretical concept is helpful in examining the preconditions for energy demand and supply in the rural area. Prahalad identifies the market at the bottom of the pyramid as people surviving on less than USD2 per day, who are classified to be living below the poverty line. The BOP as originally presented by the theory applies generally to the poor in developing regions which includes the urban poor. Prahalad (2005) says that *the poor are resilient and creative entrepreneurs and value-conscious consumers who themselves present a huge market and also cause innovations, products,* *services and business models*. He argues that the lenses through which we perceive the world are often coloured by our own ideologies and experiences, and in the case of organisations, the established management practices. Thus in the delivery of services to the poor, benefactors are often prisoners of their own socialisation. He terms this perception as the Dominant Logic (idem., p.6) which could also be explained as *inherent*[16] assumptions. Generally, the dominant logic of the benefactor refuses to appreciate a vibrant market at the BOP. Historically, the range of benefactors ranging from governments to aid agencies, Non-Governmental Organisations (NGOs), large firms, and the business sector have reached the implicit agreement that market-based solutions cannot lead to poverty reduction and economic development for the poor. Thus, their common logic restricts their ability to see market opportunities at the BOP. However, Prahalad argues strongly that there is good market at the bottom of the pyramid. To understand and check the extent of applicability of the theory, it is necessary to examine the nature of the BOP market to effectively observe the occurrence of this nature in the cases to be studied. A number of these are examined.

- The purchasing power of the BOP lies in their numbers: there is the assumption that the poor does not have the purchasing power when assessed against the backdrop of earning of less than USD2 per day. Nonetheless, the poor with their numbers are able to out-buy what individual 'rich' persons can buy with their fewness. The other aspect of this market is the poverty penalty[17] they eventually end up paying which could be many times what the rich are paying.
- The poor are very brand conscious and are also extremely value-conscious by necessity. They are value buyers who expect great quality at prices they can afford.
- Contrary to the popular view, the BOP consumers are getting connected and networked. They are rapidly exploiting the benefits of information networks. In addition, the word of mouth characteristic of the poor is a very potent force for assessing product quality, prices and options available.
- The BOP consumers accept advanced technology readily contrary to popular belief.

<u>Creating a market out of the BOP - the market development imperative:</u>

Market development at the base of the pyramid creates an opportunity to enhance the economic situation of deprived people on the one hand and to expand the consumer market of companies on the other hand (Prahalad, 2004 quoted in Amadu, 2012). Prahalad maintains that the BOP needs to be converted into a market through market development. In the process however, it is necessary to identify the incentives for the BOP to participate. He proposes four principles: (i) create the capacity to consume, (ii) identify the need for new goods and services, (iii) enable dignity and choice, and (iv) trust is a prerequisite.

[16] Author's own meaning and emphasis

[17] The poverty penalty is universal although the magnitude differs by country. It is a result of local monopolies, inadequate access, poor distribution, and strong traditional intermediaries (Prahalad, 2007).

i. The market at the bottom of the pyramid can be activated by creating the capacity to consume which in most cases translates into low-cost, high-quality products and access to credit (p.116). In the words of Michael Klein (the Chief Executive of Casas Bahia, whose enterprise was one of the main cases studied in the development of this theory) quoted in Prahalad (2005), creating a *market "is all about fulfilling the customer's dream…".* By creating the capacity to consume, benefactors must move beyond philanthropy which has been the practice for providing for the poor. The logic is that, while the rich use cash to inventory convenience, the poor have unpredictable incomes streams. Many subsist on daily wages and have to use cash conservatively. He propounds that creating the capacity to consume is based on three simple principles best describes as the Three 'As', that is, *affordability* without sacrificing quality or efficacy; *access* considering both distribution patterns for products or service as well as distance; and *availability* (and distribution efficiency) as the BOP's decision to buy is based on cash they have at hand at a given point in time; they cannot differ buying decisions.

   The issues of *affordability, access,* and *availability* have earlier been raised as phenomenal issues in addressing energy poverty and energy access. The appearance of the 3As again as a pre-requisite for creating the capacity to consume emphasises their fundamental importance.

ii. The BOP provides the opportunity for the development of new goods and services. By implication, these include innovative options in technology. Since the BOP is not mainstream market, other options for the provision of the same service must be found.

iii. This crop of consumers should also acquire a sense of dignity and the option to choose. Dignity is acquired when the BOP sees itself as a subject of importance or consideration by producers. In effect, they feel part of the "group" - they feel part of the country. Furthermore, the consumer has choices between options when a number of producers are producing for the BOP market. This promotes further innovation and upgrade.

iv. Prahalad posits further that trust is a pre-requisite. In his explanation, he asserts that both large firms and the BOP consumers have traditionally not trusted each other. Trust, he says, is difficult to build after many years of suspicion and prejudice based on little evidence and strong stereotyping.

Products and services for the BOP

Another important consideration for the BOP is in the design of products and services. In the design of products and services for the BOP, the feature-function utility is important because products and services designed for the developed market often fail in the BOP markets due to inappropriate utility. Therefore, innovations should be created in the products or services. Prahalad suggests a number of principles that should guide the creation of innovations for the BOP. This section basically addresses the BOP from the supply side. For analytical purposes, this review will consider only those that are applicable to the context of the study:

i. Focus on price performance of products and services, that is, it is not about lowering prices but about altering the price-performance envelope. By implication, the price should be packaged so that the payment schedule is comfortable for the market. Lower prices should by no means indicate low quality, because the BOP is value-conscious. Although the margin per unit might be low, investor interest in BOP markets is based on expectations of a large-volume, low-risk and high return-on-capital invested in the business opportunity.

ii. Feature and function - Product development must start from a deep understanding of the functionality and not just the form. The needs of consumers of the BOP market might not be obvious either to the firm or even to the consumers themselves. This will require the investor investing more into gaining this understanding. Product developers must also focus on the broad architecture of the system so that new features can be easily incorporated.

iii. Innovations: Prahalad further posits that the BOP requires "solutions", that is, the BOP market opportunity cannot be satisfied by watered-down versions of traditional technological solutions from the developed markets. BOP markets can become a source of innovations for the well developed markets as well. The BOP markets can and must be addressed by advanced technologies creatively combined with existing (and evolving) infrastructure. This helps in making the innovations scalable.

iv. Solutions must be scalable – given the stringent price-performance equation and low margins per unit, the basis for returns on investment is volume. From the demand side, the more scalable the more likely the greater extent of consumers that may be reached.

Significance of the theory to the study

This theory is applicable to this study because one of the definitions of poverty here is 'a daily subsistence of less than USD2 (Prahalad 2005: xii, p.29). This economic group comprises the Bottom of the Pyramid. In Ghana, poverty levels are identified as living below 1USD a day. The fifth round of the Ghana Living Standard Survey (GLSS 5) (Ghana Statistical Service 2008:94-96) shows that the average annual per capita expenditure of Ghana is GHS644[18] which translates to USD592[19]. Of course, there are high disparities between the different income quintiles with the highest income quintile having an average per capita expenditure of USD1, 261 and the lowest quintile, an annual average of GHS132. Between the country's administrative Regions, again relatively high disparities

[18] GHS – Ghana cedis, the Ghanaian currency
[19] At the time of the GLSS 5 survey, the Ghana cedi-US dollar exchange rate was 1:0.92 (Ghana Statistical Service, 2008)

occur. It is important to note that, in developing countries, per capita expenditure is normally approximated for per capita income as people are more cognisant of their expenditure patterns than of their income patterns, and are more inclined to give information on them. The two Regions of the study – the Upper East and the Brong Ahafo Regions have average annual per capita expenditure of 229GHS and 514GHS which translates to 211USD and 473GHS per day per capita, respectively. It is normally the case that rural expenditures (and in that case, incomes) are lower than their urban counterparts. Therefore, the rural communities which are being studied will be further disadvantaged. Consequently, the GLSS 5 on the rural-urban disparities and also across ecological zones shows that generally, the average annual per capita expenditure for the rural localities is GHS458 (421USD), but that of the Savannah ecological zone is 303GHS (279USD), translating further to 0.76USD per capita per day. The study District in the Brong Ahafo Region lies in the transitional zone between the forest ecological and the Savannah ecological zones. The rural forest zone has a per capita annual average expenditure of GHS505. This is equivalent to 1.27USD per capita per day.

Evidently, the income range of the cases being studied falls within the income range as defined by the Bottom of the Pyramid. The setting of the theory is India. Nevertheless, the tenets of the concept are applicable to the host of developing countries. The economic pyramid which forms the basis of the discussion of this theory is based on an analysis of incomes across the globe and therefore the various wedges of the pyramid are globally representative. In relation to the study context, the key issues being discussed are energy access (accessibility), demand, affordability, and decentralised options based on the study assumption that local energy resources have spatial locational advantages for deprived hinterland energy poor populations. The purpose of the Bottom of the Pyramid concept is to illustrate the fact that the very poor represent a set of *value-conscious* consumers. To illustrate the relationship between the main facets of this theory and the key issues of the study, the following questions are considered: how do the issues of accessibility, affordability and value affect the demand decision making for decentralised options? Is value-consciousness a pre-condition to demand? Prahalad also raises the issue of partnering with the BOP to find innovative measure. The following questions are provoked with regards to identifying decentralised energy options - to what extend have feasibility studies been useful? And what is the extent of involvement of the people in pursuit of solutions? Do the people themselves know and appreciate the resources available to them?

2.6.2 Disruptive technologies

The choice of technology is one way to make energy more affordable. The adoption of low-cost technologies at the design or planning stage can reduce investment costs by 20-30 per cent without affecting the quality of energy services (World Bank, 2010). The theory of Disruptive Technology is propounded by Clayton Christensen (1997). This theory supports the theory of Bottom of the Pyramid by Prahalad (2005) and offers a deeper depth from the perspective of technological innovations and development. It comes in full circle to point again to the market at the base of the pyramid and how these technologies find traction with this market due to a certain value identified by this market, even though unacceptable to the main conventional market. The components of the theory of Disruptive Technology can be summarised in a quote by Amadu (2012) that, *"new technologies typically enter the marketplace with a functionality level that is much lower than what incumbents in the marketplace are providing, and therefore tend not to appeal to the bigger or more affluent customers, but are very appealing to low-end customers who are more value conscious".* Even though Christensen presents this phenomenon from the technological point of view using numerous technological examples to make his case, he is quick to mention nonetheless that the Disruptive Technology extend beyond engineering and manufacturing to encompass a range of marketing, investment and managerial processes. This study will also adapt this theory to the development of decentralised energy technologies. Christensen defines *technology* to mean the processes by which an organisation transforms labour, capital, material and information into products and services of greater value. He defines *innovation* as a change in the *technology*. In this study, innovations will mean emerging *concepts* or *options.*

Key tenets of the concept applicable to study

Disruptive technologies get attracted to new customers because the development of disruptive technologies involves moving from the conventional to innovation, and markets for these technologies are not the conventional markets but rather emerging or the 'insignificant' markets. Disruptive technologies also bring to a market a very different value proposition which was previously not available (ibid., p. xv). Intrinsically, mainstream markets have certain value network[20]. Value networks strongly define and delimit what companies within them can and cannot do. From the demand side, value networks present the kind of value that customers demand of a product or service. These are customer group specific and must be clearly identified to serve this group best. The value Disruptive Technologies (DT) present appears unprofitable, unimportant and unacceptable and less than what the incumbent markets want. On the other hand, they offer a 'different package of attributes values in emerging market' (ibid., p.15). From the supply side, the context or value network in which a firm competes has profound influence on its ability to marshal or focus the necessary resources and capabilities to overcome the technological and organisational hurdles that impede innovation (idem., pp.53-54). The extent to which an innovation addresses the 'well-understood' needs of its value network is fundamental to the innovation's success.

The development of DTs also require isolation, that is, separating the implementation (including the physical implementation) of DT initiative from the mainstream company to have maximum impact to prevent the management of the mainstream unit from undermining the management of the new innovative initiative. The supply side implication of "value disposition" is closely related to this (idem, pp.199-202). The resulting products are typically cheaper, simpler, smaller and frequently more

[20] Value networks are defined as the contexts within which a firm operates - within which a firm identifies and responds to customers' needs, solve problems, procure input, react to competitors and strives for profit (Christensen, 1997:32, 54).

convenient to use. In addition, also mentioned in Prahalad (2007:23), where features and functionality are inappropriate, it becomes unacceptable to the emerging market. Christensen also asserts that in the normal unrestricted market (as against the restricted market – the rural market – of the study), the basis of competition and therefore the basis of customers' choice often evolves from functionality to reliability, then to convenience and ultimately to price (Christensen, 1997: 172). In the rural setting though where affordability is an important issue, will the sequence be the same? Will price not be considered first?

Against rational investments, the theory also asserts that for established companies, investing aggressively in DT is not a rational financial decision because – (i) disruptive products are simpler and cheaper, and they offer low profit margins; (ii) they are typically the first of the particular product commercialised in the emerging or insignificant market; and (iii) the conventional profitable customers usually do not want and initially cannot use the products. Most companies find an economic rationality in listening to their best customers and developing new products that promise greater profitability with this segment of customers. Based on this logic, they are rarely able to make a case for investing into DTs until it is too late. Then again, managing innovation mirrors the resource allocation process. Innovative proposal that get the funding and manpower they require may succeed, those given lower priority whether formally or de facto will starve for lack of resources and have little chance of success. In addition, the capabilities of most organisations are far more specialised and context-specific than most managers are inclined to believe; new markets enabled by DT require different capacities and capabilities from organisation. These capacities should be shaped by the different value network.

In conclusion, the theory of Disruptive Technologies correlates well with Prahalad's theory of the Bottom of the Pyramid. In retrospect, Prahalad seem to be advocating for the demand side while Christensen advocates for the supply side. Both theories however acknowledge their other side which is supposed to activate a complete market. Consequently, two important elements – value, and feature and functionality – appear and are emphasised in both theories. One key departure from the theory is that, according to the theory and its interpretation, disruptive technologies will eventually compete with mainstream products for the same markets and they will gradually but forcefully penetrate and take over the market. This will not be the focus for this study. The focus will however be on how new and simpler technologies present a value and functionality which serves best an insignificant but huge market. The theory also asserts that in the normal unrestricted market (as against the restricted market – the rural market – of the study), the basis of competition and therefore the basis of customers' choice often evolves from functionality to reliability, then to convenience and ultimately to price (Christensen, 1997: 172). In the rural setting though where affordability is an important issue, the research will be interested in knowing if the sequence will be the same and if price will not be considered first.

2.6.3 Rural social system

The purpose of examining this theory was to identify how the rural social system influenced household decision-making on adopting decentralised energy systems, as a precondition affecting implementation. Not much discussion and literature is found specifically on the rural social system. However, the work of Talcott Parsons which is accredited a major contribution to the theory of social systems was borrowed. Talcott Parsons is a structural functionalist who asserts that there are different system levels that interact with each other to build the structure of a society. These are the cultural system, the behavioural organism (the individual) as a system, the personality system, and the social system. All four levels are interrelated, dependent on each other, and interact with each other at some level (Parsons, 1991:3). For the purposes of the research, the social system will however be emphasised with brief clarification on the other systems to set the context of understanding. Parsons suggests that to understand the cultural system "meanings" are the units of measure and not the people. Cultural systems are the common values, beliefs, and tastes of the interacting actors (Parsons and Shils, 2008). Thus, the meaning a culture gives to different attributes such as language, morals, and values are context specific. Meanings help to socialise individuals into societies and hold societies together. For the behavioural system, the biological component, i.e. the physical environment and the physical body, is analysed. The personality system and the social system are closely linked. In the personality system, the individual is used as the unit of measurement. In the case of the social system, the roles individuals play and their interactions are the units of measurements. The social system is therefore made up of actions of individuals (Parsons and Shils, 2008:190). The actions which constitute the social system are also the same actions which make up the personality system of the individual actors. These actions are based on personal needs, motivation and attitudes, and certain beliefs about others and ourselves. The two systems are however, analytically discrete entities, despite this identity of their basic components (Parsons and Shills, 2008:190). Furthermore, individuals gravitate towards self-gratification and personal profit maximisation (idem.). The social system therefore is defined by Parsons and Shils (2008:195) as a system of interaction of a plurality of actors in which the action is oriented by rules which are complexes of complementary expectations concerning roles and sanctions. It is essentially a network of interactive relationships (Parsons, 1991:32). In a situation which has at least a physical or environmental aspect, actors who are motivated in terms of a tendency to the "optimisation of gratification" and whose relation to their situations including each other, is defined and mediated in terms of a system of culturally structured and shared symbols (Parsons, 1991:3). The interactions are based on expectations people have of each other during the role play. The role is the point of contact between the system of action of the individual actor and the social system (ibid., p.190). In a social system, roles vary in the degree of their institutionalisation. Parsons defines institutionalisation as the integration of the complementary role-expectation and sanction patterns with a generalised value system common to the members of the more inclusive collectivity, of which the system of complementary role-actions may be a part (ibid., p.191). Those who share common value-orientations as commitments to action patterns in roles constitute a collectivity (ibid., p. 194). By implication, from the interaction, there is a certain level of understanding between the two or more people involved, who complement each other, and there are certain shared behaviours. Parsons and Shils (2008) further asserts in the Theory of Action that there is voluntaristic part of action which implies a conscious mind, that makes choices and capable of making decisions. By implication, actors may voluntarily conform to social norms and values, or rather to be deviants. A third point that is of interest to this study is how territoriality and location (Loomis and Beegle, 1950) also referred to as the physical location and environment by Parsons (1991) in his description of the behavioural system also affects decision-making. By implication, where an actor lives influences how an actor behaves, and therefore the meanings an actor allocates to attributes. In essence, cultural systems are closely associated with territoriality and location. It was important to understand the extent to which different settings and geographical orientations affected the acceptance of different decentralised energy alternatives in the planning of an effective approach.

2.6.4 Institutions

In every set of human interactions, certain institutions exist. The theory of institutional economics propounded by Douglass North is useful in understanding these institutions, the actors and the role they play in the demand and supply of decentralised energy options. North (1989) defines institutions as the rules of the game; they are humanly devised constraints that structure political, economic and social interactions (idem.; North, 1991). According to him, the major role of institutions in a society is to reduce uncertainty by establishing a stable though not necessarily an efficient structure to human exchange (North, 1991). Therefore as institutions evolve, so are the options available to man altered. However, while formal rules can be changed overnight, the informal norms change only gradually (North, undated), so that that institutional change is incremental and path-dependent reflecting ongoing ubiquitous evolving perceptions (North, 1989). He explains this as being a result of how informal constraints are embedded in societies. This finds traction with the cultural systems as explained by Parsons (1991). North further suggests that institutions are the underlying determinants of the long-run performance of economies (North, 1989:107). Thus in every system of exchange, economic actors have an incentive to invest their time, resources, and energy in knowledge and skills that will improve their material status (idem.). The path dependent nature of economic change is a consequence of the increasing returns characteristic of an institutional framework. Moreover, institutions and standard constraints of economics determine the opportunities in a society (Journal of Economic Perspectives, North, 1991:97). In the context of the study, this may be related to the economic laws persisting in the rural communities, districts, as well as financial institutions which operate in the communities or the districts, i.e. the extent to which the rural households themselves are constrained or allowed by their individual economic situations, the rural economic environment and how that may shape what they determine as opportunities and consequently their economic choices and preferences. By implication, when institutions do not evolve, economies do not grow productively. North (1991) further asserts that institutions provide the incentive structure of an economy, so that as that structure evolves, it shapes the direction of economic change towards growth, stagnation, or decline.

On the other hand, organisations operationalise institutions; they are the players and the agents of institutional change. They are created with purposive intent in consequence of the opportunity set resulting from the existing set of constraints which are themselves the institutions (rules) and in the process attempts to accomplish their objectives as major agents of change. So then, the direction and form of economic activity by individuals and organisations reflect the opportunities thrown up by the basic institutional framework of customs and formal rules (and the effectiveness of enforcement) (North, 1991: xx) as well as the formal constraints of economic theory. This in essence applies to energy trade particularly in the traditional energy supply system. Furthermore, North (1991), in his description of an institutional evolution that occurred in Early Modern Europe, observed that an essential part of the institutional evolution entailed a shackling of the arbitrary behaviour of the state over economic activity. Investor confidence in statutory enabling environment is important. By implication, this may be fundamental for investment into decentralised and alternative energy options which is dominated by the private sector.

The theory is relevant for myriad of institutions and organisations both formal and informal that are identified in this research: These are (i) the rural social system and changing rural perceptions, (ii) the traditional energy supply system, (iii) the role of microfinance institutions and private investment, and (iv) the role of the local and central governments in the promotion of decentralised energy systems. Of interest is to examine the type of institutional change needed, if necessary, to promote decentralised options.

2.6.5 Economic growth and development

The essence of this section is to draw clear lines as to what socio-economic development means for a rural economy, and thereafter, identify how decentralised energy is able to influence this development. Every economy has capital and consumer needs, and investments target one or the other or both of these needs depending on the goal of the economy. An economy's choice of how much to invest in capital and consumer goods will determine how fast future growth will be. Following from this, energy needs of a rural economy may be broadly grouped under consumption (social development) and production (economic growth) energy needs. The consumption needs are derived from basic and domestic needs of cooking (feeding), lighting, water and room heating, health, education, street lighting, and other community needs. On the other hand, production energy needs will stem from livelihood needs of income, job creation and investments. While as the description imply, consumption needs take away from the economy, production needs when satisfied, give to the economy and sustains the economy. An energy supply system requires sufficient demand to keep the system functioning, and demand as earlier discussed (See section 2.5.2) implies, need combined with the ability to pay. Production, ceteris paribus, ensures the means to create effective demand. Thus, production energy needs sustain an energy system by production energy demand and by creating possible demand for consumption energy needs.

Economic development as a development phenomenon came into play when it became clear after the 1970's that the development theories of neo-classical economists and Keynesian school of thought of economic rationality failed. The whole concept of economic development was re-assessed. Economics began to be viewed in a broader perspective and was re-defined in terms of reduction or elimination of poverty, inequality and unemployment within a growing economy. A number of schools have expressed thoughts on the phenomenon and have put forth various suggestions. Adelman and Yeldan (2000) in Mutascu and Vlad (2011) suggest that economic development should entail: (i) self-sustaining growth; (ii) structural changes in patterns of production; (iii) technological upgrading; (iv) social, political, and institutional modernisation; and (v) augmentation of social human conditions. Todaro and Smith (2009) consider economic development in terms of the reduction or elimination of poverty, inequality and unemployment within the context of a growing economy. Economic development has three objectives, that is, to increase the availability and widen the distribution of basic life-sustaining goods such as food, shelter, health and protection; to raise levels of living including higher incomes, the provision of more jobs, better education, and greater attention to cultural and human values. It is expected that all of these will serve not only to enhance material well-being but also to generate greater individual and national self-esteem, and to expand the range of economic and social choices available to individuals and nations by freeing them from servitude and dependence in relation to ignorance (Todaro and Smith, 2011:22). An exposition borrowed from Amartya Sen's Capability Approach provides a phenomenal explanation to the concept of development. Sen is accorded one of the best writers on the meaning of 'development'. One of the key points which finds traction with the discussion on the role of decentralised energy in economic development is what he refers to as "functionings". Sen argues that the important thing for well-being is not just the characteristics of the commodities consumed as in the utility approach but rather, what use the consumer can and does make of commodities. Hence, the use of the commodity to the users is the most critical beyond having the commodity. The concept of "functionings" forms the basis of argument for energy development in the past few decades where much emphasis is put on energy services rather than the energy source itself. This links back to the idea of feature and functionality advanced by both Prahalad (2005) and Christensen (1997). If development must be considered in terms of the role of energy in development, then this condition must be fulfilled. So then what energy can make people do – how productive the people can be with energy, the ease in carrying out domestic obligations with energy, how easy learning can be undertaken, and what ease it brings in the administration of health services on the one hand, and access to health services on the other hand, are examples of what an energy development model could target. More often than not, there is much excitement about providing energy (from the supply side) and having energy (on the demand side) than what this energy form brings to the people. When social status, or in a broader sense, community status, are the motivating factors for having some form of energy, then essence of development is probably defeated. In a similar vein, where the social argument for the provision of energy is so strong that implementers overlook how the system will be sustained, then the catalysing effect on the broader sense of development might be lost. Furthermore, it is necessary to factor in community specific commodity (energy) requirements in planning energy development.

The growth aspect of economic development

Todaro and Smith (2011) identify three important components of economic growth. These are capital accumulation, growth in population and therefore the eventual growth in labour force, and technological[21] progress defined as the new ways of accomplishing tasks. Capital accumulation and technological progress have implications for energy development. *Capital accumulation* occurs when a proportion of present income is saved and invested to augment future output or income. It includes all new investments in land, equipment, as well as human resources (health, education and job skills). It implies increasing an economy's capital stock of real capital which is the net investment in fixed assets. These include new factories, machinery, equipment and materials. These are direct productive investments which must be supplemented by investment in the socio-economic infrastructure such as roads, energy, water and communication, in order to facilitate and integrate economic activities. There are also less direct productive investments such as the installation of irrigation systems which could improve the quality of agriculture by raising the productivity per unit of land. That is, if irrigation could double the output per unit of land to the equivalence of twice what the non-irrigated unit can produce, then the irrigated land is equivalent to doubling the quantity of a non-irrigated land. By implication, an energy input that enables irrigation of farmland would have achieved the same results as doubling the size of non-irrigated land. Again, investment in human resources can improve the quality of the human resource and resulting in greater productivity similar to an increase in human numbers. *Technological progress* is defined as increased application of new scientific knowledge in the form of inventions and innovations with regards to both physical and human capital. Even though the sources of economic progress can be traced to a variety of factors, technological progress is considered by most economists as the most important source of economic growth. It can be in the form of very simple innovations that improves routine small scale production activities. Three types of technological progress may be identified – neutral, labour-saving, and capital saving. Neutral technological progress occurs when higher output levels are achieved with the same quantity and combinations of all factor inputs. A neutral technological change that doubles output is equivalent to doubling all input factors. Neutral innovation can be as simple as division of labour which can result in higher output levels. The resulting production possibility frontier[22] (PPF) is similar to doubling the two factor inputs. When technological progress results in the saving of either labour or capital, it is referred to as labour-saving technological progress or capital-saving technological

[21] Christensen (1997) defines *Technology* as the processes by which an organisation transforms labour, capital, material and information into products and services of greater value.

[22] The production possibility frontier (PPF) allows the analysis of production choices open to an economy, to understand the output and the opportunity cost implication of idle or underutilised resources, and to portray the effects on economic growth of increased resource supplies and improved technologies of production (Todaro, 2011: 145).

progress respectively. Labour-saving technological progress occurs when for the same labour input, output is increased because of the introduction of some form of technology such as mechanical ploughs among others. Capital-saving technological progress is nonetheless a rare occurrence. On the other hand, when the quality or skills of labour force are upgraded through technology, it is referred to as labour-augmenting technological progress. In a like manner, when there is an increasing productive use of capital goods due to a technological progress, it is referred to as capital-augmenting technological progress. In the context of the study, decentralised energy is identified as a technological progress which can be labour-saving, capital-saving, labour augmenting or capital.

Endogenous development

A number of regional development theories have been developed over the past four decades to address rural development. These include agropolitan development proposed by John Friedmann (1978) and the integrated rural development approach promoted by the then Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ, currently GIZ)(Diaw, 1994), rural territorial development concept by the GIZ (2012), and the endogenous development theory. By agropolitan development, John Friedmann suggests the use of a region's resources for the benefits of its population, the development of an integrated and diversified agro-industrial economy geared toward its needs, the decentralisation of planning and decision-making, grass roots participation, and cooperative action at the local level. The integrated rural development approach is an off-shoot of the agropolitan development approach. Even though these development paradigms push for a bottom-up development which is desirable, it is based on the autonomy of regional development objectives. This does not suit the aim of this work which anticipates a strong involvement and investment by the Central Government in the rural communities and districts. The regional territorial development approach also places much emphasis on institutions. It focuses on three levels of institutional development: a) the national level, where legal frameworks are provided to create the "enabling environment" and administers financial funds, b) the meso-level (regional), where public policy is coordinated and decentralisation efforts are implemented, and c) the micro-level (district, municipal and community), where the actual management of natural resources takes place and where participation of local people must be ensured. The meso-level which is regional administrative level, among the three institutional levels identified by this development approach is of crucial importance in this development concept. While institutional development is necessary in promoting energy access at the rural level, this level however is de-emphasised for this research due to the redundant role played by the Regional Coordinating Councils in local development in Ghana. Although all these regional theories addresses the issue of economic growth and development, the Author identifies the endogenous development theory to be better suited for the objectives of this research.
The endogenous development theory provides more perspectives on local potentials for economic growth. It focuses on localities and their resources, territoriality and the participation of all necessary actors as a more effective way to animate robust

development (Oduro-Ofori, 2011). The key characteristics of endogenous development which are relevant to the study are:

a. *Territoriality* – the territoriality of development goes beyond physical territories where resources are located and where economic activities are expected to function, to recognising the territory itself as agent of transformation as various actors interact to develop that economy
b. *Exploitation of local potentials* – As Todaro and Smith (2011:91) put it, the problems of poverty, inequality, low productivity in both agriculture and industry, imbalances in economic opportunities, and unemployment have domestic potential solutions. The starting point for the development of a local area are the resources in the form of economic, human, institutional and cultural which constitute its major potential for development (Vazquez-Barquero (2002) cited in Oduro-Ofori, 2011). Diaw (1994) suggests that endogenous potentials create a logic for an area's own development in the following ways:
    - Linkages with other communities: there are a number of possible linkages with other communities spanning social, economic, and administrative, among others. Focusing on the economic linkage, the exogenous relationship between communities and other communities in its peripheries and the rest of the administrative district and beyond can result in intense interactions that promote economic growth. The role of energy in the interaction can be observed in how energy can serve as catalyst for the interactions and how energy itself can be uncovered as a local potential that could be developed to play this catalytic role. In the process of this interaction however, Brugger (1986) quoted in Diaw (1994) cautions that smaller economic areas with high levels of potential, as a rule, could have their destinies determined to a high degree by outsiders. Again, the kind and character of the linkages is also affected by the geographical and socio-economic disposition of the area (community) under consideration. Moreover, different development areas evoke different forms of productivity and therefore different forms of linkages. Decentralised energy as a catalyst will be effective when applied to specific and respective economic development potentials of targeted developing areas.

    - Small-scale enterprise employment: the use of endogenous potential promotes an increase in small-scale enterprises. Small-scale enterprise development and employment, and spatial efficiency in distribution economies are justifications for seeking out and introducing decentralised energy systems. As Practical Action (2012) puts it, (poor) communities are able to escape poverty when they have sustainable energy access to grow large or small enterprises. The effect of energy on the rural economy cuts across agriculture, industries, and service or commercial activities.

The link between endogenous development and the idea of decentralised energy options

The communities under study are rural and mainly agrarian communities. Agriculture is more likely to serve as the main leverage for growth and development in these communities. From the forgone discussion, the development process of any given economy must look at starting from within. Holistic development approaches are desired and development must embrace human capital, technological as well as institutional changes if long-term economic growth (production) will be realised. Energy development can well serve a needed technological development. The argument may hold that if the necessary technology is not available and in this case decentralised energy, two conditions may prevail – the communities might suffer extensive postharvest loses due to the absence of technology for postharvest processing and preservation and therefore negatively affect their growth, or there could be an appreciable propensity that middle women and men [a typical market phenomenon in Ghana] operating as exogenous factors could siphon the potentials of the local economies to their own economies, developing and creating growth there at the expense of the origin. Studies on rural-urban economic linkages in Ghana have shown this as a typical occurrence.

The whole concept of decentralised energy options fits it into the endogenous development framework. Decentralised energy (DE) options consider the respective energy resource potentials of respective communities and develop energy according to the resources. Thus the features of the locality, the physical boundaries and local resource potentials are featured here. It may be further inferred that the economic functions of DE options can only be realised when it targets specifically the economic opportunities of the community in question. That also means that the modelling of a DE options, when it aims at improving economic development, should also consider the kind of economic activities that are possible within the community and the DE should be modelled to suit that purpose. For example, a multifunctional platform (MFP)[23] with a cassava-processing unit cannot be modelled for a community in the Upper East Region where no cassava is produced. In a like manner, an MFP with a rice de-husking unit will be absurd in a community in the rain forest. Along the same line of thought, this may also imply that DE options have standard models which can be adapted within respective territorial units.

Energy needs for rural economic growth

Practical Action (2012: ix) argues that poor people are able to escape poverty when they have sustainable energy access to grow large or small enterprises. Income earning and productive activities in the rural areas could span small enterprise activities which may be home-based to cottage industrial activities, or agricultural activities. Energy needs for these are fuels, electricity and mechanical energy. In consonance with the tenets of local economic development, Practical Action (op. cit.) identifies that the impact of energy

[23] A multifunctional platform (MFP) consists of an energy source comprising of a diesel engine mounted on a chassis which powers a variety of end-use equipment such as grinding mills, de-huskers, battery chargers, and water pumps (KITE, 2007).

access on livelihoods may be achieved through one of the following mechanisms: (i) creating new earning opportunities not possible without energy access; (ii) improving existing earning activities in terms of returns by increasing productivity, lowering costs, and improving the quality of goods and services; and (iii) reducing opportunity costs, reducing drudgery, and releasing time to enable new earning activities. To explore these three mechanisms and the steps connecting energy access with economic growth (and development), four principal ways in which poor people earn a living are suggested (idem.). These are earning off the land, running a micro or small enterprise (MSE), getting a job, and – on the supply side of the energy access system – earning from supplying energy. Households are often involved in one or more of these livelihood activities and therefore there is often an overlap between household energy needs and livelihood activity energy needs (ibid.). Practical Action further stresses that energy access alone is not a guarantee of an improved livelihood; rather reliability, quality, and cost of energy supplies are critical success factors to enterprises (when coupled with access to markets, social networks, and a business proposition that has sufficient demand). However, to enhance analysis, this categorisation has been made in order to see how energy interacts with the earning opportunities that are available to (poor) rural people. Furthermore, energy access did not automatically create any of these outcomes, and that there were a series of steps between energy access having been created, and impacts on earnings and development outcomes. From the supply side of the energy access system, earning a living from the supply of energy is itself is asserted to be a huge opportunity in a context where so many are underserved.

From the discussion above, it may be inferred that energy plays a significant role in the social development and economic growth of a rural economy. While supporting and promoting social needs of rural communities, decentralised energy is able to augment the livelihoods of rural households in agriculture, in small scale enterprises, and from the supply of energy itself. Undoubtedly, where the energy factor which in this context is seen as the main catalysing factor is not found within the territorial limits of the developing area, then as the theory of Endogenous Development suggests, the rural system is not closed to exogenous linkages – the energy factor may be imported. Most essentially, it is expected that the energy form introduced will be self-sustaining and will initiate, generate, and sustain livelihoods.

2.7 Conceptual framework

The forgone theoretical constructs and the emerging concepts of affordability, accessibility, and availability discussed, together with the decentralised energy phenomena within the rural context being studied were brought together in a conceptual framework which defined the limit for empirical data collection and analysis. This is presented in Figure 2-4.

Three main frames are shown in the Conceptual Framework – consumer frame, a decision-making frame and a supply frame. These three represent two main processes: a decision-making process and a market process. The two processes amalgamate into one big process with a left-right flow. The details are explained as follows.

The first frame depicts a rural locality with potential consumers, whose demand is promoted by their economic development and economic growth goals. By virtue of the economic condition as well as the geographical location of these potential consumers, they are classified within the Bottom of the (economic) Pyramid (BOP). They have specific energy needs spanning domestic (i.e. cooking, heating, and lighting), and economic (i.e. enterprise or productive use) and community energy services. The key characteristics of this market are value consciousness, low incomes and potential high demand. These needs are translated to demand. In the second frame, household energy demand decision in a rural locality is influenced by affordability, availability and the accessibility to the energy product or service. In addition, there are other competing needs for the same limited resources of the decision maker apart from energy (for example education, remittance, livelihood activities, etc.). The interaction between the two frames produces the *demand side* of the market. It is important to note that the energy needs will remain energy needs and will not be translated into demand if the conditions at the decision making state are not met. Demand becomes effective when a consumer with a need offers a price at which others are willing to sell.

To address the demand, the complementary theories of Prahalad (2005) and Christensen (1997) can be operationalised. The BOP market are said to be poor, resilient and value-conscious consumers who themselves present a huge market and allows opportunities for innovations, products, services and new business models. Therefore, in order to meet their energy demand, it is required that potential suppliers drop their dominant logic and access this demand potential. The supply framework proposed by Christensen's Disruptive Technology concept suggests that for emerging markets such as the BOP, products that innovative, affordable (cheaper), simpler, more convenient to use and present features and functionality which meets that value requirements of this group of consumers are most appropriate. Within the context of study, these are Decentralised Energy options (DE). The study will not restrict these options to only tangible products but will include business models of implementation and sustainability where necessary. It is assumed that the supply side will consist both of the private and public sectors.

The market operates within a broad framework of government policies and interventions such as subsidies, supporting regulatory frameworks, private sector enablement policies, energy development programmes and projects, and technological developments. These will have strong impact on the market model particularly on the supply side. Government policies also include the policies and the lobbying skills of the District Assembly at the local level. The entire core framework will operate within a set of external factors (pre-conditions) such as the global and multi-national energy policies and agreements and the world economic situations such as changes in oil prices, and the investment will of external private investors.

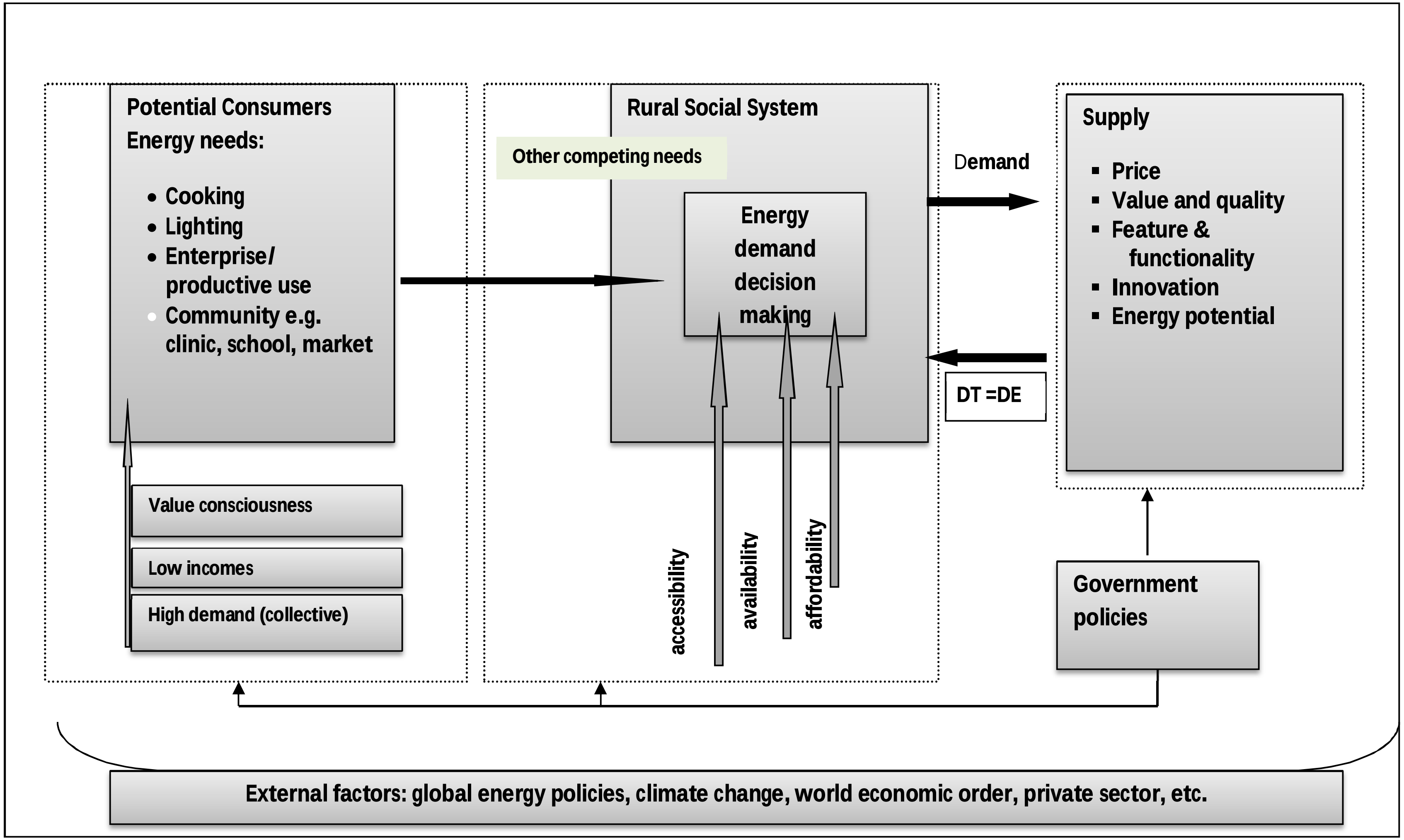


Figure 2-4: Conceptual Framework
Source: Author's construct, 2012

Legend to the conceptual framework (Figure 2-4)

Symbol	Meaning
Thick grey shaded arrow	A characteristic
Thick black shaded arrow	An input or result
Thin connecting lines and arrows	Linkage
Dotted boarder lines	Boarders of specific frames
DT	Disruptive technologies
DE	Decentralised energy options

3 RESEARCH PROCESS AND METHODOLOGY

3.1 Research design - type of research, design and reasons, philosophical worldview, research methods

A research design is the framework or plan for a study, used as a guide to collect and analyse data (Churchill (Jr.), 2010). The design ensures that the study will be relevant to the problem (ibid.) and the objectives. Another school of thought defines it as a plan that guides the investigator in the process of collecting, analysing and interpreting observations. It is a logical model of proof that allows the researcher to draw inferences concerning causal relations among the variables under investigation (Nachmais & Nachmais, (1992) sited in Yin (2009)).This research adopted a multi-design method that combined both qualitative and quantitative methods and techniques in almost equal intensities using the case study approach. This design allowed the collection of complementary data, the conduct of counterpart analysis (Yin, 2009:63), and triangulation. More importantly, the two methods engaged complemented each other and their embedded weaknesses were compensated for. The combination gave the advantage of access to richer and strong array of evidence (Yin, op cit.). De Vaus (2001) iterates that a well-designed case study will avoid examining just some of the constituent elements. It builds up a picture of the case by taking into consideration information that will be gained from many levels, which one element of the whole cannot present. In this study, the qualitative method was engaged to gather data from both international and national experts and from key informants of different categories from national level to the community level, to obtain detailed household data in an attempt to understand key processes in the household decision-making, demands and preferences, and was used to guide field observations. The quantitative aspect involved household survey and other specific technical inquisitions such as economic activity survey and to obtain technical information from specific departments such as the Agriculture and Veterinary Departments of the District Assemblies. The results were intended to be generalised for issues arising and for similar physical and contextual settings.

3.2 Philosophical worldview - pragmatic

The research adopted a pragmatic worldview to understanding the problem and in the analysis of the data gathered. This worldview is pluralistic and allows the researcher to use all approaches necessary, and in this case, a combination of quantitative and qualitative methods to understand the key issues under investigation (Creswell, 2009). The worldview is not committed to any one system of philosophy and reality and allows the researcher to look at the ‘what’ and ‘how’ questions based on intended consequences. It also allows the researcher to undertake the investigation from all contexts which may be applicable, viz, social, historical, political, cultural, etc., contexts (ibid.). In general, this worldview fits more appropriately for a mixed-method research as in the case of this study.

3.2.1 Case study approach

Rationale for selecting the case study approach

Case study is a strategy of inquiry in which a researcher explores in depth a program, event, activity, process, or one or more individuals (Creswell, 2009). It is bounded by time and activity, and detailed information is collected using a variety of data collection procedures over a sustained period of time (ibid.). It is an empirical enquiry that investigates a contemporary phenomenon (Yin, 2009:11) in depth and within its real-life context (Yin, 1993; Inkoom, 1999) especially when the boundaries between phenomenon and context are not clearly evident. The method is also appropriate when the investigator desires to cover contextual or complex multivariate conditions and not just isolated variables, and relies on multiple and not singular sources of evidence (Yin, 2003: xi) as in the case of this study. Poor energy access in rural regions of developing countries and in Ghana for that matter, is a contemporary development issue which draws global attention and which requires considering a range of perspectives and disciplines, cutting across finance, socio-cultural, economics, politics, and environment among others, to be addressed. The rural context itself is an inter-marriage of numerous processes and complex variables which do not allow such phenomenon to be easily understood either with numbers alone or with stories alone. In this case, the case-study approach was seen as more appropriate to use. The study approach also allowed for the direct observation of events being studied in addition to interviewing of the persons involved. Even though the field instruments were designed before the actual field study, during data collection, the types of instrument or methods of collection were altered when it was necessary to obtain the data needed. Again, the case study approach was adopted because the research questions investigated consisted mainly of 'what'- questions which were in this case exploratory providing insights (Yin, 2009:10; Churchill et al., 2010:60).

Concluding and generalising from the case study

While the contextualisation of aspects of the case strengthens this form of research, it is difficult to know where 'context' begins and ends. Subsequently, case studies have the problem of generalising beyond the case as against pure survey research. Yin (2009) however suggests that analytic generalisation is possible beyond the case. The same is referred to as theoretical generalisation by Mitchell (1983) (quoted in Bryman, 2012). The critical thing here is the quality of theoretical reasoning which the case study researcher engages (Bryman, 2012:71). Similar to experiments where generalisation is made based on multiple set of experiments, multiple-case studies are generalisable to theoretical propositions and not to populations. This study adopts this multiple-case studies approach to make the generalisation stronger. Three different Districts, representing three different cases in two different ecological zones were studied.

Type of case and case study design

This study is a representative or typical case. With this kind of study, the aim is to capture the circumstances and conditions of an everyday commonplace situation as suggested by Bryman (2012:70) and Yin (2009:48) because it exemplifies a broader category of which it is a member, or it provides a suitable context for certain research questions to be answered (Bryman, op.cit.). The selected rural areas are typical cases representing the Guinea-Savannah and the Transitional ecological zones of Ghana. They exhibit similar characteristics of typical rural areas in Ghana. Moreover, the conditions of the Savannah communities to a large extent give a general picture of a larger proportion of energy-deprived areas in Sub-Saharan Africa. This research was also a multiple-case study research. Multiple-case study research has the advantage of its evidence being more compelling and therefore expected to be more robust. The study was undertaken in two extensive ecological zones in Ghana and covered three rural Districts. Two of the three rural Districts investigated were selected in the same ecological zone to predict similar results, that is, literal replication (Yin, 2009:54), and one District was selected in a different ecological zone for limited comparison to predict contrasting results satisfying the demands of a theoretical replication (op. cit.).

3.3 Unit of analysis

One school of thought attempts to define the unit of analysis in the reverse way, indicating that it is called unit of analysis because it is the analysis a researcher does that determines what the unit is. It is the major entity being analysed in the study. The unit of analysis has critical significance in doing case studies (Yin, 2003:114) and serves later as the means for generalising the findings of the case study to similar cases that focuses on the same unit of analysis (ibid.). Again Yin notes as a general guide, that the tentative definition of the unit of analysis is related to the way research questions are defined (Yin, 2009:30). From the study's research questions, two levels of unit of analysis are defined - the rural district as the larger unit of analysis, and the household as the sub-unit.

3.4 Research process

The study involved a number of eclectic processes and followed the schematic presented in Figure 3-1. The study began with a research idea which the Author attempted to frame into a topic, subjected to further modification and reviews as the study progressed. The research idea was informed by the Author's personal professional experiences and literature in the field of energy. The idea was conceptualised through a more detail review of literature and through discussion with experts within the field of study to fine tune the idea to one that was contemporary and useful. It was also necessary to relate the research to a larger ongoing dialogue in the field. Research questions were formulated which were further reviewed and refined through literature review. Through literature, key issues relevant to the topic and in consonance with the research questions were identified. Furthermore, theories were identified to investigate these issues and to assign a limit to their discussion, from which a conceptual framework was developed. In attempt to fully understand the implications of the research questions, the questions were further broken down into indicators and specific variables that were to address these indicators. In Appendix III, a matrix attempting to coordinate research questions, their indicators and variables, means of verification, data collection method and data collection tools was drawn.

The field study commenced with key informant interviews of the responsible agencies both public and private, as well as the responsible officers of the District Assemblies to set the tone of the survey. A pre-testing of the community instruments was undertaken in a neutral rural community, Drobonso, in the Sekyere Afram Plains District in the Ashanti Region. This helped to sharpen the instruments and the parameters being investigated with local significance. Community study involved quantitative household surveys, in-depth interviews, community key informant interviews, economic activities interviews, and energy source and resource inventory. Data was analysed using a combined set of quantitative and qualitative measurements; on the field, memos were written consistently which helped to define categories for the qualitative part of the research. Key informant interviews were transcribed, and household survey data were analysed using the Statistical Programme for Social Sciences (SPSS) to derive inferential and descriptive statistics and all other statistics that were relevant to bringing out the required meanings. Data triangulation was a key aspect during the analysis as data from community survey were triangulated among themselves and also triangulated with key informant interviews as and when necessary. Findings were synthesised with theory and the conceptual framework. The analytical framework took into consideration the four principles of good case study analysis (Yin, 2009:161) – giving attention to all evidence, limiting rival theories, addressing the most significant aspect of the research, and employing prior expert knowledge. Conclusions and recommendations for practice, policy, and theory were made based on these.

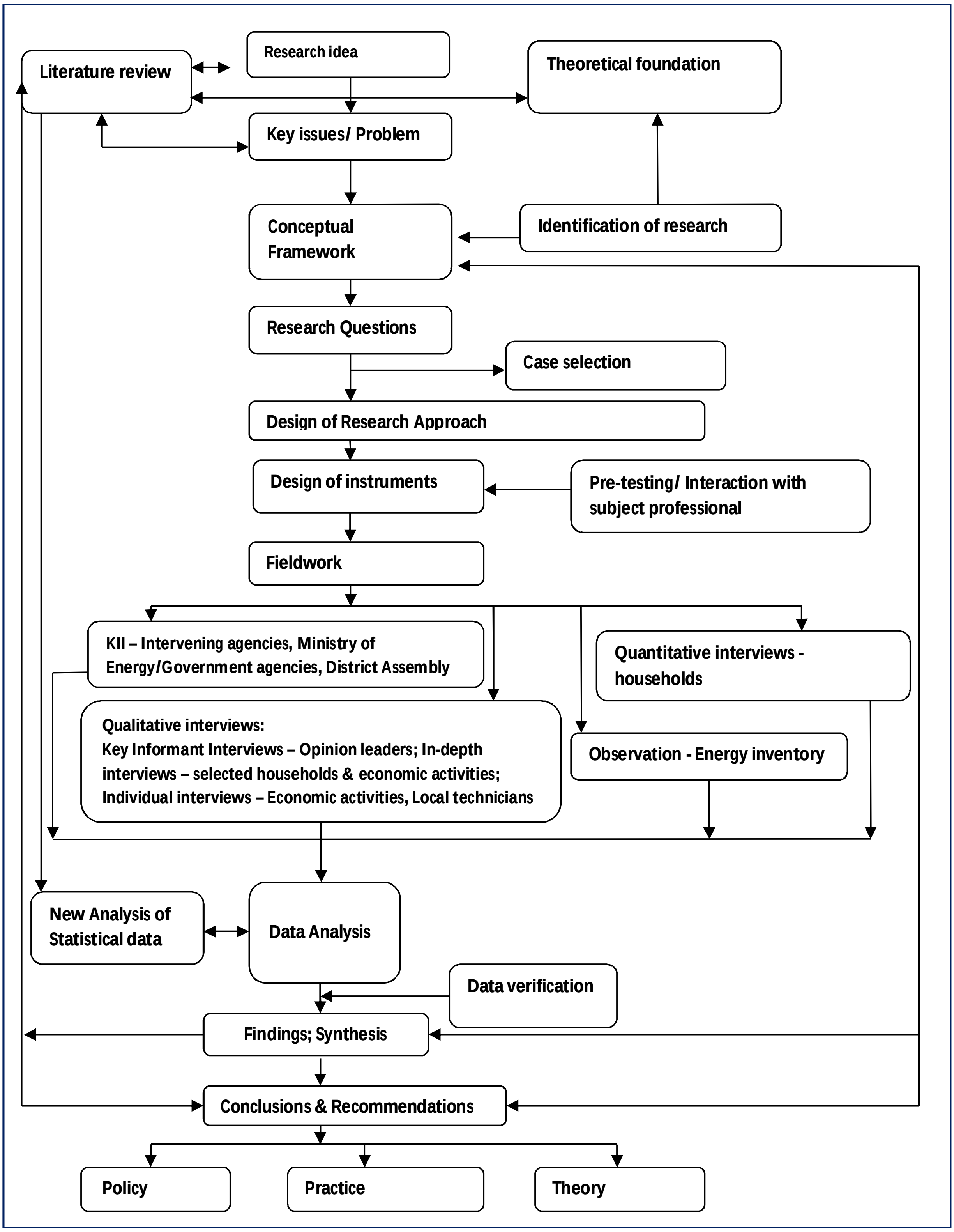


Figure 3-1: The Research Process

Source: Author's construct, 2012

3.5 Research design and quality

The research adopted a multi-design method that combined both qualitative and quantitative methods in almost equal intensities to address the different aspects of the research, using a case study approach. The qualitative method was employed to gather data from key informants, obtain detail household data, and also to assist in observation to be able to understand certain key processes in the household decision-making, demand and preferences, and identify energy resources and potentials. The results were intended to be generalised for issues arising and for similar physical and contextual settings. Case studies have been marked to have challenges of generalising beyond the case as opposed to survey research. However, it is still possible to do theoretical generalisation beyond the case (Yin, 1993; 2009). Ocloo (2011:89) iterates that the case study approach has its protocols for quality which a user has to follow in order to come up with well-grounded findings; the research has to subject itself to tests. The research design should show a logical relationship between the various components of the research and mechanisms incorporated for testing trustworthiness, credibility, “confirmability” and data dependability (Yin, 1994). To be able to overcome these challenges, the tests of replicability, reliability, validity, and triangulation were adhered to.

Replicability

Data for the quantitative aspect of the research which is the household survey was collected through universal standards of data collection and analysed using statistical procedures. Data was collected using a well-defined survey instrument, a questionnaire developed by the researcher, which fitted responses into predetermined response categories (Appendix IV). This can be used for a similar research on the same issues in the future. On the other hand, for the qualitative aspects as suggested by Miles and Huberman (1994:2), methods of analysis are not clearly pre-formulated. The extent to which qualitative research is replicable is a matter of concern that fits it as a scientific research or otherwise. Thus interviews were guided by predetermined themes which allowed for flexibility for the emergence of new themes. Memos were also written consistently to help the researcher later remember the emerging lines of thoughts and to develop new categories and new themes when it became necessary.

Reliability

A research is said to be reliable when in spite of the researcher’s own eccentricities and perspectives, similar conclusions could be drawn by another researcher given the same data. This is necessary to affirm the scientific nature of the qualitative aspect of the research. To address this issue, data was triangulated within methods, between methods, within cases, and between cases. Aspects of the same issues under investigation were investigated through community in-depth interviews, during household survey and in key informant interviews. In addition, on the field, data was verified and proofed at the end of each day and where necessary, methods or tools were altered to obtain the data needed. Pre-testing at the beginning of the research also helped to sift out questions that conflicted or were ambiguous. Rapport with community elders in this case was established for future data clarification where data gaps were detected or where even after triangulation, issues remained unclear. Understanding the issues being investigated by the respondents was also of prime importance to the researcher. The Research Assistants were amply trained. Pseudo research assistants from the communities first of all served as respondents and much time was devoted in getting their understanding of the concepts being studied. This was to make sure they relayed similar understanding to the other respondents during interviews. Where language barriers existed, the researcher found assistants who understood the local language of the community as well as the local language of the researcher ('Twi') or spoke English. A few of the household interviews and their interpretations were recorded and given to a reliable neutral person to translate as a way of cross-checking for consistency. Memos were also drafted on the field to document first impressions which were also checked and re-checked on the field, and also checked for similarities and conflicting results from the questionnaire. Through the memos too, important issues which were not covered in the instruments were quickly identified and addressed on the field. In addition to these field processes, the research process has been carefully documented and described, and data collection methods have been explained. Data sources as well as contact details of informants have also been well documented.

Validity

Construct validity

Construct validity concerns itself with the extent to which the research actually measures what it set out to measure and consider all the issues that should be considered in researching into the topic (Ocloo, 2011:89). Blaxter et al. (2006:74) cautions that the disadvantages of case studies are linked to their advantages, and in particular, while contextualisation of the aspects of the case is a strength for this form of research, it is difficult to know where 'context' begins and ends. To address this, certain theoretical foundations were established prior to field work to set the research in theoretical limits and to tailor the key issues of investigation to be in consonance with these foundations so that even though the phenomenon studied – decentralised energy options – could be studied from diverse disciplines, this study limited it to a socio-economic study. Again the phenomenon had numerous linkages cutting across social, economic, technical, technological, political, and global perspectives among others. These were given certain limitations within a theoretical and conceptual framework to guide the research.

External validity

Transferability and generalisation often depend on the context and the sample size. A purely quantitative approach is able to address this issue as sample sizes are normally huge. In the case of mixed method case study approach where the quantitative component is limited, the issue of generalisation beyond the scope and context of the study require careful consideration. To ensure that sufficient generalisation could be made, the selection of the Districts was carefully done using a set of criteria (See Chapter 3.6). A multiple-case study approach was used to help provide enough evidence for generalisation. The findings of the study were also crossed-checked with existing literature.

Triangulation

Developing converging lines of inquiry from multiple sources of evidence is likely to make study findings or conclusion more convincing and accurate. Data triangulation encourages the collection of information from multiple sources aimed at corroborating the same phenomenon (Yin, 2009; Creswell, 2009; Bryman, 2012). This addresses issues of construct validity and strongly recommended for the case study approach to research. The study employed both quantitative and qualitative methods in data collection. Particularly at the community and household level, it was important to understand the issues being investigated from different perspectives. A number of issues were discussed both at the household level and at the community level – types of energy resources in the community and District, patterns of energy use, the system functioning of the community especially with regards to decision-making and specifically energy decision-making. Similarly, community information obtained at the District Administration through interviews and document reviews were compared with what was either observed in the communities or obtained through interviews within the community. These included patterns of energy use, connectivity to the grid or otherwise, proximity to the grid, opportunities for productive uses of energy, technical backstopping and the financial support landscape. Diverging views were further verified. The same applied regarding interviews on specific issues with key informants both within the public and the private sectors, that is, the Ministry and agencies responsible for energy and private alternative energy investors both at the country level and at the administrative regional levels of the country.

3.6 Selection of the settlements

The research was undertaken in three rural Districts: two Districts in the Upper East Region which falls in the Guinea Savannah ecological zone, and one District in the Brong Ahafo Region which lies within the Transitional ecological zone which is an ecological transition between the wet semi-equatorial and tropical savannah climate regions. The ecological zones were purposively selected. These Districts were selected because the characteristics of both ecological zones are close representation of the general picture of a larger proportion of energy-deprived Sub-Saharan African and that is important for analytical generalisation; the two Districts in the Guinea Savannah allowed for literal replication, while the District in the Transitional zone allowed for limited comparison to predict contrasting results, that is a theoretical replication. Specifically, the Districts and their communities were selected based on the following criteria:

- rural districts in the Guinea Savannah ecological zones, preferred administrative region of study being the Upper East Region: the characteristics of the rural districts and the communities present a good prototype for other Sub-Saharan energy poor regions;

- a rural district in the Transitional ecological zone that exhibits similar levels of rurality but with forest characteristic for comparison and a basis for limited cross-case analysis: preferred administrative region was the Brong Ahafo Region;
- have a drawback in economic and social development;
- generally energy deficient and poor;
- the District is, or falls within a zone characterised by previous programmes to promote decentralised or some form of alternative energy - to be able to identify respondents who had the at one time used some form of decentralised energy system to enable an assessment of acceptability, adaptability and the decision-making process;
- settlements in the District are widely scattered and present a challenge for centralised energy supply;
- the District should be identified with at least one alternative energy resource;
- the communities are fairly accessible;
- access to respondents was important because the period of data collection was the rainy season. Since target respondents were more likely to be farmers, it was necessary to find farming communities where farmers could be reached. Particularly in the Upper East Region, preference was given to Districts where households farmed around housing compounds over Districts such as the Garu-Tempane District where farmlands were in the 'bush', as the natives described it.

Based on the above criteria, the Builsa and Kassena-Nankena East Districts were selected in Upper East Region. Communities were selected across both Districts respectively in order to have a fairly good representation of the Districts. At the time of the research, the Ghana Energy Development and Access Project (GEDAP) off-grid electrification solar project was being implemented in a number of remote communities. Both the Builsa and the Kassena-Nankana East Districts were beneficiaries of this project. Notably, not all households were able to access the facility. This provided a good basis for the survey. In the Brong Ahafo Region, in addition to satisfying the conditions above, the Atebubu-Amantin District was purposively selected because it lies more within the wet semi-equatorial ecological zone of the Region. The communities selected were in the south-eastern corridor of the Aebubu-Amantin District. Some communities in this corridor were beneficiaries of the Ghana Multifunctional Platform Programme which consisted in the deployment and installation of the multifunctional platforms which are decentralised energy systems.

3.6.1 Sampling

For the household survey, the selection of households employed a combination of stratified random sampling, simple random sampling as well as purposive sampling techniques. Stratified sampling was used in Districts where clear lines of heterogeneity existed. Bryman (2012:192) suggests that stratified sampling is employed when the population can be grouped by criterion and it is easy to identify the strata. The Kassena-Nankana East and Builsa Districts are made of different ethnic groups. These respective ethnic groups are also closely located within physical boundaries. In the Districts, they could also be identified by their cardinal locations in the District. After taking a list of the communities from the District Assemblies, the communities were grouped under ethnic stratification and then were randomly selected. In addition, lists of communities who were involved in the GEDAP off-grid electrification project were also obtained from the project officers from both Districts. Again, in the selection of communities, it was preferable to engage more communities to obtain a fairly good representation of the Districts [even though the populations of the individual communities were not too large], than to undertake census of a few communities. This was because, it was noted that communities within the same corridor of the Districts exhibited significantly different perspectives on issues and sometimes exhibited vast differences in their development levels, and in their cultural and traditional values. The final selection of communities was done comparing the re-grouped communities with the project community list. After that, simple random sampling was applied in the selection of households. Simple random sampling is a sampling process where each unit of the population has an equal chance of being included (Bryman, 2012). Even though random numbers were not generated for the sampling process, a proportionate spread within the communities was sought as much as possible. This was also influenced by the situation on the field: houses and households were widely scattered due to the agricultural practice of farming around housing compounds. In cases where different densities were identified in the communities, that was also taken into consideration. Transect walks in the communities were done to determine this. The transect walks gave visual impressions of the communities allowing the researcher to map out the communities; guestimations of densities in the communities were made. Community facilities and resources were also identified. The physical sketches of the communities were discussed with opinion leaders and at least one member of community to confirm or correct. In the Upper East Region, the land sizes of communities were physically large but houses were few and sparsely populated which gave additional advantage in carrying out the exercise. Through this, physical proportions could be guestimated into figures to give proportions of strata. These then formed the basis for simple random sampling among strata. The sampling among strata was hence unequal but proportional. In the Atebubu-Amantin District, as earlier stated, the communities in the south-eastern corridor of the District were purposively selected. Transect walks were also carried out in these communities. The communities themselves were transected by feeder roads. It was necessary therefore to ensure a good spread of sample households from both sides of the communities and avoid concentrating the sample on one side of the communities. Simple random sampling was then employed in the selection of households.

Given the population of the communities, the households were sampled using the following formula:

$n=N/(1+(N*10\%^2))$, where n = sample size, N= the population

In all 199 households were interviewed. For in-depth household interviews, non-probability sampling methods were applied. Quota sampling method was used to select 20 percent of households. The percentage allocated was based on time, saturation, and the need to avoid respondents fatigue and boredom to be able to illicit as much information as needed. Again, even though the interviews were guided, it involved longer discussions and in some cases, game-play. Thus, the fewer the number of interviews, the better it was to engage both interviewers and respondents. Households that had had previous experiences or were using decentralised energy systems at the time of the field study were of interest and were identified through snowball sampling from other households interviewed. This was due to the fact that these households were few and scattered. The quota allocated was intended to be equally distributed among the two cases of respondents who had previous DE experience and those who had not, to be able to have a balance view on issues from both sides. However, even though the sampled communities were indicated to communities where the GEDAP off-grid electrification was being implemented, the number of households which had adopted the DE system at the time of the field study were quite few and did not reflect the presumed rate of penetration and the impression given by stakeholders involved in the implementation of the project. There were households who claimed they had not heard about it. Consequently, on the field, the proportional sampling approach had to be adjusted so that respondents were selected non-proportionally, with a target to reach at least one-third of respondents who had previous DE adoption experience. In all, 40 households were interviewed in the ratio of 31:9 in favour of those who did not have previous experience of using a DE.

In the case of the other community interviews, respondents were purposively selected. These were community opinion leader interviews, economic activity interviews, energy producers and distributors' interviews, and individual interviews of technically oriented persons. In some cases, snowball sampling was necessary to identify respondents. In the case of key informant interviews at the community, district and national levels, the initial key informants were purposively sampled and snowball sampling was used to identify the rest. The communities selected and the sample households interviewed are summarised in Table 3-1. The Districts and communities are described in the Chapter 3.7.

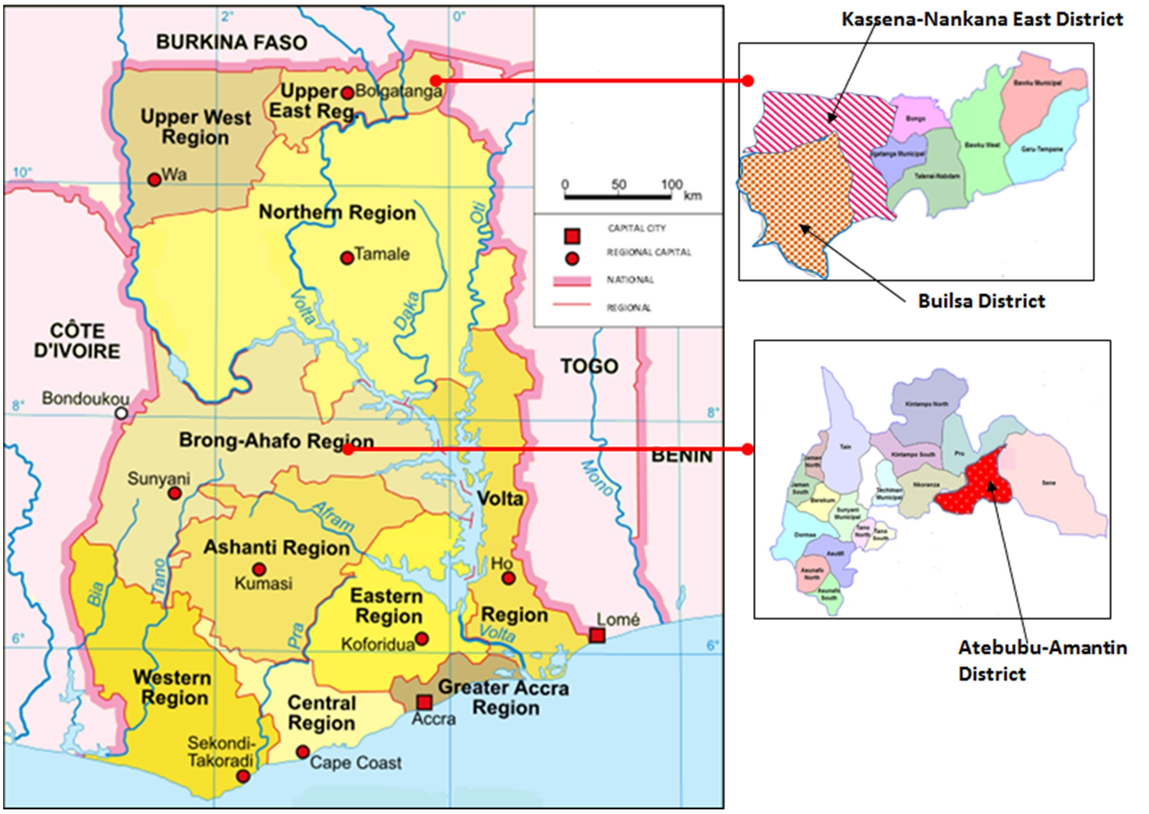
Table 3-1: List Settlements and questionnaire administered

Region	**Districts**	**Community**	**Number of households interviewed**
Upper East	Kassena-Nankana	Wuru	17
		Nagalikenia	17
		Atosaale	15
		Akudugu-Daboo	27
	Builsa	Kori-Alamyeri	22
		Kandema	15
		Balansa No. 1 and 2	12
Brong Ahafo	Atebubu-Amantin	Sabidi	27
		Fakwesi	23
		Kumfia	24
Total			**199**

Sources: Author's Field Survey, April-July 2012

3.7 Overview of study Districts - Builsa, Kassena-Nankana East, and Atebubu-Amantin Districts

The study was undertaken in the Builsa and Kassena-Nankana East Districts in the Upper East Region, and the Atebubu-Amantin District in the Brong Ahafo Region. Map 3-1 shows the geographical location of the study Districts in the national context.



Map 3-1: Study Districts in national context

Source: Modified based on internet maps [24]

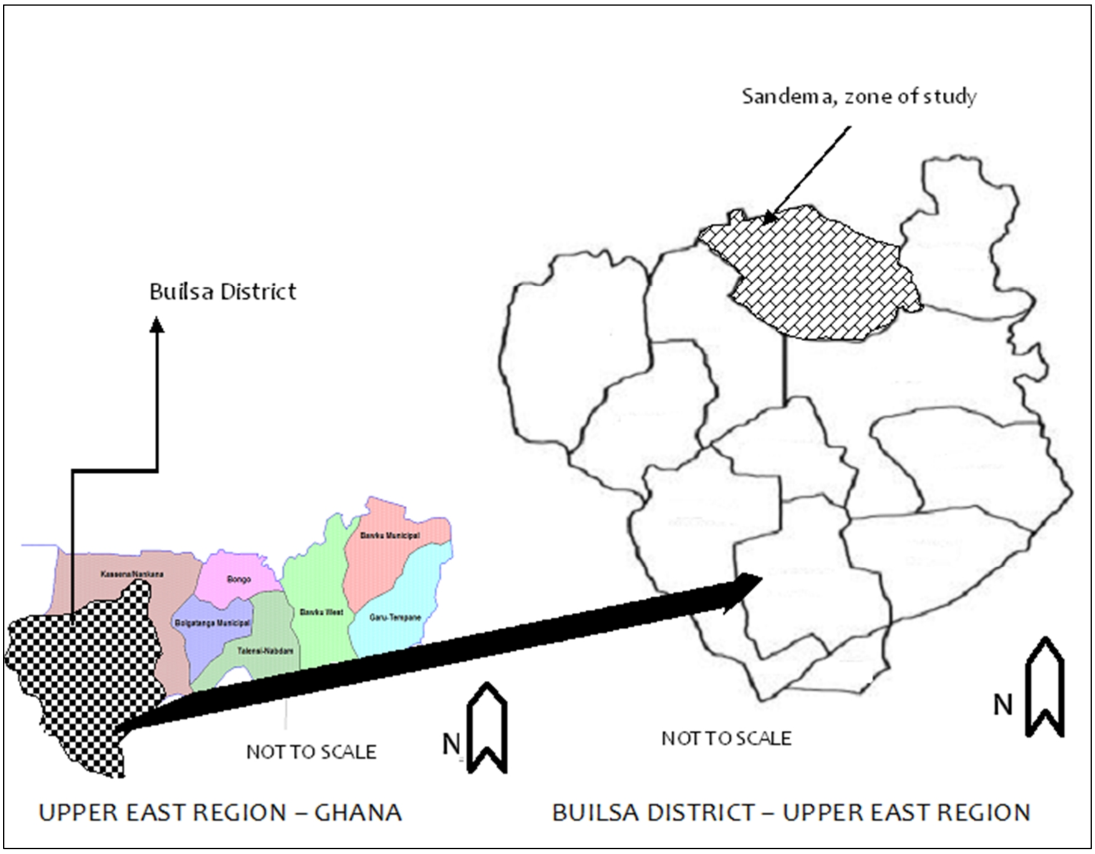
3.7.1 Builsa District

The Builsa District is one of the nine districts of the Upper East Region of Ghana[25]. The Administrative capital of the District is Sandema. The District lies between longitudes 1°

[24] http://de.wikipedia.org/w/index.php?title=Kultur_in_Ghana&oldid=133293564; http://en.wikipedia.org/w/index.php?title=Brong-Ahafo_Region&oldid=639720376; http://de.wikipedia.org/w/index.php?title=Upper_East_Region&oldid=135814427 – All accessed 01/11/2014

[25] Four more Districts have been created since the Author's field study, i.e. since July 2012. The Builsa District has consequently been split into Builsa North and Builsa South Districts. However the administrative and logistical machinery that should accompany the division is not completed and therefore both Districts follow the original development framework of the erstwhile Builsa District.

05' West and 1° 35' West, and latitudes 10° 20' North and 10° 50' North. It shares boundaries with both the Kassena-Nankana West and Kassena-Nankana East Districts to the North, the Kassena-Nankana East Municipal to the East, and the Sissala East District in the Upper West Region to the West. Map 3-2 shows both the study District and the Sandema zone where rural study communities were selected.



Map 3-2: Builsa District in regional context
Source: Modified maps based on Builsa District Assembly, 2012 and http://mapsof.net/uploads/static-maps/upper_east_ghana_districts.png. (Accessed 26/07/2013)

Physical characteristics: The topography of the area is undulating with slopes ranging from 150 to 300 metres. A few inselbergs and outcrops occasionally break the monotony of the topography. The District has a very high drainage density as it falls within the Volta River basin and is heavily dissected by a number of tributaries of the White Volta such as the Sissili, Kulpawn, Tono, Asebelika, and Belipieni. Its low-lying nature makes most part of the District liable to floods. The District is also occasionally at the receiving end of the flood waters from the dammed portions of the Volta River in Burkina Faso. Most of the streams are however seasonal and dry up during the extended dry season with an adverse effect on the supply of water for both agricultural and domestic use. The mean monthly temperature ranges between 22 and 34 degrees Celsius (°C). The highest temperatures are recorded in March and this may rise to 45°C, whereas the lowest temperatures are recorded in January. The dry season is characterised by dry Harmattan winds (North-East Trade winds) and wide diurnal temperature ranges. The wet season is influenced by the South-Westerlies also known as the Tropical Maritime winds. Rainfall patterns reflect the general rainfall situation in the Northern Regions of Ghana, i.e. single maxima rainfall, starting from April, building up into heavy torrential rainfalls between August and September. Annual rainfall volumes range between 85 millimetres and 1,150millimetres. This period is interspersed with irregular dry spells between June and July. Thereafter, the volumes decline until the rains stop completely in October.

Vegetation: The vegetation is characterised by Savannah woodland and consists mostly of deciduous, widely spaced fire and drought resistant trees of varying sizes and densities with dispersed perennial grasses and associated herbs. The impact of human activities has transformed the Savannah woodland into open parkland particularly within the immediate perimeters of settlements. Economic trees such the baobab, sheanut, "dawadawa" (soumbala balls, a local spice tree) and acacia have however been mostly preserved over time. In spite of the decreasing availability of fuelwood, its commercialisation has resulted in further exploitation of the wood resources. Trees that are affected by fire outbreaks especially during the dry season are harvested for fuelwood instead of being allowed to regenerate.

Water and soil resources: According to the District's Medium-Term Development Plan (2010-2013) the District has seventeen dams and dug-outs. These dams serve as sources of drinking water for a wide range of livestock besides being used for dry season vegetable production. In view of the high market demand for vegetables like onions, tomatoes, peppers, garden eggs and most leafy vegetables, dry season irrigation gardening has enormous potential for boosting the income generating capacity of the District. However, field survey results indicated that not all parts of the District had access to the dry season farming potential. Furthermore, the soils of the District are considered the greatest asset of the District and therefore agriculture is an important livelihood activity in the District.

Demographic characteristics: The District has a population of 92,991 and a growth rate of 0.82 percent. The average household size of the District is 5.15 persons and this compares favourably with the national figure of 5.1 persons for Rural Savannah areas. The household sizes in the larger communities are relatively smaller - for example, Sandema, Fumbisi and Wiaga have average household sizes of 4.3, 4.4 and 4.1 respectively. The household size of Sandema will later be compared with the study communities to see the extent of divergence and the implication for energy planning.

The traditional and cultural structure and power relations: The household structure in the Upper East conforms to the general pattern found in the Northern belt of Ghana and also among settler communities within the middle belt of the country where the inhabitants are originally from the Northern parts. This structure of the household defines the power relations in the house and extends to influence the power relations in the communities. Men normally live in their parents' family houses from their fathers' generation, together with their brothers and the families of their brothers. Thus in a household, there is a presiding elder whose authority overrules. Family cases are handled through these structures of authority: from a man's own family through to the household head who is the elder, to the sub-chief, and when necessary to the village chief. A group of related households form a clan. Again an elder presides over the clan. Several clans form a section, and a number of sections form a village with a chief. The elders of the various clans form part of the chief's advisors. The chiefs of the various villages are sub-chiefs of the Paramount Chief.

Communities studied

Four communities were studied in this District. These were Balansa, Kori, Alam-Yeri, and Kandema. The Builsa District has 155 communities. However the District has a peculiar community clustering: the 155 communities have been clustered into eight zones. The zones are represented by the bigger communities. The communities studied – Kori-Alam-Yeri, Kandema and Balansa – fall within the Sandema zone. Coordinate-wise, Kori-Alam-Yeri lie on the east of Sandema, the main town, while Kandema and Balansa fall to the west. Sandema is the District capital. It is the largest community in District in terms of population. According to the 2010 Population and Housing Census, Sandema as a zone had a population of 5,955 (Ghana Statistical Service, 2012) showing an increase from 4,926 in 2000. The zone is therefore the only urban zone in the District. However if the zone is separated into the respective communities, there is no urban community in the District. The District is a rural District. The Sandema Township serves as the centre of all activities for these communities. It is the administrative centre as well as the commercial, education, and health centre. None of the communities visited had any form of commercial sale point such as kiosk or petty-trade convenient shop. All commercial activities including petty trading were contracted in Sandema. Again, Sandema marked the closest proximity to the national grid for all the communities studied. This distance is close enough to have the communities electrified according to the specifications given under the Self Help Electrification Programme[26] (SHEP). However, other factors such as the terrain, dispersal of households, and the productive capacities of communities were deterrents for utility services to commit investment. In later analysis, it will be demonstrated how some respondents vehemently disagreed that their communities will be connected to the national grid even in the next ten years from the time of field study. The communities are described below.

<u>Kori-Alam-Yeri</u> is a twin community, i.e. Kori and Alam-Yeri. Even though the two communities are put together in the District's statistics, some members of the community wished to identify the two communities separately from each other. A basic school is a physical demarcation between Kori and Alam-Yeri. The built-up area of Kori begins from the Kori-Sandema entrance to the shared primary school between the two communities, and Alam-Yeri begins from the school to an outlying forest lying to the east of Alam-Yeri. Houses were sparsely distributed. Distances between them ranged between 200 and

[26] The SHEP was designed for communities within 20kliometres of an existing 33kilovolts or 11kilovolts network (See section 4.3.2).

400metres radius and these made up the compound farmlands. Where clusters of houses were seen within 20 metres radius of each other, they were mostly the extensions of the main house for married young men. A main house of the same family consisted averagely of three smaller households. Both Kori and Alam-Yeri shared boreholes, a primary school and a Junior High School (JHS), as well as a Community-based Health Planning and Services (CHPS) compound. In addition, Alam-Yeri had two more wells. Community social amenities and infrastructure identified which could have energy implications were the primary school with the JHS, the CHPS compound, and the two manually operated boreholes. The land is flat and within the plains of the Volta River flowing downwards from Burkina Faso and thus very liable to flooding which is actually the case with heavy rains or when the floodwaters from the Burkina Faso dam is released. With good rains the land is very suitable for rice farming. In 2012, when this field survey was undertaken, the rains were late. As at the month of June, there was still no significant amount of rainfall. In such weather situations, the soil is dry and sandy (white), depicting sediments of the Volta River basin (Figure 3-3). Livestock rearing was common in households though on subsistence basis (Figure 3-2). Sheep and goat were the commonest seen in these communities. Cattle-rearing was very minimal. The number of cattle per household ranged between three and eight. It was reported during interviews that during the floods of the previous year, the cattle and most of the livestock were carried away by the waters or were drowned. The inhabitants did not apply synthetic fertilisers to their compound farmlands. Rather cow dung was used as manure which was gathered from the kraals or from the fields. With insufficient cattle, most compound farmlands witnessed looked rather impoverished. At the time of the research, millet, the main staple in the District was late with midget growth, almost unable to grow beyond the early germination stage as shown in Figure 3-3. There was generally food shortage in the communities. Households practically ate all they produced. Malnourishment was easily identifiable among children.

Figure 3-2: Livestock grazing – both sheep and cattle in Kori-Alam-Yeri

Picture taken from the Alam-Yeri part which borders the forest and thus has relatively more greenery. Source: Author's field survey, May – July 2012

The distance between Kori and Sandema, the District capital which is also the closest proximity to the national grid lines is four kilometres. At the time of field survey, the road between Sandema and both communities was however undeveloped, laterite with underlying sedimentary rocks, rendering the link not easily motorable. There were no public transports were plying the route. Members of both communities travelled on foot to Sandema for all purposes including head-carrying agricultural produce for market days in Sandema or Navrongo. In few cases, community members had bicycles.

Figure 3-3: Dry white sandy sediments of the Volta basin
Picture taken from the Kori section of the twin communities
Source: Author's field survey, May – July 2012

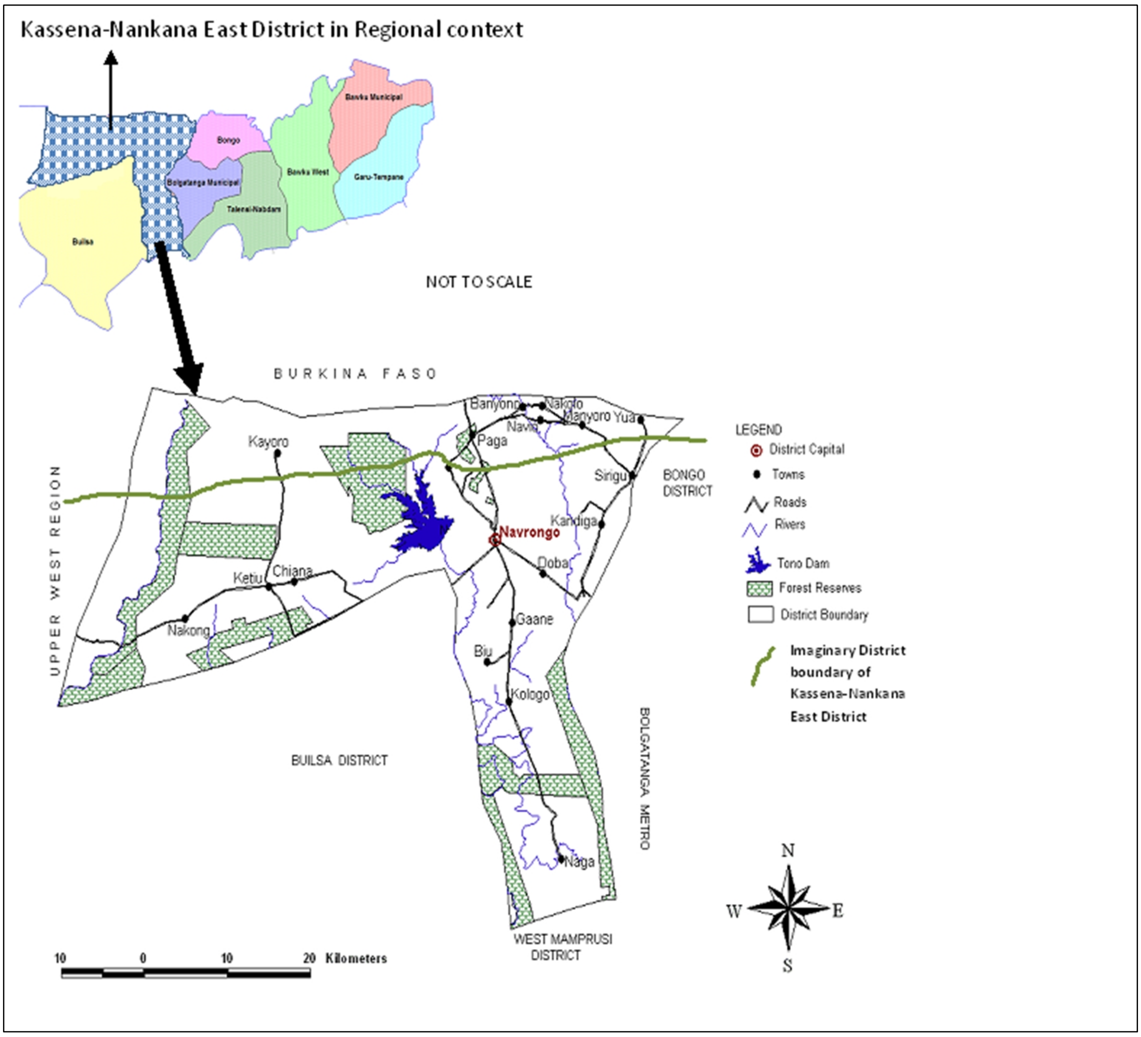
<u>Balansa No.1 and 2:</u> These two communities were also twin communities that wished to be treated separately from each other. They had different community traditional leaders referred to locally as headmen. The traditional differences between the two communities were significant in the way they related to each other. However as in the case of Kori and Alam-Yeri, both communities shared common infrastructural facilities and social amenities which were strategically located. Community facilities identified were a primary school at Balansa No.2, another primary school at Balansa No. 1 that used solar energy for evening lessons, and a clinic at Balansa No.1. The Balansa No. 2 community received door-to-door health delivery services even though a clinic was located in Balansa No.1. The two communities were separated by a dry river valley which overflowed its banks during the rains and therefore members of the Balansa No.2 could not cross over for health services. Solar street lights and boreholes were also identified in Balansa No.2 (Figure 3-4). The physical and agricultural characteristics were similar to that of Kori-Alam-Yeri. The communities were about four kilometres from Sandema, with undeveloped routes. No public transports plied the route, and trips to Sandema had to be made on foot.

Figure 3-4: Infrastructural and physical conditions in Balansa No.2
Source: Author's field survey, May-July 2012

Kandema exhibits similar physical and environmental characteristics as Balansa No.1 and 2 described above. The community is about six kilometres from Sandema. The road conditions were similar to the conditions between Kori and Sandema. No public transport plied the route and trips to Sandema, the District capital which was also the marketing centre had to be done on foot. In terms of infrastructure and social amenities, the community had harsher conditions than the rest of the communities studied in the District. The community is mainly served with door-to-door primary health delivery services. There are no schools or water supply system. It is a unique rural community. It was the only rural community among the communities visited where people still used straw torches to light their way in the night. The community is a typical traditionalist community which believed in supernatural occurrences so that farming seasons are controlled by the spirit of the wind. Community members were forbidden to use any form of metallic roofing as they believed that metallic roofing attracted the spirit of wind and brought about strong winds to destroy their houses. The community tried to prove their point by pointing to Christian church that attempted to build a metal-roofed structure opposite the compound of the Traditional Authority and the consequential destruction by strong winds. Incidentally, metallic roofing was one of the basic requirements of the GEDAP solar home system installation for the installation of the solar panels. This requirement could not be met in this community.

3.7.2 Kassena- Nankana District

The Kassena-Nankana East (KNE) District also lies within the Guinea Savannah woodlands in the Upper East Region.



Map 3-3: Kassena-Nankana East District in regional and district contexts
Source: Modified based on Kassena-Nankana East District Assembly, 2012 and http://www.ghanadistricts.com/districts/?news&r=8&_=105. Accessed 26/07/2013

It shares boundaries to the North with Kassena-Nankana-West and Burkina Faso, to the East with Kassena-Nankana West and Bolgatanga Districts, to the West with the Builsa District and South with West Mamprusi District in the Northern Region. The District capital is Navrongo. Map 3-3 shows the whole of the Kassena and Nankana enclave. Kassena-Nankana East District is a new District created in 2008 out of the erstwhile Kassena-Nankana District. Till date, the actual demarcations of the District boundary have not been successful. The Author, based on interview with officials of the District Assembly as part of the study community selection process assumes an imaginary boundary indicated by the faint blurred line drawn across the upper section of the map. It is important to state that this is solely for academic purposes.

Physical characteristics: The District is low lying and undulating with isolated hills with heights of about 300 metres in the southern and western parts of the District. The tributaries of the White Volta – the Sissili, Asibelika, Afumbeli, Bukpegi and Beeyi form the drainage system of the District. The Tano River which is a tributary of the Asibelika River has been dammed for irrigation farming especially during the dry season. In addition, there are dugouts and ponds for livestock farming and domestic purposes. Climatic conditions and vegetative characteristics are as recorded in the Builsa Districts. The economic trees in the District are dawadawa, baobab, sheanut and mangoes. An interview with District Planning Coordinating Unit indicated that because of the Tano irrigation project and the possibility of farming along river banks, this District is able to engage in both wet and dry season farming (Interview with District Officials – KNE District – 5th June, 2012). Dry season farming engages the production of vegetables especially tomatoes. Not all communities of the District though have this advantage of dry season farming. In addition, the Tono irrigation facility has also made rice farming popular in the District.

Demographic characteristics: According to the 2010 Population and Housing Census, the District has a population of 109, 944 (Ghana Statistical Service, 2012). The average household size in the District is 5.4, slightly above the national average for rural Savannah areas. The reason given is the improved reductions in mortality rate combined with the high fertility rate in the District.

The traditional and cultural structure and power relations: The traditional and cultural structure and power relations is as reported for the Builsa District. The District consists of two tribal groups – the Kassena and the Nankana tribes.

Communities studied

There are 97 communities in the District. Of the ten largest communities, only Navrongo, the District Capital, is urban, with a population of 15,983. Four rural communities were studied in the District. These are Akurugu Daboo (Atosaale), Azaasi, Nagalikenia, and Wuru. Coordinate-wise, the first two communities were located on the Eastern part of the District along a branch route off the primary road linking Navrongo to Bolgatanga, that is, from Kandiga Junction to Kandiga (Kandiga is a major rural settlement and a commercial centre located at the end of this branch route). The closest proximity to the national grid for both Akurugu Daboo and Azaasi is Navrongo-Bolgatanga primary road which is about two kilometres from the communities. Akurugu Daboo is the closest to the road. The other two study communities on the Western part of the District were along the Navrongo – Sandema road.

Akurugu Daboo (Atosaale) and Azaasi are located along the same corridor. Akurugu Daboo was originally known as Atozaale. Both names are names of persons believed to be founders of the village. The community was originally known as Atosaale. However there was a traditional conflict concerning who the founder is and therefore the name of the community. At the time of the study the name Akurugu Daboo was strongly advocated. Community facilities identified in Akurugu Daboo are a health post, a primary and JHS. Azaasi also had a primary school, but depended on Akurugu Daboo for health services. Even though both communities had high tension grid lines running through them from

Kandiga Junction to Azaasi, there was no electric power in the grid lines. There was no regular public transport plying this corridor from Kandiga Junction except for hired ones. Community members trekked on foot to the junction to connect to Navrongo, Bolgatanga or even to Kandiga because it was easier to get a detour from the junction to Kandiga than from the communities. The typical economic activities in both communities were farming and animal rearing. As in other parts of the Upper East Region, the rains were late in 2012. At the time of field research, the early millet which is the name given to this species of millet which should have been ready for harvesting between June and July had barely passed the seedling stage. Farming is purely subsistence – they eat what they grow and only sell portions to take care of financial requirements (or to be able to purchase other commodities such as fish or industrial commodities). One of the tributaries of the White Volta flows through the Akudugu-Daboo community. During the dry season, dams along the river are used for dry season vegetable cultivation. Part of Azaasi is also within the catchment area of the Tono irrigation project and therefore able to undertake dry season farming. In Azaasi, bicycle repair work was also identified as an economic activity. All major trading activities were contracted in Kandiga or Navrongo.

Wuru and Nagalikenia are also located on the same corridor of the District along the Navrongo-Sandema road but do not lie next to each other. There are two communities named Nagalikenia in the District, that is the Upper and Lower Nagalikenia. The study community was Lower Nagalikenia, which was not connected to the grid. However, the Upper Nagalikenia was electrified. In terms of community infrastructure, Wuru had a CHPS compound. In Wuru, it was only the chief's house in the whole community that had electricity. Nagalikenia had three boreholes and a school but access health services from neighbouring community called Korania which was connected to the national grid, at Wuru or at the Navrongo Main Hospital. Nagalikenia has electrification materials which according to interview with community leaders had been deposited in the community for the past five years but had not been installed:

> *"The poles were brought a long time and we erected these ones within 2008. The poles were lying here for more than five years before they were erected. The Volta River Authority*[27] *sub-station is close by, and on our land. There have been several requests to Volta River Authority to connect us but as at yet there is still no power. When the poles were erected, we were asked to wire our houses. Most houses are wired waiting to be connected." (*Key informant interview with Opinion leaders, Wuru- 7th June, 2012)

Typical economic activity in the both communities is farming. However, due to the closeness of Nagalikenia to Navrongo, the community also serves as a dormitory to workers engaged in other economic activities such as government workers or even workers of some non-governmental organizations. Most of these were also farmers. Other commercial activities such as petty trading and food vendor activities could also be identified. Both communities lie within the catchment area of the Tono irrigation project and are therefore intensely engaged in dry season farming of vegetables. In Figure 3-5,

[27] The Volta River Authority is the utility service responsible for electrification in the three northern regions in Ghana, that is, the Upper East, Upper West and Northern Regions, as well as the Brong Ahafo Region.

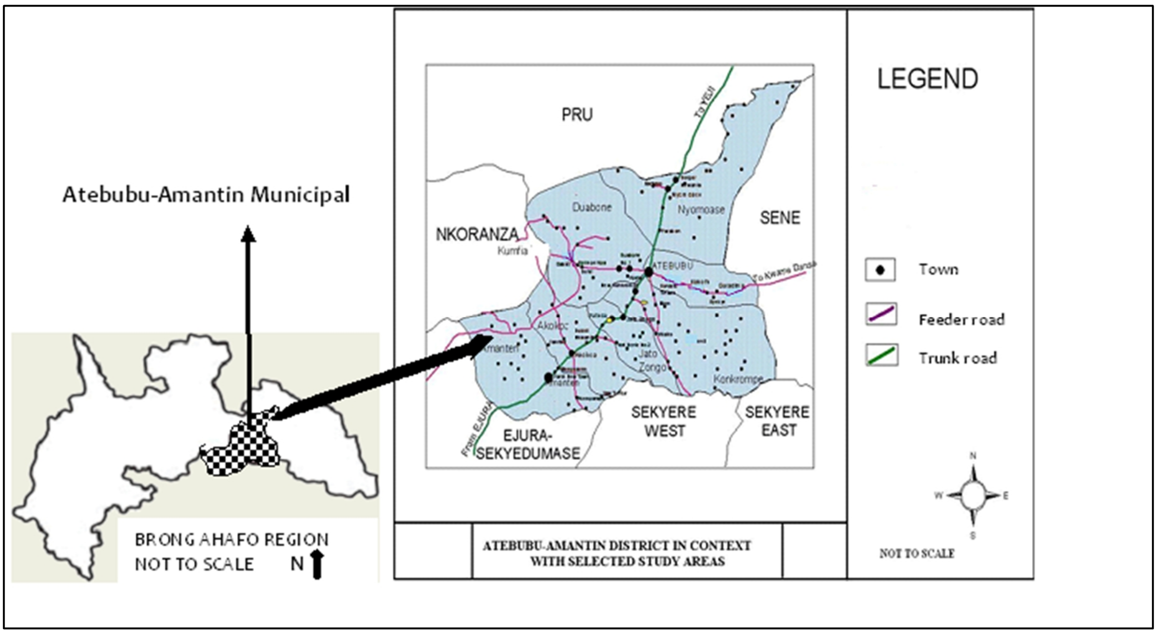
two farmlands in Wuru are shown non-irrigated and irrigated. Even though the non-irrigated farmland was ploughed it could not be utilised because of the delayed rains. However the farmland within the catchment of Tono irrigation project looked grown and greener.

Figure 3-5: Irrigated and non-irrigated farmlands in Wuru
Source: Author's field survey, May-July 2012

3.7.3 Atebubu-Amantin Municipal

The Atebubu-Amantin Municipal lies in the transitional ecological zone in the Brong Ahafo Region. It is located between latitudes 7°23' North and 8°22' North and longitudes 0°30' West and 1°26'West. It shares boundaries to the south with the Ejura-Sekyeredumase, Sekyere East and Sekyere West Districts in the Ashanti Region, and the Pru and Sene Districts in the Brong Ahafo Region to the North and to the East respectively (Map 3-4). Atebubu is the Municipal capital.

Physical characteristics: The District has generally an undulating topography with elevations between 60-300 metres above sea level. The Pru River which is a right tributary of the Volta Lake, the Nyomo, and the Bresuo Rivers are the main rivers draining the District. There are smaller streams draining the communities. The rivers are within their lower courses in the District and therefore flow sluggishly leaving behind alluvial soils which have become an important potential for agricultural activities in the District. However, apart from the Pru River, the other water bodies quickly dry up in the dry season. Mean monthly temperatures range from 24-30°C. The District has a double rainfall pattern with a mean annual rainfall of about 1400 millimetres.



Map 3-4: Atebubu-Amantin Municipal in Regional and neighbouring District contexts

Source: Based on http://ghanadistricts.com/districts/?news&r=10&_=33 (Accessed 26.07.2013) and Amaka-Otchere, 2006

Vegetation: The vegetation type is the interior wooded savannah. The District lies in the transitional zone between the tropical semi-deciduous forest ecological zone and the Guinea savannah zones and therefore shows savannah characteristics as well as tropical semi-deciduous characteristics especially along the river banks and areas with low human activity. It is therefore not uncommon to find baobab, dawadawa, acacia and shea nut trees which are typical of the Upper East Region within the vegetative cover. The woodlands are exploited for housing, hunting and energy production especially charcoal production. The District is one of the biggest charcoal producers and suppliers in Ghana. Another wood, Rosewood, locally known as "*krayie*" has also recently found high economic value. At the time of research, this wood was being exploited by international companies because of its high resistance to heat and its malleability. Until then, information from opinion leaders in the communities visited indicated that it was one of the trees used in charcoal production. However since its new economic value was discovered, the chiefs have banned its exploitation for charcoal production (Interview with Traditional Authority – Kumfia, 20^{th} June, 2012).

Demographic characteristics: The 2010 Housing and Population Census estimated the District's population as 105,938 with an average household size of 5.1 (GSS, 2012) at a growth rate of 6.2 percent (estimated)[28] .

[28] Estimated growth rate by Author given that the District's population was estimated at 65,253 by the 2000 Population and Housing Census

The traditional and cultural structure and power relations: Very scanty documented information is available on the traditional and cultural structure which persists in the District. The District's MTDP (2010-2013) indicates the ruling of two paramount chiefs in the two major towns in the Municipality, i.e. the Atebubu and Amantin Paramount chiefs (Atebubu-Amantin District Assembly, 2010). The Author's field study showed that the communities had their chiefs and sub-chiefs who paid allegiance to the Paramount chiefs (Community interviews in Atebubu-Amantin District, June 2012). There is also no documented report on the power relations which persist in households. In subsequent chapters, the study will attempt to derive these from field interviews.

Communities studied

Three communities were studied in the District. There were Fakwesi, Kumfia and Sabidi. All three communities are within the same corridor of the District, in the North-Eastern part of the District towards the Nkoransa District. The connecting link between Atebubu and the three communities is a feeder road, rendered almost non-motorable during the wet season. The three communities were however farming communities and also well recognized for charcoal production. Public transport was unpopular except on weekly market days which fell on different days in Kumfia and Fakwesi. Otherwise, commuters hired motorcycles or joined agricultural farm trucks or tractors of middlemen or women buying agricultural produce or charcoal from the farm gate. At the time of field study, a few individuals had begun running taxi services from Atebubu which moved between every one to two hours due to the extremely low traffic on the link. The communities are briefly discussed below.

Fakwesi is located on the border between Atebubu-Amantin Municipal and the Nkoransa District. The community is approximately 37 kilometres from Atebubu, the District Capital. It had a CHP compound. In addition, the community had a public basic school and kindergarten as well a private primary school. In terms of strata, the community had a pattern of sandcrete and landcrete mixed houses along the main feeder road running through the community. Behind this linear block of houses were the purely landcrete houses locally referred to us "atakpaame"[29] which are typical rural houses. The community depended on the River Tamfe and rain water harvesting for all domestic applications.

Kumfia is located approximately 28kilometers from Atebubu. It is the biggest community in this corridor in terms of its population. Community facilities identified are health clinic, two basic[30] schools both provided by the government and a private organisation respectively, teachers' quarters (low cost housing for teachers), two boreholes, and a

[29] "Atakpaame" is the local name given to the building material and process used for traditional building in Southern Ghana. The housing architecture makes provision for an internal square-shaped compound defined by the arrangement of rooms, culturally suited for the communal and extended nature of the typical southern Ghanaian rural family.

[30] In Ghana, a basic school consisted of the primary and the Junior High School. Some communities had only primary schools without the Junior High School.

church. The community also depended on the Tamfe River for domestic uses. One significant observation was the charcoal depot, referred to locally as "Achimota"[31]. The community also has a vibrant petty trading industry at its centre. There are one major and one minor feeder road that divide the community into four quarters. As in the case of Fakwesi, the housing strata showed mixed sandcrete and landcrete households along the centre of the community with the traditional mud houses behind this row of blocks.

Sabidi is a community about 20km from Atebubu. It is a settler community made of up Dagatis, Kokombas, and Sisalas all from the Northern tribes of the country. There are however some indigenous Bonos (the people of the Brong Ahafo Region are referred to as Bonos) who are the landowners living among them basically to control the activities of the settlers on their land. The settlers have an elected ruler who is subject to the ruling Bono landlord of the Sabidi land. The community rules are made by the Bono ruling landlord. The main activity of the settlers is charcoal burning, and subsistence farming only as source of food unlike the other two communities whose main economic activity was farming. The community was the most under-developed among the three communities. In terms of community infrastructure it had only a primary school. The community depended on Kumfia or Atebubu for health services. Even though the Atebubu water pumping station constructed over the Pru River is located at Sabidi, the community depended on the Tamfe River for domestic applications. It also depended on the River for dry season farming. The houses are mud houses with thatch roof, very typical of housing characteristics in the Northern Ghana. The difference was that the housing architecture was not circular as in Northern Ghana but square shaped, conforming to climatic conditions of the south. There were few instances where galvanized metal sheets were used (See Figure 3-6).

Figure 3-6: Sabidi community showing both housing characteristics
Source: Author's field survey, May-July 2012

From the District and community descriptions, the striking feature about the communities in the Upper East Region is their level of rurality even though they lie so close to major

[31] Achimota is vibrant commercial suburb and a transport hub in Accra, the capital of Ghana. It is one of the charcoal depots in the capital city that receives charcoal imports from charcoal producing hinterlands of the country.

urban centres. All the communities lie within less than five kilometres of the Districts' capitals. However the infrastructure and social amenity provision, housing characteristics, economic characteristics and physical characteristics showed such extent of rurality and consequently, significantly low levels of development. The communities in the Atebubu-Amantin District were chosen in the more forested sections of the District to present a contrast to the Savannah conditions that prevailed in the two Districts studied in the Upper East Region. These were of considerable distances from the District capital but were comparatively more developed than those in the Upper East Region. The distances between the communities were covered by farmlands and farming hamlets. Except for Sabidi through which the Pru River directly flowed, the other communities had smaller streams which dried up during the dry season and overflowed their banks during the wet season. Dry season irrigation is therefore not possible in these other two communities.

3.7.4 Socio-demographic characteristics of communities studied and their relevance in determination of energy needs

Respondents of the household interviews were husbands, wives, young people of the households, or in a few cases, the elderly or members of the extended family living in the house. Most importantly, the respondent had to be in the position to answer all questions, and where not possible, the data was supplemented by responses from other members of households. From Table 3-2, the majority of respondents, that is, 50 percent were husbands, followed by 26.7 percent of wives. This is typical of rural settings where normally if male household heads existed, the households preferred questions to be directed to them. However during interviews, the women were allowed to answer questions which the husbands could not effectively answer. The importance of this gender disaggregation was necessary in observing in later analysis which gender was biased towards which energy form and use, that is, either energy for cooking or lighting, or for domestic or productive use. One of the contentious issues with energy provision at the rural level is the 'whose decision' and for what reason that decision is made.

Table 3-2: Type of respondents

Gender	**% of respondents, N=199**
Husband	50.0
Wife	26.7
Son	11.6
Daughter	6.2
Other	5.5
Total	**100.0**

Source: Author's field survey, May-July 2012

The average age of respondents was 35 years. This was the modal age of respondents. This was preferred because the range was as high as 71 with outliers of 89 and 18. Table 3-3 shows the average household size for all communities studied as five. In the Upper East Region, there were outliers as high as 32 and 52 persons in two households in Kandema. These were households of local chiefs who had multiple wives and children by each wife. Ironically, these are households whose energy information particularly energy expenditure, rarely affect the rest of the data because of the extreme traditional inclination and very minimal energy use. Disaggregated into the three Districts, the average household sizes were eight, five and six for the communities studied in the Kassena-Nankana East, Builsa and Atebubu-Amantin Districts respectively. With the exception of Kassena-Nankana East communities where the variation between the District recorded household sizes was wide, the averages in the communities in the Builsa and Atebubu-Amantin Districts compared favourably with the 2010 Census figures of the Districts of 5.5 and 5.1 respectively.

Table 3-3: Average household size in study communities in the Districts

Aggregated average household size for study communities	District	Average household size	
		Study Communities	2010 Census
5.0	Atebubu-Amantin	6.0	5.1
	Builsa	5.0	5.5
	Kassena-Nankana East	8.0	5.4

Source: Author's field survey, May-July 2012; 2010 Population and Housing Census-Ghana

The educational background of respondents indicated that majority of respondents had no formal education as depicted in Table 3-4. The highest educational level attained by respondents was the tertiary indicated by 6.1 percent of respondents; 16.3 percent had some primary education. It was however notable that 98 percent of the respondents had their children in school. The statistics on the number of children under and above 18 years of age gives a fair idea of the domestic energy needs for educational purposes. Considering the educational system in Ghana and the age for schooling, it can be presumed that the more children there are under the 18 years of age, the more the necessity of energy for night learning. Moreover, averagely, there were three children per household enrolled in school which therefore presupposed that energy for learning after school would be necessary.

Table 3-4: Level of education

Adult educational level		Education of children		
Educational level	% of respondents, N=199	Average No. of children under 18	Average No. of children above 18	Average No. of children in school
Primary	16.3	3.0	2.2	3.1
Junior High School	11.6			
Senior High School	9.5			
Middle school	2.7			
Tertiary	6.1			
None	53.7			
Total	**100.0**			

Source: Author's field survey May-July 2012

3.7.5 Housing characteristics

Information on housing helps to establish poverty levels or otherwise in the communities studied. Flooring and roofing types, as part of housing characteristics are proxy determinants of the standard of living of a populace. Sixty-two percent of respondents had earth and mud flooring, about 27 percent had concrete flooring, and stone or bricks and other types of flooring took the remaining 10.7 percent as depicted in Table 3-5. In the case of roofing, the majority 58 percent of households had corrugated iron roofing sheets, followed by 33 percent that had thatch roof. The corrugated iron roofing generally were rusted and corroded giving communities a rather brown aerial look. On the market, these are often the most economical and the required support structure is also most economical emphasising the relatively lower living standards of users. In a few cases which were particularly observed in the Upper East Districts, the galvanised iron sheets used were also coated with zinc or aluminium to make it less corrosive and rusty. Metallic roofing was an important precondition for the implementation of solar projects in the Upper East Region, specifically the Ghana Energy Development and Access Project (GEDAP) for the rooftop installation of solar home systems. Invariably, these characteristics give an idea of the number of households in the study sample who were technically ready for such projects. In the communities in the Atebubu-Amantin District as in most rural communities in Southern Ghana, metallic roofing was commonly used in the building of traditional houses, and most of these have been handed down from generation to generation with very little consideration to changing the roofs. In the communities in Builsa and Kassena-Nankana East Districts, the traditional houses were built in the form of compounds. In almost all compounds visited, there were the huts built with traditional local materials of landcrete with thatch for roofing, and at least one structure built out of a mixture of landcrete and sandcrete with corrugated aluminium or zinc roofs. This was normally a two-room section which represented the head of household's quarters.

Table 3-5: Housing characteristics

Type of flooring	**% of respondents, N=199**	**Type of roofing**	**% of respondents, N=199**
Earth and mud	62.4	Thatch	32.9
Stone or brick	9.4	Wood	1.3
Concrete	26.8	Corrugated iron	57.7
Other	1.3	Asbestos	2.7
Total	**100.0**	Other	5.4
		Total	**100.0**

Source: Author's field survey, May-July 2012

One of the socio-economic indicators of wealth in social science research is ownership of houses. Table 3-6 shows 88 percent of respondents were owners of their accommodation. About 10 percent had free accommodation from relatives; this is a common phenomenon considering the fact that the communities are rural. The statistics on house ownership does not necessarily imply a state of financial well-being as might be suggested for a similar scenario in the urban areas, because in the rural areas lands are normally owned by family members in the communities. Building materials, with the exception of metallic roofs and cement, were local building materials such as sand and clay which were relatively easy to access. In most cases, especially in the study communities in the Upper East Region, family members assisted by personally provided physical labour in the construction process.

Table 3-6: Ownership of houses

Ownership of dwelling	**% of respondents, N=199**
Own	87.9
Rent	2.0
Free accommodation	10.1
Total	**100.0**

Source: Author's field survey May –July 2012

The average number of rooms per house was four. The essence of checking this average is to determine the domestic use of energy especially for lighting purpose and the possible cost to users.

In summary, the socio-demographic characteristics of respondents provide background information on the category of respondents being studied. From the data on gender of respondents, it is evident that the communities were predominantly male dominated even though the women and other members of the households were allowed to provide information which the male-heads of households could not provide. The information was to help in determining how the decision-making process in adopting a decentralised energy system was influenced. The aggregate average household size for communities was five but district disaggregated figures showed higher household sizes in Kassena-Nankana East District and Atebubu-Amantin District of eight and six respectively. Household sizes are indicators of household energy consumption and projection. Though the majority of respondents did not have formal education, the majority of respondents had their children in school. This presupposes the importance respondents put on child education in modern times, an important input for human capital development. It also presupposes the energy need necessary for learning both at school and at home.

3.8 Data collection

Levels of data collection

Data was collected at the international, national, district, and community levels. The Regional administrative level (which is between the national and the district level) was omitted due to the dormant supervisory role played by the Regional Coordinating Councils in development planning in Ghana. In this case, the role of District is much stronger.

Study components and tools

Interviews: In the qualitative part of the research, in-depth interview, key informant or expert interviews, and individual interviews were conducted. The key informant and expert interviews targeted energy experts at the international and national levels, the District Assembly officials, energy research institutions, rural banks, and microfinance institutions to address various aspects of the research. Key informant interviews were also conducted with opinion leaders – the Traditional Authority, i.e. the "tandams" in the Upper East Region, and 'Akrontihenenom[32]' in the Brong Ahafo Region and other representatives of the Traditional Authority; Assemblymen; and members of the Unit Committee – to understand the energy situations as well as initiatives they have taken in their communities. In-depth interviews were conducted with selected households to understand the household energy decision-making process. Furthermore, individual interviews were conducted with fitters and electricians and other potential technically oriented persons to determine the potential technical capacities in the communities. Economic activity interviews addressed issues on production utility and sustainability with particular emphasis on productive uses of energy and respondents' appreciation of economic opportunities of energy. Interviews with energy suppliers, producers and distributors provided information on the dynamics in the energy system environment in the communities, at the district levels, and supply chain of alternative energy supply at the national level. Interview guides used in this study were semi-structured and open-ended. The semi-structured nature allowed the researcher to pick on key points as they evolved during the interviews to probe further. An overview of these interviews and the variables they addressed are presented in Appendix III.

Questionnaire survey: Structured household questionnaire interviews for cross-sectional household survey were formulated, administered and addressed to households in each of the participating ten communities. These interviews addressed research questions one, two and four on household energy needs, energy use patterns, energy decision-making process, and the preconditions necessary for the implementation and sustainability of decentralised energy systems. The questions were addressed to members of the households directly involved in the energy use and management of the household. A copy of the structured household questionnaire survey is attached as Appendix IV. Table 3-7 shows the research tools and number of interviews for each type of interview which were conducted.

Observation: An observation guide was designed for direct observation of energy resources and potentials in the communities.

Document review: In the process of data collection, some policy information was available as documents. These included government policy documents on energy over the years, the institutional frameworks of energy institutions in Ghana, the Ghana Action Plan towards the UN Sustainable Energy for All, the Renewable Energy Acts, the medium term

[32] "Akrontihenenom" is the plural form for "Krontihene", an Akan sub-chief in Southern Ghana.

development plans of study districts, as well as a number of alternative energy project implementation documents. At the international level, the energy policy frameworks of multi- and bi-lateral, non-governmental, as well as donor organisations were part of the important documents reviewed.

Table 3-7: Tools used and the number of interviews administered

Tools of data collection	No. of interviews administered
Household survey	199
Household in-depth interview	40
Economic activity interviews	15
Community interviews	10
Energy producers and distributors interview	20
Individual interview – local technicians, electricians and fitters	3
District level key informant interviews	12
Guided key informant interview on financing	6
Guided interview on past or on-going decentralized projects	6
Key informant (expert) interview - international	4
Key informant (expert) interview - national	16

Source: Author's field survey, May-July 2012

Other tools - Energy access performance

The study borrowed the Energy Development Index matrix developed by the International Energy Agency (see Table 2-1), and the minimum standards for energy service matrix developed by Practical Action (see Table 2-2). The two matrices were originally developed to be used at the country level. This study did not intend to measure them. However, they were borrowed for limited evaluation of energy access performance in the study communities. These were filled and compared with the IEA and PA suggested minimum standards in Chapter eight.

Ethics observed

In social science research, ethics are expected to be observed for confidentiality, consent, privacy, and anonymity and to guard against consequences for research participants which can be predicted to be harmful (Bryman, 2012). For this study, the purpose of the research was communicated to all respondents. Particularly for the household survey, it was necessary for respondents to understand clearly the purpose of the research given that a majority of respondents were illiterate. It was necessary to ensure a level of confidence in providing data, particularly when data on household finances was sought; moreover, issues of energy were found out to have political connotations that needed to be cleared. Respondents were assured that this was purely an academic process; even though it was necessary for them to provide the responses as accurately as possible since the information that was finally obtained could help the country's database. In the case of qualitative key informant interviews, where respondents preferred anonymity, the details of such respondents were altered to ensure that they are to a large extent unidentifiable.

In some cases, the researcher used her discretion to decipher such occurrences based on the sensitivity of information provided. In a few instances, key informants preferred interviews to be hand-recorded and not tape-recorded, and even ensured that the tape recorder as well as mobile phone recorder of the researcher was off. These were adhered to.

3.9 Selection and training of research assistants

Yin (2009:68) asserts that conducting case studies offers no parallel as with experiments and surveys where assistants carry out data collection activities with a minimum of discretionary behaviour. Rather, well-trained investigators are needed to conduct high-quality case study because of the continuous interaction between the theoretical issues being studied and the data being collected (ibid.). For the study, Research Assistants (RAs) selected were past Teaching Assistants of the Department of Planning of the Kwame Nkrumah University of Science and Technology (KNUST). This calibre of research assistants were chosen due to their familiarity with developing planning issues, their understanding of the planning process, and their experience in undertaking field research. In addition these had been previously engaged in similar energy and decentralised energy projects which required the administration of household questionnaires and community interviews and therefore were also conversant with the issues of this research. These core research assistants were not chosen at the case study locations because it was significantly clear, particularly in the Upper East Region, that the Region is made of up so many different tribes and languages so much so that sometimes districts lying next to each other could not speak the language of the other. In that case selecting RAs from the study areas would not have been particularly useful since that would have required training RAs over and over again; the research could then lose the required depth and understanding that are developed through repetition. The RAs were trained for two days and were engaged in the pre-testing of field instruments.

In addition to the core RAs, pseudo research assistant were selected from among the field officers of District Planning Coordinating Units (DPCU) and the agricultural extension officers who had a good appreciation of research work and were familiar with the local situations, as well as from past field workers of energy research institutions and non-governmental organisations. Translators were also sought among Twi or English speaking residents of the communities. These were briefed and it was clearly emphasised that they related the stories behind every answer just as the answers were said. They also helped in clarifying idiomatic expression used by respondents. The core research team monitored and regulated this. In addition, the researcher who had learnt to pick few words of the local language could help tune the responses. Again, some interviews were recorded and with the help of a trusted source, the translations from the translators were compared with the direct translation by the trusted source. A good community entry was also useful in getting trusted responses from community assistants as well as in gaining the trust of respondents.

3.10 Quality verification and maximisation

3.10.1 Pre-testing

A pre-testing of the community instruments was undertaken in a neutral Region, District and rural community. The purpose was to increase validity, accuracy, clarity and timing. The selected community, Drobonso, was a remote community located in the Sekyere Afram Plains District of the Ashanti Region. The District Assembly assisted the research team with two Assemblymen from the community. Even though the physical terrain was a difficult one and almost inaccessible without a private means of transport, the field experience was a good preparatory one for the research team. All instruments with the exception of expert interviews were tested in the community. Interviews were timed, the understanding of respondents was assessed, and the fluency of the research team in conducting the interviews in the local dialect was assessed to check how efficiently the issues could be expressed in the local dialect. The level of interest of respondents in the subject matter was also assessed by observing their body language. Altogether, the pre-testing helped to sharpen the instruments and the parameters being investigated with local significance, and also sharpened the research team's approach to respondents. Time plays a very significant role in rural life, and in such an informal setting, the degree of distraction can be minimized when researchers are conscious of the time factor. Questions were therefore adjusted where necessary to prevent interviewee fatigue or interviewer bias.

3.10.2 Order of activities – ensuring checks and balances

The activities undertaken on the field followed the research process illustrated in Figure 3-1. Even though a considerable level of flexibility is encouraged for case study research (Yin, 2009:62), it was necessary to plan field activities to follow a certain sequence weighing the advantages in the observance of this sequence to the correctness, quality, validity, and robustness of the research. One step led to the fine-tuning of the next. The structure of activities also made room for reflection and jotting of on-field memos to include and address issues which were missing in the original instruments. A protocol of field activities is attached as Appendix II.

3.10.3 Community generated maps

Each community set of interviews began with a transect walk. The purpose was to identify the level of homogeneity or heterogeneity to stratify the community where necessary, to identify important community land marks, to identify physically identifiable potential energy resources, and to be generally familiar with the community being studied. After these maps were independently generated, they were discussed with the community members who made input to them (See sample - Appendix V). This process also created a level of excitement among community members, some of whom had never before had the opportunity of pictorially appreciating their community.

3.10.4 Monitoring the conduct of interview

Each day's activities were reviewed. Interviewers had time to fill in the gaps, edit questionnaires and jot down field observations and critical issues that came up during the course of the day's work. These were discussed and compiled as part of field memos. Where certain challenges had ensued, the team discussed ways around it. The principal investigator also acted as the supervisor to review, edit, and demand correctness in the presentation of the filled questionnaires. Monitoring the conduct also meant monitoring the observation of field protocols by the team to enhance the best possible corporation from interviewees.

3.10.5 Data management and analysis

Qualitative data from interviews were recorded. These were transcribed for easy reference and storage. The data were categorised and grouped under themes even though most of the interviews were guided with pre-determined themes. Most importantly, new themes and issues were noted. When the data provided were unclear, these were further clarified with respondents through email correspondents or telephone calls as were appropriate. In the case of qualitative data which were not gathered from key informant interviews, the research assistants engaged during the field work were further engaged to verify data. Quantitative data was inputted in a Statistical Package for Social Sciences (SPSS) template developed by the researcher. Data was run for completeness, and missing values were re-checked. In this form, the data was appropriately stored and ready for the first phase of analysis facilitated by the software.

The purpose of a good analytical framework is to address the issues of internal and external validity of the research. The research made use of pattern-matching and limited cross-case analysis as the main frameworks of analysis. Within these frameworks, critical applications such as triangulation of data and methods were employed to increase the construct validity of the study. It also included the new analysis of statistical data, and text analysis. For the quantitative aspect of the research, univariate and bivariate analysis were employed. Descriptive statistics including frequencies, diagrams, measures of central tendencies and dispersion were used. In the case of the bivariate analysis, relationships between variables were examined. Computer programmes used were SPSS and Microsoft Excel for data entry and analysis of statistical data. The statistical analyses were presented in tables and figures giving the researcher the initial idea of the results of the survey. Where outliers were identified, the researcher used discretion to determine the peculiarity of outliers to discuss them as separate cases or to remove them completely from the data set.

In the case of qualitative, interviews were transcribed, coded and grouped under themes which were organised according the research objectives. Matrices were used in organising information under the various themes and sub-themes. These were collated with memos already written on the field and throughout data inputting and assembling. In addition, secondary analysis of existing data was also undertaken. Data from both qualitative and quantitative sources were expected to complement each other. Thus, quotations from interviews were matched with data from the quantitative survey for correctness or otherwise. Where complete discrepancies were noted, these were verified. Similarly, various interviews were matched with each other for consistency or rivalry in opinions. Where contradictions emerged, a third data source from the same method within which triangulation was being (that is, quantitative or qualitative) was compared with. Where the third data source within the method also contradicted, another source from the complementary method (that is, qualitative or quantitative) was cross-checked for verification. For instance, in a key informant interview with key informants at the District Administration of the Atebubu-Amantin District, one key informant remarked that the District has relatively enough tree resources as fuelwood for cooking. However, from the community interviews – both community key informant interview with opinion leaders and household survey, it was evident that access to fuelwood was not as easy as previously. In other cases, triangulation provided the opportunity to infer the depth of data provided from one source of data over the other and assisted in drawing conclusions beyond the general picture. There was the instance where qualitative data confirmed or disproved a quantitative inference. The whole process of analysis was iterative linking all parts of the research consistently. Computer programmes employed were Microsoft Word for transcriptions, figurative descriptions and report writing.

3.11 Limitations of the study

Collecting information on income at the rural level was a challenging task. Rural households rarely keep accounts of their revenue in-flows, and when they do, they are reluctant to disclose. This information was important to analyse the ability to pay to access the necessity or otherwise for financial support options. The researcher selected a sub-sample of 70 percent of the sample under study to obtain income information to be able to illicit as much information as was possible. This quota was selected randomly. The key approach was to avoid asking the questions directly. Rather questions were framed around the livelihood activities (mostly agriculture) of respondents – e.g. how much they harvested, sold, how much was consumed by household, how much stored for the next season, and the unit price of commodities. The analysis of the income data still showed a lot of discrepancies and inconsistences. To overcome this challenge, expenditure was used as a proxy for income due to the fact that respondents were more willing to disclose how much they spent than how much they earned. This approach is accepted in development practice.

In the Upper East Region communities (and houses) were highly dispersed with considerably long travelling times which in some cases were half a day’s journey. Considering the time frame for data collection, it was expedient not to select communities where farmlands were miles and miles away from the communities but to consider Districts and communities where households farmed around their housing compounds. Again, the period of the research also coincided with the farming season. The time of interview had to be scheduled so as not interfere with the farming activities. However, when there was no alternative but it was possible, interviews were conducted on the farm. This was particularly so in the study communities in the Upper East Region where agricultural lands were around the homesteads. Local knowledge gathered also showed that the farmers took their rest in the afternoon when the sun was high up. Advantage was taken of this period of the day. In the Brong Ahafo Region, it was sometimes possible to reach some of the respondents in the early hours of the morning before they left for their farms. Other than that, the other community interviews were conducted until late afternoon when farmers started arriving from the farmers; then the household surveys were undertaken.

In addition, it was difficult to obtain data from some of the District Administrations. Documented data was not readily available, and some officials either did not have key informant information that could be documented during interviews or were simply not interested. To circumvent this challenge, data was gathered from other District Departments and from the communities themselves; observation was also an important tool used. These were triangulated with scanty information from the District Administrations and with independent past reports of other studies.

4 NATIONAL PROVISION FOR RURAL ENERGY SUPPLY

4.1 Rationale

This chapter will be discussed in two parts – the energy development policies defining the institutional framework for energy development in Ghana, and energy improvement interventions both past and present that have had bearing on rural energy development and related rural economic development.

4.2 Energy sector development policy framework

The energy sector development policy framework was first prepared by the Ministry of Energy in 2001 and has undergone three reviews (Ministry of Energy, 2009). It was developed to create among other things an energy economy to secure a reliable supply of high quality energy services for all sectors of the Ghanaian economy. The policy spells out the framework for all the energy sub-sectors. It was developed along a number of key development areas. The development areas that are related to decentralised energy supply for rural areas are the renewable energy sub-sector, the petroleum energy sub-sector, energy efficiency and conservation, and energy and environment. The goal of the energy sector is to make energy services universally accessible and readily available in an environmentally sustainable manner. Subsequently, the objectives of the sector include the following:

i. reducing technical and commercial losses in power supply
ii. increasing access to modern forms of energy,
iii. minimising the environmental impacts of energy supply and consumption through increased production and use of renewable energy and making energy delivery efficient,
iv. ensuring the productive and efficient use of energy,
v. promoting and encouraging private sector participation in the energy sector, and
vi. diversifying the national energy mix by promoting renewable energy sources.

These objectives are well-aligned and support the development of decentralised energy systems. The last mentioned objective emphasised nuclear as its path but, has till date placed more emphasis on other less risky options such as solar, wind and off-grid power production, supported by the well-purported feed-in tariff (FIT).

4.2.1 Government policy on the renewable energy sector

Decentralised energy systems are taken care of in the government policy on the renewable energy sector. The goal of the sector is to achieve ten percent as the contribution of renewable energy, particularly solar, wind, and mini-hydro to the national energy supply mix by 2020 (excluding large hydro), and to develop legislation to encourage renewable energy technology development and utilisation (Ministry of Energy, 2010:20; http://www.energymin.gov.gh/?page_id=212[33]). Even though biomass is not

[33] Accessed 25/11/2013

listed among the renewable resources in the goal above, it is also considered under this sub-sector. The government policy on wind and solar energy focuses on improving the cost-effectiveness of solar and wind technologies, creating a favourable regulatory and fiscal regime, supporting indigenous research and development to reduce the cost of solar and wind energy technologies, and supporting the use of decentralised off-grid alternative technologies where they are competitive with conventional electricity supply. A wind resource study by Solar and Wind Energy Resource Assessment (SWERA) shows total wind capacity of about 5640MW in the country but the potentials are concentrated in the Volta, Eastern, Northern, Brong Ahafo and Ashanti Regions in order of decreasing potentials (See Table 4-2), (SWERA, undated). These areas which are estimated to have Class 3 and higher wind resource occur mainly on exposed terrain features such as hilltops and ridge crests at elevations normally above 450m. In this regard, the Upper East Region does not qualify as a location for wind resource (Table 4-2). Thus the study Districts in the Region are most unlikely to have wind potentials.

Table 4-1: Moderate-to-excellent wind resource at 50m

Wind resource utility scale	Wind class	Wind power at 50m W/m^2	Wind speed at 50m m/s	Total area km^2	Percent windy land	Total capacity installed MW
Moderate	3	300 – 400	6.4 – 7.0	715	0.3	3,575
Good	4	400 – 500	7.0 – 7.5	268	0.1	1,340
Excellent	5	500 – 600	7.5 – 8.0	82	<0.1	410
Excellent	6	600 – 800	8.0 – 8.8	63	<0.1	315
Total				1,128	0.5	5,640

Source: Solar and Wind Energy Resource Assessment, undated (http://en.openei.org/datasets/files/717/pub/ghanawindreport_245.pdf, Accessed 02/01/2014)

Assumptions: Installed capacity per km^2 = 5MW; Total land area of Ghana = 230,940km^2

Table 4-2: Potential moderate to excellent wind resource by Region

Region	Class 3 (km^2)	Class 4 (km^2)	Class 5 (km^2)	Class 6 (km^2)	Good to Excellent Potential (MW)	Moderate to Excellent Potential (MW)
Ashanti	93	11	0	0	55	520
Brong Ahafo	83	17	16	2	175	590
Central	0	0	0	0	0	0
Eastern	285	26	0	0	130	1,555
Greater Accra	0	0	0	0	0	0
Northern	73	53	0	0	265	630
Upper East	0	0	0	0	0	0
Upper West	0	0	0	0	0	0
Volta	181	161	66	61	1440	2,345
Western	0	0	0	0	0	0
Total	715	268	82	63	2,065	5,640

Source: Based on Solar and Wind Energy Resource Assessment, undated

On the other hand, even though the Brong Ahafo Region has elevation ranging between 152m and 712m[34] above sea level, exhibiting possible potential, the study District has elevation ranging between 60m and 300m above sea level (Atebubu-Amantin District Assembly, 2010) and therefore do not fall within potential wind resource. In the case of mini-hydro, the government policy is to provide pricing incentives for mini-hydro projects. Even though the overall potential of mini-hydro is limited, 22 potential medium and small hydro power sites with capacities ranging from 5.6MW to 24.5MW have been identified that could be developed for power generation (Energy Commission, 2012:33).

In the case of biomass, the policy acknowledges that biomass remains an important source of energy and therefore makes provision for sustained production. The policy strategies are to support sustain regeneration of woody biomass through legislation, fiscal incentives, and attractive pricing. Other strategies are to promote the establishment of dedicated woodlots for woodfuel production, promote the production and use of improved and more efficient biomass technologies, and promote the use of alternative fuels such as liquefied petroleum gas (LPG) as substitute for fuelwood and charcoal, by addressing the institutional and market constraints that hamper access to LPG in Ghana. The government also aims at a controlled consumption level of woodfuel of about 16.5 million tonnes per year from the current estimated 20 million tonnes consumed per year (Energy Commission, 2012:14) at a deforestation rate of two percent per annum (Ministry of Lands and Natural Resources, 2012: iv). A number of policies have consequently been put in place to operationalise this control. These are, to support the forestry sector to ensure sustainable management of the country's natural forests and woodlands; ensure the design and implementation of a regulatory framework for commercial transportation and marketing of woodfuel; and regulate charcoal exports to ensure that only charcoal from wood waste and planted forest are exported. Others are, to establish an institutional framework to enhance and co-ordinate woodfuel related activities as an integral part of national energy development including the establishment of a national woodfuel office within the Energy Commission; promote improved technologies and higher levels of efficiency in the production of charcoal and use of woodfuels; and to support the development, promotion and introduction of alternative fuels for the substitution of woodfuels (Energy Commission, 2006). Consequently, some strategic targets have been set for the sector (idem., p24). These are:

i. To reduce the wood intensity of charcoal production (ratio of wood input to charcoal) from existing 4:1 to 3:1 in the Savannah zone and from 6:1 to 4:1 in the forest zone by 2015; and
ii. To ensure that the energy share of traditional biomass (woodfuels) in the national final energy mix is reduced from about 60 percent at present to at least 50 percent by 2015 and subsequently to 40 percent by 2020.

A number of projects were proposed to be implemented between the year 2009 and 2014 in accordance with policy implementation. These included grid connected solar

[34] http://www.ghanahealthservice.org/region.php?dd=6&region=Brong percent20Ahafo percent20Region, Accessed 02/01/ 2014

photovoltaic projects, wind farms, mini hydro development demonstration project, and biofuel project. In addition, the development of the Renewable Energy Law was proposed. Apart from the solar projects which were concrete projects, the stated targets for the other renewable energy were in project preparatory states in the form of feasibility studies. A careful look at the achievements listed by the Ministry of Energy (MoEn) (*Meet the Press – Energy for a better Ghana, September 2012)* as at September 2012 shows that the Renewable Energy Act 2011 (Act 832) has been passed. With regards to the proposed renewable energy projects, solar development has taken the lead as a result of the Ghana Energy Development and Access Project (GEDAP) which has resulted in the distribution of about 9,536 solar systems to rural households in off-grid communities in 80 Districts since its inception in 2009 (idem.). Solar systems were also supplied to remote health facilities also known as the Community-based Health Planning and Services (CHPS) compound. The promotion of bio-energy in the form of improved cookstoves has been achieved as public-private partnership with the UN Foundation for the provision of cookstoves (idem.). The Ministry has as well signed onto the Global Alliance for Clean Cookstoves. However, the other proposed renewable projects - wind, mini-grid electrification, and small and medium hydropower - are in the prefeasibility and preparatory stages. In addition to the achievements listed by the Ministry of Energy, there have been numerous other private interventions being implemented before the passing of the Renewable Energy Law, which nonetheless have been hindered due to unclear government will and support. The energy policy document asserted that high cost of solar and wind technologies is one of the deterring factors for the development of the renewable energy sub-sector (MoEn, 2010:29). Nevertheless, it is internationally acknowledged that over the years there has been exponential development in the sub-sector bringing their costs considerably lower.

4.2.2 Energy efficiency and conservation

Energy efficiency and conservation has also become one of the key areas of concern in addressing energy sector issues. This cuts across grid electricity, biomass and petroleum consumption. However, the emphasis of the policy document rests mainly on power and petroleum sub-sectors. Estimated losses in electricity are 25 percent in distribution and 30 percent end-use (MoEn, 2010:37). In the past, the government used pricing to regulate energy conservation and efficient use. The current policy direction among others is to continue to use pricing regime through a demand-side management programme as an incentive for domestic and industrial consumers to voluntarily manage their energy consumption, and to create public awareness (idem.). The effect of this can be observed in two-fold: for urban consumption, the objective of the pricing regime is achieved and wastage is controlled. For rural consumption however, the costs are prohibitive for fuel consumption. For example, the current cost of kerosene (in addition to its unavailability which increases the ex-pump price when fuel is transported from main retail fuel stations to rural areas by local retailers) is deterring rural consumption (Author’s field study - Key informant interview with Official at Ministry of Energy, 25th May 2012; Household survey May-July, 2012). The same is true of LPG. A National Petroleum Authority (NPA) survey of rural LPG use in the Northern Regions of Ghana indicated that 96 percent, 86 percent and 98 percent of rural respondents in the Northern, Upper East and Upper West Regions were willing to use LPG if it were accessible at affordable price (NPA, undated). Cross-subsidisation introduced in the petroleum sector into the price build-up of petroleum to subsidise other petroleum products such as LPG (Key informant interview with Official at Ministry of Energy, 25th May 2012) only favoured urban consumption. In the case of electricity, the lifeline tariff band which designates consumption below or equal to 50kWh to a specific flat rate (Public Utility and Regulatory Commission, 2013) was introduced.

Even though the efficiency on the use of biomass resources are not specifically discussed in the policy document, the provision for their efficient utilisation through the use of improved technology is discussed briefly under policies and strategies for renewable energy without specific strategies. The Author's field research (May-July, 2012) showed that, the issue of biomass use efficiency is handled mostly by the private sector through the promotion of improved cookstoves. "Gyapa", (which translates as *good fire)* and "Ahebenso" (which translates as *hard rock that does not burn easily*, implying the efficiency of the coal pot in saving charcoal) are the most popular improved cookstoves on the market. Envirofit, another improved cookstove that was identified during the field research that uses gel-ethanol is also mainly a private sector-led promotion programme. In section 4.4.3, this is further discussed.

From the discussion above, government efforts at energy efficiency and conservation seem to dwell much on cooking energy. Nonetheless, energy efficiency and conservation concerns create a niche for decentralised energy power supply systems. Decentralised energy (DE) promotes efficiency in energy production and use by their design. Even though in the African context and in the context of the study, a major reverse from centralised energy to decentralised energy systems is not advocated or anticipated, it is anticipated that inefficiency and the related losses that would have accompanied the transmission of power over long distances to remote areas could be prevented with DE systems. Again, even though the policy goal to address energy inefficiency dwells more on urban than rural consumption, inefficiencies at the urban end affect supply to both urban and rural consumption. Energy inefficiencies affect both and more especially rural areas which are more or less given second grade consideration when alternative options for energy supply is sought: when power supply is not enough, there is a high propensity for load shedding to be considered in favour of the urban against the rural; petroleum product shortage affects rural supply more than urban supply, affecting productivity. Even with biomass, market forces play a critical role as biomass producers in the rural areas take advantage of urban demand and direct their supply there as against rural demand (Amaka-Otchere, 2006), a phenomenon which affects the dynamics of traditional rural energy supply. The Author's field research (May-July, 2012) showed that charcoal producers in the rural areas do not sell to their communities but export to urban centres for higher prices.

4.2.3 Energy and the environment

Production and use of energy has an impact on the environment. These impacts include deforestation, and carbon dioxide (CO_2) emissions from fossil-based interventions. CO_2 emissions have become topical in all energy discussions from large scale energy consumptions in the developed countries, to small scale consumption in less industrialised developing countries. The UK branch of Greenpeace, an international environmental activist network indicates that as well as massively reducing wastage of energy and resources, DE systems present the opportunity to reduce CO_2 emissions through the efficiency in the energy production and use (Greenpeace, undated[35]). The policy direction is to promote the use of environmentally friendly energy supply sources such as renewable energy in the energy supply mix of the country and promote the use of improved wood fuel burning equipment for cooking in households and other commercial activities (MoEn, 2010). The policy also seeks to ensure that Environmental and Social Impact Assessment are conducted on energy projects, and in addition establish and implement environmental facilities such as carbon credit. In addition, the policy aims at supporting and promoting active participation of the government in international efforts and cooperating with international organisations that seek to ensure sustainable delivery of energy to mitigate negative environmental impacts and climate change (ibid.).

4.2.4 Inferences from government policy on the power sub-sector

The power sub-sector is fundamentally concerned with centralised grid connected electricity generation and distribution. This research does not intend to investigate the policy framework for the power sector development due to the centralised nature of the sub-sector. However, the challenges of the sub-sector identified by the policy document (MoEn, 2010) provide a good platform for the development and promotion of decentralised energy (DE) systems and put the argument for the development of DE systems on a pedestal. The energy policy strategy document identifies the following as the challenges in the power sub-sector: (i) inadequate power supply infrastructure requiring huge investments; (ii) inadequate access to electricity; (iii) high cost of fuel for electricity generation; (iv) inadequate regulatory capacity and enforcement; (v) operational and managerial difficulties in utility companies, and (vi) vulnerability to climate change (ibid.). The challenges enumerated show that one of the significant challenges of the power sector is to attract investment to build the necessary infrastructure for generation, transmission and distribution of electricity. Then again, world oil prices are unstable, unpredictable and on the continual rise rendering thermal generation of electricity increasingly costly. By implication, the country has insufficient capacity to solely undertake these centralised electrification activities. This presents a strong argument for the development of DE systems which do not have huge cost implications which is totally dependent on foreign capital investment. Again, DE systems may not need oil to function. When they do, as in the case of the multifunctional platforms (MFP), the oil requirement is much less. What is more, there are recent technological investigations that seek alternative biomass-based fuel for oil based decentralised systems.

Cost recovery is also another challenge of the sector when the public sector partners with the private sector in the development of new plants for the power sector. These are often results of other challenges such as inadequate regulation as well as operational and management difficulties. Even though DE programmes could also suffer from this challenge as was in the initial stages of implementation of the Renewable Energy

[35] http://www.greenpeace.org.uk/MultimediaFiles/Live/FullReport/7154.pdf. Accessed 02/11/2013

component of the Ghana Energy Development Access Project (GEDAP), the risk is considerably reduced because the investment is less. Furthermore, in an assessment of the poverty and social impact of electricity reforms, a collaborative report between the World Bank and the Government of Ghana observed that tension existed between political incentives of expanding grid connection and the incentives of the commercially-oriented utility (Government of Ghana/World Bank, 2004). While for political reasons grid extension to low consumption communities is of interest, the more dispersed customers who are more lifeline consumers (that is, consumers who consume between 0-50kWh of power per month and pay a flat rate) create an upward pressure on tariffs for the other categories of customers and increases in cross-subsidies (ibid.). This upward pressure when effected, is not always a welcomed situation for the higher tariff band category of customers or for the politics.

4.2.5 International affiliation - UN Sustainable Energy for All

In recognition of the critical need to improve global access to sustainable, affordable and environmentally sound energy services and resources, the United Nations General Assembly declared 2012 as the International Year of Sustainable Energy for All and urged Member States and the UN system to increase the awareness of the importance of addressing energy issues and to promote action at the local, national, regional and international levels (Energy Commission, 2012). The target is to achieve Sustainable Energy for All by the year 2030. The key objectives under this goal are: (i) ensuring universal access to modern energy services; (ii) doubling the rate of improvements in energy efficiency; and (iii) doubling the share of renewable energy in the global energy mix. The Ghana action plan of the initiative reiterated the policy objectives stated under the various components of the Energy Sector Development Plan, viz, (i) universal access of electricity, (ii) ensuring universal access to clean fuels and devices for cooking and heating through the promotion of liquefied petroleum gas (LPG), improved cooked stoves and productive uses of energy, (iii) energy efficiency, and (iv) increasing renewable energy supply in the national energy mix. Of interest in this study is the rural energy supply improvement component embedded in all components of the action plan. Apart from the universal access to electricity which emphasizes the central energy connection through the national grid, all the other components of the plan dictate a decentralised energy approach using both renewable energy resources and fossils. The plan of action cuts across all possible energy demand from domestic to economic uses. These have been identified and listed in Table 4-3.

Table 4-3: Rural energy supply component in the Ghana Action Plan

Component of Action Plan	Rural energy supply component
Electricity	i. Promotion of productive use of electricity to accelerate agriculture and industrial development to address limited productive uses of electricity. ii. The national target for electricity use in agriculture and fisheries is two percent by 2015 and five percent by 2020 as against the UN target of ten percent by 2030
LPG access	i. The national target is 50 percent across all households including rural households by 2015 as against the UN target of 50 percent by 2030 ii. Expanding storage capacity and extending bulk distribution infrastructure to all parts of the country: re-capitalise the Ghana Cylinder Manufacturing Company (GCMC) to expand production capacity with the production of cylinders focused on small sized cylinders that will be portable and affordable to households in rural communities
Improved cookstoves	i. Enhance the capacity of local and national institutions to promote advanced biomass cookstoves ii. Promote awareness, consumer research and business development taking into account consumer preferences and behaviour iii. Reduce rural household woodfuel use intensity by ten percent by 2020. The UN target is ten percent by 2030 putting the country plan in the lead.
Productive use of energy	i. The National Energy Policy 2010 specifies that productive uses of electricity will be promoted as an integral part of the Rural Electrification Programme. The objective is to stimulate economic development by ensuring that energy plays a catalytic role.
Share of renewable energy in the national energy mix	i. The national target for renewable energy as decentralised energy in the rural energy mix is ten percent by 2020. The UN target is to double the share which was 13.1 percent in 2009 ii. Long-term sustainability of biomass production iii. Financing for energy generation from solar, wind and mini-hydro

Source: Author's Construct based Energy Commission, 2012 – Country Action Plan

The forgone discussion throws light on government's will concerning rural energy supply. So far the policy on renewable energy sector demonstrates a commitment to rural energy supply. This is because most of the proposals are more rural focused than urban. Among the proposals, solar lighting initiatives are the most advanced. However there are other possible technological applications of solar that are still under-developed such as water pumping, irrigation, and water heaters. These could increase rural productivity. The other decentralised energy technologies are untouched by government policy with regard to implementation: wind measurements have been over explored but till date no significant wind project has successfully taken off, and small hydro sites remain unexploited. Extra efforts are required to move policy from the formulation stage to the implementation and execution stages. The government's commitment to current international drive on ending energy poverty has also demonstrated a rural energy pathway. Important to the achievement of this pathway is the structuring of implementable and sustainable projects that specifically address the economic development needs of the rural populace for which they are planned.

4.3 Stakeholder analysis: Institutional framework for decentralised energy supply

To assess the role, interest, degree of influence, and the level of organisation of stakeholder institutions in the renewable energy sector, an analysis of the stakeholders was undertaken. The purpose was to understand how the actors involved in making or influencing policy affect the outcomes of the policy. Stakeholder analysis can also be used to gauge incentives for individuals within institutions and organisations that influence how policies are implemented in practice (Government of Ghana/World Bank, 2004). A careful look at the structure of the energy sector showed that until 2010, the major institutions involved in the energy sector were mainly the power sub-sector and petroleum sub-sector institutions, and the regulatory agencies. In both the energy policy framework and the accompanying strategy document (MoEn, 2010), there was no specific provision for a renewable energy sub-sector institution, even though the documents provided strategies towards promoting the sector. This clearly indicates a handicap in the technical provision for the sector and in the development and promotion of the sector. Drawing inference from the Bottom of the Pyramid theory, it would be difficult to achieve expected results when the dominant logic prevailing in the energy sector was focused on making conventional energy sources work. This logic refused to appreciate a possible vibrant and profitable industry particularly for the rural areas in a non-conventional energy sub-sector. The renewable energy sector therefore remained suppressed and undermined until 2010 when the Renewable Energy Directorate was created.

4.3.1 The Ministry of Energy

The Ministry of Energy (currently Ministry of Energy and Petroleum) is responsible for the formulation, implementation, monitoring, and evaluation of energy sector policies. The Ministry deems electricity as the dominant modern energy used in the industrial and service sectors (MoEn, 2010). It also acknowledges that the generation and supply of electricity provides employment for a significant number of Ghanaian professions, and is as well an important source of foreign exchange earnings through the exportation of power to surrounding countries. Consequently the Ministry prioritises the provision of electricity through the grid over other forms of electricity production. Being a traditional institution, it was for a long time more concerned with the conventional forms of energy provision and thus, until the year 2010, its main directorates were the Petroleum and Power Directorates. Although a rural electrification agency was suggested, it was not implemented because it required the creation of another level of bureaucracy (Abavana, 2010). It may be inferred that with the current establishment of the Renewable Energy Directorate, the Ministry currently acknowledges the importance of separating this Directorate from the core priorities of the other two Directorates to prevent the dominant logic of the two Directorates from overshadowing the renewable sector and to ensure that the goal of ten percent renewable energy proportion in the country's total energy mix is achieved. In addition, the Renewable Energy Act 2011, Act 832, taxes the Ministry as responsible for providing the policy direction for the achievement of the objectives of the Act (Government of Ghana, 2011).

4.3.2 The Renewable Energy Directorate

The aim of the Renewable Energy Directorate is to develop policies and promote renewable energy to increase access to sustainable energy services (http://www.energymin.gov.gh/?page_id=205[36]). Renewable energy resources considered by the Directorate are woodfuel, hydro, solar, wind, biofuel, waste-to-energy, and animal traction. This study is concerned with all but waste-to-energy which has more significance in the urban areas where large tonnes of waste are generated. To provide a legislative and institutional framework for operation, the Renewable Energy Act was passed in 2011.

The Renewable Energy Act 2011 – Act 832

The Renewable Energy Act (832) was passed in 2011 to provide a legislative and institutional framework for the promotion of renewable energy (Government of Ghana, 2011). The objective of the Act is to provide for the development, management and utilisation of renewable energy sources for the production of heat and power in an efficient and environmentally sustainable manner. The Act among others made provision for (i) feed-in-tariff scheme under which electricity generated from renewable energy sources are offered at a guarantee price, (ii) licensing regime for commercial renewable energy service providers to ensure transparency in the renewable energy industry, and (iii) the establishment of the Renewable Energy Fund to provide incentives for the promotion, development and utilisation of renewable energy resources.

The idea of the feed-in-tariff (FIT) is designed to promote investment in renewable energy for the purpose of guaranteeing the sale of electricity generated from renewable energy sources. The tariff only becomes beneficial when communities are connected to the national grid. Experiences from the past have shown that where the possibility of connection to the national grid exits, communities will not be interested in solar and other off-grid electrification and would rather want to be connected to the national grid, unless the communities had first the decentralised system before the option to connect to the national grid. This isolates rural communities which are not connected to the grid. The Renewable Energy Fund is yet to the established; feasibility studies are still in progress[37].

4.3.3 The Regulatory Agencies

In terms of regulation, the Energy Commission (EC), the Public Utility Regulatory Commission (PURC) and the National Petroleum Authority (NPA) are three regulatory agencies established by Acts of Parliament to ensure the proper functioning of all players in the energy sector and to create the requisite conducive environment for the protection of private investment in the sector. Their roles with regards to the renewable energy sub-sector have been identified in Table 4-4.

[36] http://www.energymin.gov.gh/?page_id=205. Accessed 14/11/2013

[37] http://www.energymin.gov.gh/?p=882. Accessed 07.11.2013

Table 4-4: Regulatory Agencies in the Energy Sector

Regulatory agency	Role
Energy Commission (EC)	• Regulation, management, development and utilisation of energy resources particularly with licensing of operators and setting technical standards • Advises the Minister of Energy on energy matters Specifically for Renewable Energy development, it i. Creates a platform for collaboration between government, private sector and civil society for the promotion of renewable energy ii. Advices on incorporating renewable energy into educational curriculum iii. Advices on tax and levy exemptions for the development of renewable energy iv. Consults with the PURC on rates chargeable v. Promotes the development of renewable energy through local manufacturing of components, training, advocacy vi. Implements the provisions of the Renewable Energy Act 2011, Act 832
Public Utilities Regulatory Commission (PURC)	Generally responsible for monitoring quality of service and consumer protection, and providing guidelines for rates to be charged for the provision of utility services For the development of Renewable Energy, it performs these specific roles: i. Approves rates chargeable for the purchase of electricity from renewable energy sources by public utilities ii. Approves charges for grid connection from renewable energy iii. Approves rates chargeable for wheeling of electricity from renewable energy sources
National Petroleum Authority (NPA)	Responsible for both the licensing of operators in the downstream petroleum sector and setting technical standards and enforcement as well as pricing of petroleum products With regards to renewable energy development, it considers the nature of fuel produced from renewable energy resources to ensure the integration of relevant renewable energy project into the fuel supply system

Sources: Ministry of Energy, Ghana – National Energy Policy, February 2010; Renewable Energy Act, 2011 (Act 832); Energy Commission of Ghana, http://www.purc.com.gh/purc/ (Accessed 07/09/2014)

Among the three regulators, the role of the EC is paramount in the promotion of decentralised energy since the EC by the commission of the Renewable Energy Act - Act 832 is mandated to implement the provisions of the Act. Energy resources considered under the Act and relevant to the study are wind, solar, hydro, biomass, and bio-fuel.

4.3.4 The District Assemblies

Ghana has a decentralised form of government and therefore the country is administered through a system of local governments. These local governments are referred to as Districts Assemblies. There are currently 138 Districts Assemblies who are responsible for the overall development of their Districts. According to their sizes, populations and functionalities, District Assemblies may be upgraded to Municipal or Metropolitan Assemblies. At the District Assembly (DA) level, issues of energy are treated under the

Works Sub-committee (Institute of Local Government Studies and Friedrich-Ebert-Stiftung, 2010). The sub-committee is basically concerned with power transmission and distribution. In terms of power supply, the DAs have very minimal control. Their control is limited to community selection and communicating the results of the selection to the Ministry of Energy. They lack the power to implement. Fossil fuels are supplied and depots built according to central government mandates over which the DA has no control. The other energy concerns are unconventionally handled among different district departments, i.e. Forestry Department, Department of Food and Agriculture, Department of Water, and Environmental Protection Agency (EPA) in collaboration with the private sector. For example, the Departments of Food and Agriculture, and Forestry, and the EPA by virtue of their mandates are concerned about bio-fuel and woodfuel production and use. The provision of other non-conventional energy is mostly undertaken by non-governmental organisations, private investors, or by development partners as part of central government programmes. In the following discourse, the situations as pertains in the three study Districts are examined.

The Medium Term Development Plan (MTDP) (2010-2013) of the Builsa District treats energy under the Human Development, Productivity and Employment thematic area, instead of under Infrastructure, Energy and Human Settlement Development (Builsa District Assembly, 2010). The major energy activity mentioned is an on-going rural (grid) electrification programme, even though an off-grid electrification programme has been underway in the District since the year 2010. This iterates the scattered and disaggregated manner in which energy is handled, and the priority given grid electrification over other energy forms. Furthermore, even though it is part of the MTDP to increase energy for domestic use through 'assisting communities to develop woodlots, introducing renewable energy technologies such as solar PVs and biogas, and introducing and promoting energy efficiency technologies' (Builsa District Assembly, 2010), attention was not given to specific strategies and activities that will make these objectives implementable under the logical framework under the energy thematic area. The DA as an agent of change and development is not active in the energy development of the District. In a key informant interview with the District Planning Officer, it was asserted that the DA is rarely consulted on government and development partners' intended interventions (Author's field study - Interview with District Official, 4th June, 2012).

In the Kassena-Nankana East District, energy challenges named in the MTDP (2010-2013) were inadequate supply of electricity, unreliable electricity supply, and high cost of alternative source of energy, precisely solar (Kassena-Nankana East District, 2010). These were discussed under the Expanded Development of Production Infrastructure theme. This is an indication that the DA recognises the important role energy plays in the production equation. The corresponding development priorities were extension of electricity to more rural communities, promoting the use of solar lighting system, and promoting the use of LPG. This District was relatively specific in the development of the energy infrastructure within the planned period: to increase the number of communities with access to electricity by ten percent by 2013, and to connect 45 communities to solar lighting system by 2013. Detailed time schedules and specific communities were indicated. Similar to the national situation, grid electricity provision was the most prioritised. Other equally important energy needs such as cooking and agriculture production were overshadowed. It is also important to note that these districts are rural districts. Apart from the district capital and a few other towns, the majority of the communities are rural communities according to Ghana's definition of rural communities. In Kassena-Nankana East District, out of the 216 communities, only the district capital, Navrongo, is urban. The remaining 215 communities are all rural. According to the National Electrification Programme Report (Abavana, 2010), all district capitals are connected to the grid, including Navrongo. Therefore the indication in the District development plan to extend electricity to ten percent of the communities and to connect 45 communities refers specifically to rural communities. It is much clearer in this District that the lead implementing agency is the DA with collaboration from donors. However, the District still depended principally on the central government and other external partners for funding rather than on the District's Internally Generated Funds (IGF). This continues to serve as a weak point in the role of the DA. Even though it may be effective in policy formulation, the needed investment lies outside their control and therefore hindered effective implementation.

In the Atebubu-Amantin District, about 45 percent of the District's population reside in the two main urban centres in the District, that is, Atebubu and Amantin (Atebubu-Amantin District, 2010). The remaining 55 percent live in rural communities. There are 29 recognised communities in all with a number of dotted hamlets. The Author of this study had no access to the detailed Action Plans over the planned period of the District's MTDP or the list of development priorities. The part of the MTDP that was available was the situational analysis. Thus, information presented in this report on the energy situation was gathered from the situational analysis, interview with District Planning Officer and from community survey carried out from May to July 2012. Power supply in the District is available to the two major communities – Atebubu and Amantin - and their immediate surrounding communities which by virtue of their closeness are able to connect with additional low tension poles. Power is supplied from a sub-station in Techiman, which is the district capital of a neighbouring district, Techiman District. Power supply is unreliable because of the load on the Techiman sub-station which serves the district itself, the Atebubu-Amantin District and three other surrounding districts, that is Pru, Nkoransa and Sene Districts. Cooking energy in Atebubu-Amantin District is basically supplied from biomass. The District Planning Officer asserted that *"there is enough firewood in the District from the farms and the bush" (*Author's field study - Key Informant interview with District Officials - Atebubu-Amantin District, 19th June, 2012*)*. The District is also intensely involved in biomass energy production for the country, producing and supplying charcoal to the major cities of the country, viz, Kumasi, Accra, and Tema. The District obtains its supply of liquefied petroleum gas (LPG) from Ensanwakyi, a community which is about four kilometres from the District capital, Atebubu. However, the capacity of the depot is unable to serve the whole District. Alternative sources of LPG are Techiman and Ejura which are neighbouring Districts but the supply is also inadequate. The District Assembly's involvement in the development of energy in the District is very minimal. It plays the defined role of DA in government electrification project which is the selection of communities for the Ministry of Energy in District electrification projects, but it has no implementation power. Two of the communities studied, Kumfia and Fakwesi, were recommended for electrification before the change of government in 2008 and transmission poles were erected. Reports from the communities indicate that the projects have been abandoned since the change of government (Author's field study, May-July 2012). Moreover, there was no indication that the DA initiated or supported alternative energy initiatives at the time of study. The only one identified was the United Nations Development Programme's (UNDP) multifunctional platform project implemented in April 2005. Without an action plan or medium term development priorities, the energy development direction of the District cannot be easily determined.

The issue of political interest also plays a major role in District energy policy. Some political interests are handed down to the District Administration from the Central Government. Grid electrification suddenly appears where access had been planned in the next five or ten years. Although these end up increasing access, it also distorts planned District energy supply programmes as well as alternative energy supply plans and investments by development partners. On the other hand, planned energy supply programmes are sometimes halted due to change in government and the necessary change in the administrative machinery that comes with it. An example of that was reported in both Kumfia and Fakwesi, two of the study communities in the Atebubu-Amantin District in the Brong Ahafo Region, (Author's field study - Key Informant Interview with Unit Committee Chairman, Kumfia Community 20th June, 2012; Key informant interview with Assemblyman, Fakwesi Community 21st June, 2012).

4.3.5 Private investors and research institutions

Private investors, non-governmental organisations (NGO), and research institutions have been the major players in promoting renewable energy at the time the Central Government concentrated itself on expanding the grid. Private investors include chains of suppliers and distributors. The rural market has been recognised as mainly unprofitable, a situation which deters private investment. Consequently, NGOs and private investors which venture into the market do so in most cases according to their own rules of operation. Private investors may also have exploitative interest for the mere reason that energy resources are unequally distributed around the globe. One such example in the development of renewable energy is the development of biofuels by Kiminic Corporation. Kiminic's marketing strategy is focused on the distribution of Jatropha crude oil and biodiesel among other products in other West African countries, Europe, and Asia in addition to its marketing targets in Ghana (http://kimminic.com/about/market-focus, Accessed 18/11/2013). It has an off-take agreement with a major strategic partner for the distribution of biodiesel in Europe. In that case, production concentrates on satisfying the bigger international market to the detriment of the smaller local market. In some cases, the effect of these interests on the resource ownership and the local people are ignored. A key informant interview conducted in the Atebubu-Amantin District revealed that family lands stretching over thousands of hectares, supposed to serve as sources of livelihood have been leased out by traditional rulers who are custodians of these lands to Kiminic Corporation for biofuel production (Author's field study – Key Informant Interview, Atebubu-Amantin District, 20th June 2012). However, the land owners have not been necessarily employed on the Jatropha farms or its subsequent processing activities to compensate for their loss of their source of livelihoods.

On the other hand, the renewable energy policy formulation process by the government rarely involved the private sector and the sector complains of unfavourable investment conditions (Author's field study - Key informant interview with selected renewable energy providers, May-July 2012). Attempts have been made to bring the government and private investors together in Stakeholder Consultative Fora for such discussions. These stakeholders are also faced with a challenged due to the fragmented way in which they implement their individual activities with little coordination between them. This presents a weak front and not enough leverage for their involvement in policy formulation in the sector. For instance, during interviews with key private sector investors they expressed dissatisfaction with their level of involvement in the drafting of the recently passed Renewable Energy Bill and the implications of the provisions of the Bills on their activities as private investors.

Energy research institutions cover a broad spectrum of activities in energy development and access, covering research into emerging technology, conducting baseline and feasibility studies, partnering with the government and development partners to pilot and/or implement energy supply initiatives particularly in the rural and peri-urban areas of the country, facilitating knowledge sharing on findings, and even spear-heading energy stakeholder consultative fora between the private sector and the government. Through their research activities and active involvement with national and international stakeholders, the research institutions are able to prompt energy development trends and stimulate policy implementation.

4.3.6 Development partners

Almost all large and medium scale energy access initiatives in Ghana have been funded by international development partners such as the World Bank, African Development Bank, United Nations Development Programme, and Shell Foundation which provide both the capital investment and the technical support for these initiatives. Areas of intervention cut across power, petroleum and renewable energy sectors. For instance the World Bank was involved in the poverty and social impact assessment (PSIA) of the power sector reform of Ghana and the implication of tariff adjustment on the poor (Government of Ghana/World Bank, 2004); Shell Foundation funded a biogas feasibility study in collaboration with Netherlands Development Organisation (SNV) and KITE, a not-for-profit energy and development organisation based in Ghana, in the three Northern Regions of Ghana (KITE, 2008); and Phillips Lighting played a leading role in promoting solar energy supply in energy poor sections of the country through the Affordable Energy for All (ALFA) project (KITE, 2008). The recent Ghana Energy Development Access Project (GEDAP) is a multi-donor funded project involving the World Bank-International Development Agency (IDA), Global Environment Facility (GEF), African Development Bank (AfDB), Global Partnership on Output-based Aid (GPOBA), Africa Catalytic Growth Fund (ACGF), and the Swiss Agency for Development and Cooperation (SECO) (MoEn, 2007). The extent of their investment has given them significant leverage in influencing policy decisions. For instance, development partners are key members of the Ghana Energy Sector Working Group[38].

4.3.7 Local financial institutions

Local financial institutions in the form of microfinance institutions (MFIs) and rural banks play a major role in the promotion of renewable and decentralised energy sources at the rural level. They are contracted by both the government and private investors in the process of supply and deployment. It is usually the case that rural consumers do not have the full financial requirement to acquire DE systems. Most rural consumers are farmers and the seasonality of their incomes presents a financial challenge for immediate and whole payments. Hence, the local financial institutions play a mediation role by providing facilities such as guarantee trust funds and loans. Local financial institutions are mostly contracted separately from the mainstream programme. The roles these local financial institutions play are quite critical in the sense that the deployment of DE systems is commercial. The local financial institutions are in most cases familiar with the rural economic landscape and may be better adept in loan recovery than a private or even government investor (Author's field survey - Key informant interview with GEDAP Project Officer, Builsa Community Bank, 8th June, 2012). Then again, these institutions could also serve as financial support for further development and improvement in DE technologies. In spite of these roles, they are not involved in policy formulation. From the field research, the financial institutions were only involved when financial issues arose in the deployment of energy systems and therefore were separated from the planning of the deployment of energy systems (Author's field survey- Financial institutions interviews, May-July 2012). In many past instances, loan recovery had been extremely poor due to failure of the DE systems and the resulting disillusionment of beneficiaries. Thus, other than not being involved in the deployment planning, the financial institutions are sceptical to be involved in DE programmes and promotion. Some have changed their loaning policy to loaning only for productive uses. For three out of the four rural banks and MFIs interviewed, they no longer operated farm loans let alone loans for DE systems, the productive capacity of which the banks could not readily ascertain. The financial institutions that were actively involved in the distribution of DE at the time of field research were those under Apex Bank[39] contracted by the GEDAP project. The provisions under the GEDAP project were different from those of previous projects, an improvement over the failures of past DE projects such as the Danish Development Agency (DANIDA) fee-for-service implementation strategy. The local financial institutions could also not be certain of cost recovery when government energy policies, especially electrification policies, change

[38] http://www.energymin.gov.gh/?p=1497. Accessed 13/11/2013

[39] The GEDAP component to provide off-grid electrification with solar-PV systems in the rural areas involved the provision of solar PV systems (25 - 200 Wp) for lighting in 15,000 homes away from grid power lines. The line of credit facility was to provide long term liquidity for financing consumer loans. The International Development Association (IDA) line of credit provided 80 percent through ARB Apex Bank for consumer loans and the rural banks contributed 20 percent of the loans. The Solar PV grant provided partial subsidies of up to 50 percent to consumers to make solar home systems (SHS) affordable and ensure adequate demand.

overnight: where grid was expected in ten years, communities could be connected in three years, distorting repayment for DE facilities by beneficiaries. When they are involved in policy formulation, such pertinent issues could be thoroughly considered.

4.3.8 The Rural community

The rural community is rarely involved in the formulation of rural energy policies. It serves as the source of data for baseline studies, feasibility studies and pilot programmes. Notwithstanding, through the baseline studies, information is also derived on energy expectations of rural communities which could inform policy. Sometimes, the rural communities organised themselves to request for energy, particularly to be connected to national grid (Author's field survey - Community interviews, May-July 2012). Requests are sent to the DA either through the Assemblyman who is the community's representative at District Assembly's sittings or through the Unit Committee.[40] Community requests could thus also influence development plans and programmes of the DA. In the case of renewable decentralised energy supply, most rural communities are ignorant of what options there are and can therefore rarely contribute to policy decisions in that regard.

The above discussion highlights the fact that energy decision making lies more with policy makers than with beneficiaries; it also shows the low degree to which the private sector which is the key force behind renewable energy development participates in decisions that affect their operations. Again it is obvious that the central government plays a key role in the development of renewable energy: this key role could serve as an assurance for private investors and financial institutions and a surety for beneficiaries if all the stakeholder units are adequately involved. The discussion is illustrated graphically in Figure 4-1.

[40] The Unit Committees are at the lowest level and form the basic unit of the Local Government structure. The Unit Committee consists of not more than 15 persons made up of ten elected persons ordinarily resident in the unit and not more than five government appointees. The Unit Committees provide structured mechanisms of representation, participation and accountability from village levels upward (Institute of Local Government Studies and Friedrich-Ebert-Stiftung, 2010)

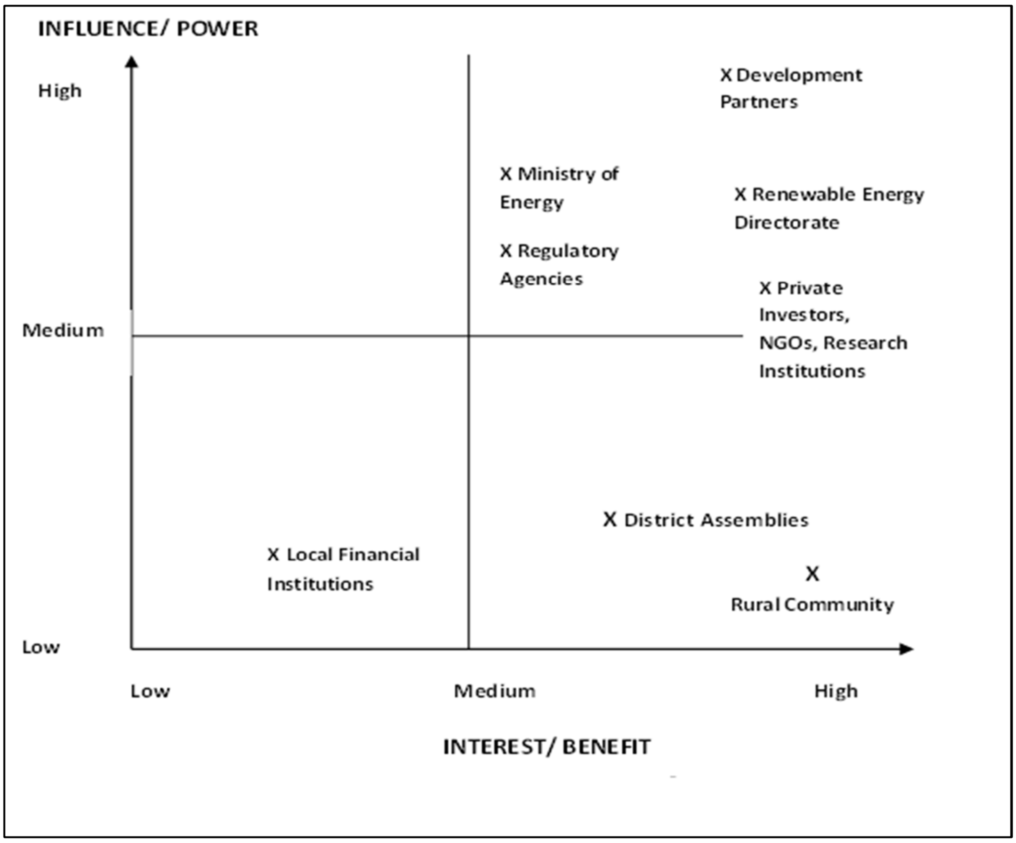


Figure 4-1: Influence and interest of key stakeholders in rural energy supply
Source: Author's construct

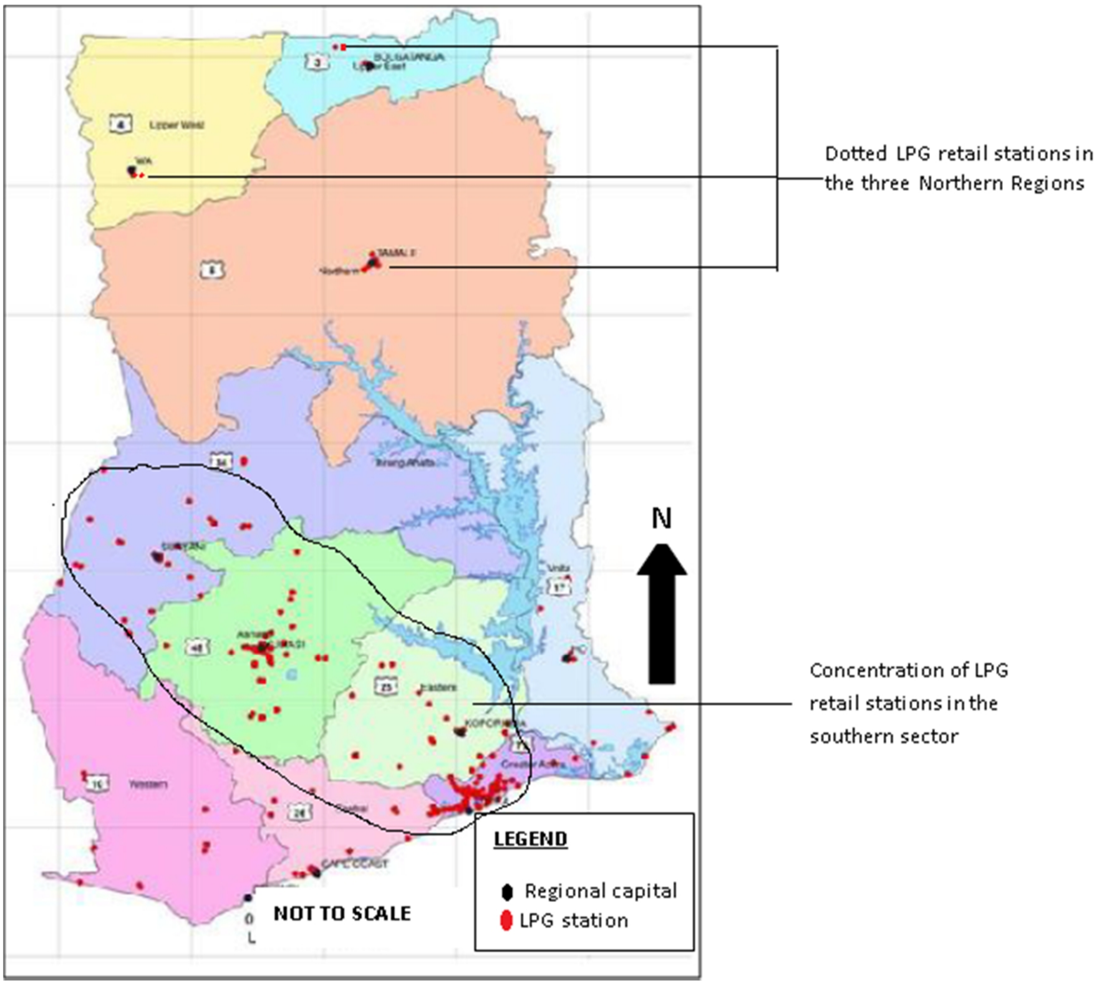
4.4 Specific energy supply improvement programmes

There have been several national decentralised energy access initiatives towards improving energy supply in the hinterlands. These are reviewed to assess the extent of their contribution to rural energy supply.

4.4.1 LPG Promotional Programme

The first national Liquefied Petroleum Gas (LPG) promotion programme was launched in 1989 (Energy Commission (EC), 2012). It aimed at ensuring wider use of LPG as a substitute for charcoal and firewood. The strategies were to make the product affordable with low first cost particularly with the purchase of cylinders and LPG cookstoves, improve the distribution throughout the country, create public awareness on its safety to diffuse fears on its risk of usage, and to promote the establishment of a local appliance manufacturing industry (ibid.). However, the priority of the programme was the urban populace, giving minimal consideration to the rural population. Consequently, till 2008, less than one percent of the rural populace (0.7 percent) used LPG while about ten percent of urban consumers used it (KITE, 2008). Another significant aspect of the programme was the subsidy component, i.e. cross-subsidies from other petroleum products particularly gasoline and diesel which aimed at making the fuel affordable to households. This however served as an attraction to the transport sector – taxis and commercial buses – increasing the transport sector's consumption over household consumption. This, in addition to the gross inefficiencies of the country's only refinery – the Tema Oil Refinery (TOR) - resulted in an acute shortage of supply. Most urban public institutions particularly educational institutions which were earlier co-opted into the programme reverted to the use of charcoal and firewood. Households in the urban centres also either reverted to the use of charcoal, or increased their use of charcoal as supplementary cooking fuel. With this level of shortage in the urban centres, rural access to supply has been almost negligible. Moreover, LPG depots are located in urban centres. In Map 4-1, the LPG retail stations in the country are shown. Generally, the stations are located in the middle and southern belts. There is a high concentration of stations in and around Accra, the capital city, and also around Kumasi, the second largest city in the country. The rest are scattered within the southern sector. The situation in the northern sector of the country is very different. There are a few dotted stations in Tamale, Bolgatanga, Navrongo and Wa. Obviously, this has implications for access. While the number of stations and therefore the fuel is inadequate for the urban centres where they are situated, it is a disincentive for rural dwellers in these three Northern Regions to travel long distances for the fuel. The 2000 Population and Housing Census data indicated that the percentage of household LPG use was six percent with an urban-rural distribution of 11.8 percent and 1.1 percent respectively (Ghana Statistical Service, 2005). The 2010 Census report shows a 203 percent increment of the residential consumption to 18.2 percent with an urban-rural distribution of 28.9 percent and 4.8 percent respectively (Ghana Statistical Service, 2013). The current government policy is to achieve 50 percent national access to LPG by 2015 (EC, 2012). The key policy issues are to address the technical capacity challenges of TOR, increase the number of filling stations beyond the majority which are located in the regional capitals [the national average of households per filling station is 24,739], and provide tax incentives for LPG filling stations especially those located in rural and deprived areas for a period of time. In addition, the policy will aim at producing LPG locally from the country's natural gas resources, use the legislature (LI 1592)[41] to regulate the use of the fuel by the transport sector, and increase the price margins for marketers, dealers, and manufacturers. The intended distribution strategy will be the LPG bottle recirculation model using smaller bottles of 2kg and 3kg which would be relatively affordable to greater proportion of consumers (EC, 2010). An intended policy revision on subsidies is still unclear: while the removal of subsidy is perceived to discourage motorists from consuming it, it is feared that it will also be a disincentive to the domestic users for whom the programme was initially intended.

[41] Road Traffic (Use of Liquefied Petroleum Gas) Regulations, 1994, LI 1592 was passed to regulate the use of LPG as fuel in vehicles



Map 4-1: LPG Retail stations in the Ghana
Source: Based on Energy Commission, 2012

4.4.2 Rural electrification

The Government of Ghana as part of the Economic Recovery Programme (ERP) launched the National Electrification Scheme (NES), a 30-year electrification programme that aimed at extending the grid to all communities with population above 500 (KITE, 2008). The programme included a rural component called the Self-Help Electrification Programme (SHEP). This component was designed for communities within 20km of an existing 33kV or 11kV network. The communities were required to have already acquired low voltage poles and have a minimum 30 percent of houses wired. Subsequently, the communities were connected irrespective of whether or not the planned schedule for grid connection as per the National Electrification Scheme was due. The NES is still ongoing and has placed the country's electricity access at 72 percent in 2012 from the 28 percent it commenced with. However, effectively, household demand is 50-60 percent in terms of households in electrified communities that are actually connected (EC, 2012:31). Till date, the SHEP has been well patronised by rural communities. As at 2009, the total number of communities which had been connected totalled 2,837 under the different phases of the programme, that is, SHEP 1 to SHEP 4 (MoEn, 2011 quoted in Abavana, 2010). The principle implementer of the SHEP has been the Ministry of Energy. The District Assemblies' major role has been to select the communities which were ready and relay the information to the Ministry of Energy. The Ministry hired contractors and consultants to execute the project. In the process of implementation, a Rural Electrification Agency as an autonomous body outside the Ministry of Energy with a Rural Electrification Fund was suggested as a business model to enhance rural electrification. This model was however not adopted due the bureaucratic process involved (Abavana, 2010).

The process of implementation of the SHEP once again shows the over-shadowing role played by the central government through the Ministry of Energy. The District Assemblies are not well capacitated to handle the energy projects that concern them. That aspect is still not decentralised. The national electrification plan with its ad hoc self-help electrification projects which allowed rural communities to be connected to the national grid irrespective of the fore-planned schedules under the NES seem to defeat the objective of rural off-grid electrification.

4.4.3 Woodfuel use initiatives

Ghana's current rate of forest depletion is estimated at two percent per annum (Ministry of Lands and Natural Resources, 2012: iv). It is estimated that the average annual firewood consumption per household is 1,064.7kg, bringing the annual woodfuel consumption to about 20 million tonnes. Regional and urban-rural disparities exist. Average household consumption in the Upper East Region (UER) and the Brong Ahafo Region (BAR) are estimated at 1,037.4kg and 1,361kg respectively, which shows a relatively greater consumption in the BAR than in the UER. This may be due to the fact that the BAR is more wooded than the UER and therefore the availability of wood for fuel is greater than as pertains in the UER. In urban-rural terms, household consumption is estimated at 986.2kg, 1,113.4kg, and 1,165.5kg for urban, rural, and rural Savannah areas (EC, 2012:14). At this rate, it is feared that the country is at a risk of reaching consumption of about 25million tonnes by the year 2020. However, if this is regulated, it is possible to reach a controlled consumption level of about 16.5million tonnes per year (Energy Commission, 2012).

Part of the efforts to curtail the quantum of charcoal used and address end-use inefficiencies was the LPG promotion programme earlier on discussed (See Chapter 4.4.1). In addition, the 'Ahebenso' improved charcoal cooking stove was promoted nationwide to replace the traditional 'coal pot'. The design of the improved cookstove allows a level of technical efficiency saving between 35-40 percent charcoal otherwise combusted using the traditional coal pot (EC, 2012:20; Key informant interview with Energy Commission official – 5th July 2012). [The charcoal production process is itself not efficient. It is produced in simple earth-mound kilns with carbonisation efficiency below 20 percent (EC, 2012:17)]. In addition, early users of the improved cookstoves attested that they saved between 15-20 percent of their normal expenditure on charcoal. That presumably released a little more disposal income for other purposes. The programme however was discontinued by the mid-1990s after funding for the Ministry of Energy ended (idem.), a situation similar and familiar with donor funded development projects in the country, where post-funding maintenance is not well planned often resulting in the suspension or premature closure of projects. At the time of field interviews for this research work, two independent private institutions, Enterprise Works and Toyola Energy Limited, were however vibrant on the market with improved cookstoves – the 'Gyapa' and the Toyola Cookstoves respectively. Both stoves have design similarities (see Figure 4-2).

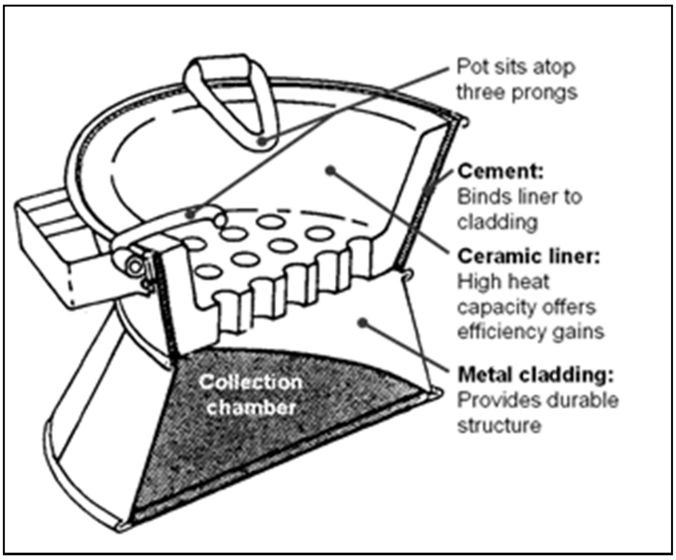


Figure 4-2: Cross-sectional view of the Gyapa and Toyola cookstoves with technically improved design for heat conservation and efficiency
Source: Based on E+ Carbon, 2006

'Envirofit' is also a new effort on the market also aimed at efficient use of woodfuel. The project is however still at its pilot stage. It is a joint collaboration between the Centre for Energy, Environment and Sustainable Development (CEESD) and Envirofit International. The project presents two cookstove designs – improved charcoal cookstove and improved firewood cookstove. It introduces a new technology with a new form of fuel - gel ethanol - as the burning fuel because the gel emits relatively low levels of greenhouse gases (GHG). The production of this gel is the main challenge to the project due to inadequacy of feedstock for its production. Consequently, the price of the cookstove is relatively high and has not been able to address rural energy supply as it initially intended: the product is currently promoted within the peri-urban communities where income levels are relatively higher than rural incomes.

Figure 4-3: Envirofit charcoal cookstove showing the external view, interior and the base
Source: Author's field survey, July 2012

While both programmes are very innovative and have efficiency leverage, the problem with the cookstoves has been the price. The efficiency details incorporated makes the cost higher than the traditional coal pot. In the first place, very few rural households use the traditional coal pot due to the first cost involved. The Ghana Population and Housing Census report (2010) shows clearly that only 15.9 percent of rural households used charcoal as against 47.9 percent of urban household. International research arguments have often concluded that energy for cooking is normally the last to be switched among all other energy needs both for domestic and economic purposes. Even though the cost appears to be a problem, reports on rural demand and acquisition of solar home units promoted under the GEDAP project is indicative that under a well-planned payment schedule, rural households are likely to be able to purchase improved cookstoves if they so desire. While the price per one GEDAP facilitated solar units was GHS 600 (USD 415.7), the cost of the "Gyapa" at the time of the field study was GHS28 (USD 19.4) for the large size, GHS 8 (USD 5.6) for the medium size and GHS 7 (USD 4.9) for the small one. The cost of Envirofit was GHS 24.0. In that case, there are other reasons why the cooking energy suffers the opportunity cost. Some reasons given include the difficulty in preparing certain traditional dishes over the improved stoves due to its design and the loss of the traditional taste of certain traditional meals (Key informant interview with Project Coordinator for promotion of Envirofit – 12th July 2012). These design issues in an interview with project demonstrators at New Energy (a water and energy NGO in Tamale) have been improved over the years. Nonetheless, for those who primarily use firewood, switching to the improved cookstove implied an additional cost that consists in the purchasing of charcoal if they were not also charcoal producers. Despite the health benefits of an improved cookstove over a firewood fireplace, the seemingly free access to firewood is still a deterrent to the use of improved cookstoves. To address this issue, the Council for Industrial and Scientific Research (CSIR) (EC, 2012) and Practical Action (http://practicalaction.org/improved-cooking-stoves) have attempted innovations at the traditional three-stone. Referred to as improved woodstoves, Practical Action trained local women to build these stoves in the same manner they are traditionally trained to build fireplaces. The method of training is therefore familiar and the knowledge easily transferable to other women. The final product is as shown is Figure 4-4. One advantage of the stove is that it can be moved from the point of manufacture to the point of use. On the other hand the CSIR-IIR improved firewood stove cannot be moved and must be moulded at the point of use. Both models have the advantage of using local materials such as cow dung and clay.

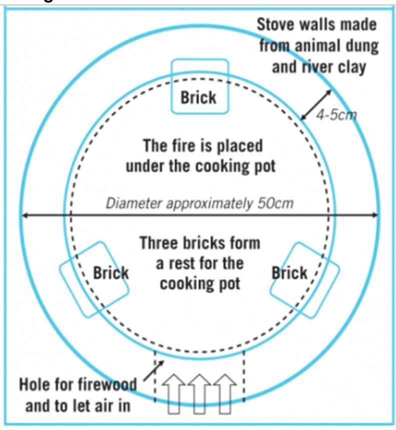
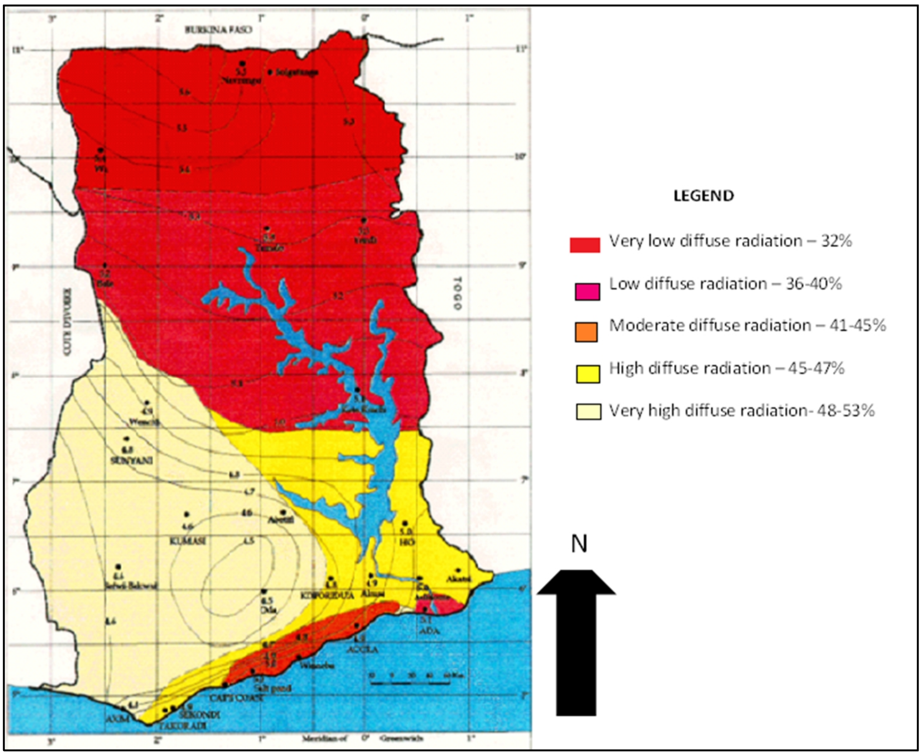
A: Practical Action fuel efficient movable woodstove		CSIR-IIR Fixed improved immovable firewood stove
Design and dimensions	Woman with completed woodstove	
		

Figure 4-4: Fuel efficient woodstove
Source: Practical Action [http://practicalaction.org/improved-cooking-stoves]; Energy Commission, 2012

4.4.4 Ghana Energy Development Access Project (GEDAP)

The Ghana Energy Development Access Project (GEDAP) is a multi-donor funded project implemented from 2007 to 2013 (MoEn, 2007). Its objectives include increasing the country's population's access to electricity, and helping to transition Ghana to a low-carbon economy through the reduction of greenhouse gas emissions. The project has various components including a rural energy component termed Electricity Access and Renewable Energy Development (EARED). The sub-components of the EARED include rural electrification through grid extensions, mini-grids and grid-connected renewable energy, off-gird electrification with solar-photo voltaic (PV) systems, and capacity building (idem.). During the period of the field research (May-July, 2012), this project was at its peak and included two of the Districts of study – the Kassena-Nankana East and the Builsa Districts both in the Upper East Region. The Region and therefore the Districts fall in the very low diffuse radiation zone and thus very suited for the solar PV component (Map 4-2). In these two Districts, the off-grid electrification with solar-PV systems sub-component was being implemented. This was being done concurrently with the capacity building sub-component. Significant within the capacity building component were the support to the private sector for the development and supply of renewable systems, the support to the Agricultural Rural Bank Apex Bank and other participating Rural Banks, and the monitoring and verification services of inspection agents to check solar equipment installed. The GEDAP therefore appears to have addressed the key issue of private sector participation and rural financing in energy supply in rural areas, and as well, made provision for training implementing agencies for technical backstopping.



Map 4-2: Levels of solar radiation in Ghana showing very low diffusion in Upper East Region
Source: Energy Commission, 2012

<u>Observation from field survey</u>

This solar-PV off-grid electrification project was well patronised by the rural communities than previous programmes. As per the project subsidy package, 50 percent partial subsidies were provided to consumers to make the solar home systems affordable and ensure adequate demand. Even though the field research did not show whole communities purchasing the systems, indicatively, the level of penetration was much higher. This was confirmed during interviews with the private sector partners of the project, NorthLite Solar Limited, as well as the project officers who were associated with the Builsa Community Bank and Naara Rural Bank in the Kassena-Nankana East District for advocacy, community and client selection, and loan recovery in the Upper East Region (Author's field survey, May-July 2012). One key issue which ran across communities visited and which was also topical in discussions with project officers was the inadequate after-sales service. Impliedly, the capacity building component was still a challenge. After-sales service for periodic re-checking of installation and servicing were asserted as not part of the cost allocated to the private distributors. The main aim of distributors was to sell off the systems:

> "*The private distributors delivered their products quickly and simply moved on because they had timelines and specific population targets to meet. Very little information was provided on the product itself to a less literate population (as could have been delivered in*

a product manual) but rather only instructions on what to do and what not to do were given."

(Statement by a key informant from NorthLite, one of the main distributors in the three Northern Regions)

Consumers complained that there was poor and delayed response to urgent requests for servicing, and even if the technical services responded, the faulty parts of the solar systems were either not replaced or repaired or were taken for repair and were never returned. This affected repayment of loans granted by Banks to the consumers for this purpose particularly in the first year of project implementation. In an interview with one project officer, this was confirmed:

"The project officer has more daily contact with beneficiaries because we were selected from the communities. However, we are not trained technicians. We have various professional backgrounds but were chosen to work with the rural banks with regards to loan recovery. For that reason when clients came with technical challenges, I am unable to address these challenges. At the same time, I am also unable to promptly access technical service from the distributors. This made some clients angry and thus within the first year of implementation, there was gross failure as beneficiaries refused to repay their loans. The project had to re-strategise and recommence. Even though the technical challenge persists, it is manageable."

(Statement by Project Officer, Builsa Community Bank, Builsa District)

In the two study Districts, it was reported 'thousands' of solar home systems had been deployed. However, specific quantities could not be provided at the time of field study.

4.4.5 The multifunctional platform (MFP)

The multifunctional platform (MFP) was a United Nations Development Program (UDNP) sponsored project implemented by KITE (a not-for-profit energy and development organisation) in Ghana between 2005 and 2008 (KITE, 2007). The goal of the Ghana MFP was to provide rural communities access to modern energy services using the MFP as a decentralised energy system and a poverty reduction tool. The programme objectives were to facilitate the provision of modern energy services to rural communities, and to facilitate increased income generation and social service activities through Enterprise Development Services (EDS) and literacy training aimed at empowering the rural people and communities. It also particularly targeted improving women's access to mechanical energy for agro-processing to improve their socio-economic life. The MFP is a diesel engine mounted on a chassis which power a number of end-use equipment such as grinding mills, de-huskers, sharpeners and battery chargers. It can also be configured to generate electricity for lighting, refrigeration, and water pumping. The MFP operates however with fossil fuel which has a centralised source of supply and not always in adequate supply. In addition, a number of the platforms are currently not functional. The project target of forty installations was not achieved. Subsequently, an intended up-scale of the project has not been realised. In order to address the issue of centralised supply of fossil fuels, there was an on-going feasibility study at the time of field research to explore the use of rice husks as an alternative fuel instead of diesel. The Atebubu-Amantin District which is one of the districts studied for this research was a major benefactor of the project.

4.4.6 Productive uses of energy (PUE)

The promotion of productive uses of energy is an important aspect in the design and implementation of rural energy projects (Energy Commission, 2012). Productive uses of energy involve the utilisation of energy both electric and non-electric in the form of heat or mechanical energy for activities that enhance income and welfare. These are mainly in the agriculture, rural enterprise, health and educational sectors. Specific activities include water pumping, agro-processing, lighting, information and communications, and vaccine refrigeration (idem.). In Chapter 4.4.2, it was mentioned that in the case of electrified communities, studies have shown that only 50-60 percent of households in electrified communities are actually connected. In the rural communities, a greater proportion of these consumers are within the lifeline tariff band. It may be inferred consequently that electricity is used primarily for domestic lighting in the rural communities. Thus, the productive uses component of the National Electrification Scheme (NES) has not been achieved. The Ghana programme of the UN Sustainable Energy for All programme consequently targets agriculture, agro-industry and services to enhance productive uses of energy in the rural hinterlands (EC, 2012). These sectors are rural economic sectors that could enhance economic growth and development in the rural areas. Specific planned activities include irrigation, agro-processing, cold-chain refrigeration, and Information and Communication Technology (ICT) services. To prevent the re-occurrence of the failures recorded under the NES, the country's action plan suggests the following strategies:

i. The design of PUE programme should be based on appropriate feasibility and planning, and clearly defined objectives and scope. Prioritised interventions should be related to already existing medium, small and micro enterprises, and the capacity of partners for implementation must be critically assessed.
ii. The intervention strategy should analyse the local economy and potential for productive uses of electricity, take stock of the economic activities in the target area, and identify those which could be upgraded through electricity use, select partner institutions, and determine what capacity development interventions will ensure the sustainability of productive use.
iii. Create financial accessibility: this should involve raising awareness among microfinance institutions to improve access to loans for productive use investment and establishing partnerships with financial institutions to facilitate access to credit.
iv. Monitoring and evaluation will involve defining a results chain, collecting baseline data to assess impact and feeding the result and lessons into further planning.

4.5 Conclusion

The energy initiatives discussed all aimed at improving energy supply and /or improving energy efficiency. However rural energy access still remains below acceptable levels. Even though rural electrification access is 49 percent (Kemausuor et.al, 2012), the situational analysis reported by the Energy Commission showing only 50-60 percent household connection, is an indication that actual rural household connection is less than 49 percent. The LPG energy access programme still has challenges although there is a slight marked improvement in access between 2000 and 2010 with the rural-urban ratios improving from 1.1%:11.8% to 4.8%:28.9%. The improved charcoal cookstoves have not penetrated the rural market while the firewood alternative is not widely dispersed. Again, a careful observation of the energy initiatives discussed shows that with the exception of MFP, the initiatives had weak productive uses components. They aimed more at domestic energy provision than productive and industrial energy, and thus creating a backlog for economic growth, even though in most rural communities, enterprises are home-based. For example, some users of the GEDAP promoted solar home systems charged the mobile phones of community members at a cost but that was not the primary aim and therefore these petty businesses were not institutionalised. With regards to rural electrification, the anticipated productivity that was expected to characterise electrification has not been achieved (Energy Commission, 2012). Nonetheless, productivity in the sense of human capital development could be achieved when domestic energy oriented initiatives as domestic lighting enhances children's ability to study at home after school, and health. As advanced by the endogenous growth theory, productivity can be linked to both a faster pace of innovation - in this case, alternative options of improving energy access - and investment in human capital. This is however a long term intervention, which could be propelled with short-term leverage. It remains therefore that rural energy supply and access is improving at a rather slow pace with considerably high propensities of not being sustainable.

5 HOW THE ENERGY NEEDS OF RURAL HOUSEHOLDS ARE BEING MET

5.1 Rationale

This section discusses the pattern of energy consumption in structure and magnitude. Energy services considered are cooking, lighting, learning, ironing, other domestic purposes, and economic activities. The analysis considers the first, second, and third energy options of respondents to be able to assess the energy options available to respondents when their principal energy was not available and therefore their ability or otherwise to enjoy the various energy services in the absence of their principal energy source. The disaggregation also provides indicative information on dependence or otherwise of respondents on the principal energy option and the implication for planning.

5.2 Energy for cooking and heating

The cooking energy forms identified among the study communities were firewood, charcoal, millet stalks, liquefied petroleum gas (LPG) and straw. Households were asked to prioritise these energy forms on three levels, i.e. the first, second, and third energy used for cooking.

Table 5-1: Proportion of households having first, second and third source of energy for cooking and heating

Energy for cooking and heating	% of respondents, N=199
First energy	100.0
Second energy	71.1
Third energy	6.7

Source: Author's field survey, May-July 2012

Table 5-1 shows that all respondents had a first source of energy for cooking and heating. The striking feature here is that 71 percent of respondents had alternative energy and 6.7 percent even had a third option. It can be inferred from Chart 5-1 that respondents who had second alternative for cooking and heating switched the first energy options especially between firewood and charcoal. Both options were biomass. Again, by implication, almost 30 percent of respondents had no alternative cooking and heating energy, and for a third alternative cooking and heating energy, the options were even less.

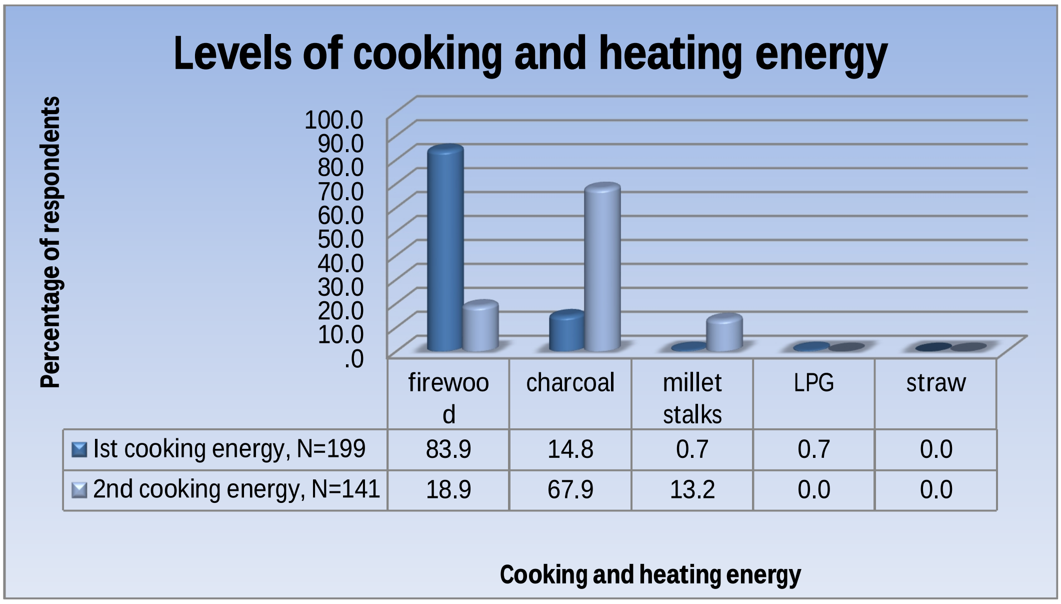


Chart 5-1: Energy use for cooking and heating

Source: Author's field survey, May-July 2012

Chart 5-1 shows graphically the structure of energy use at two levels of priority. For first energy, approximately 84 percent which constituted the majority used firewood for cooking, followed by 14.8 percent who depended on charcoal. A minority 0.7 percent of respondents used millet stalks and LPG respectively. For second cooking and heating energy, out of the 71 percent of respondents, 68 percent used charcoal, 19 percent depended on firewood, and 13 percent depended on millet stalks. The 6.7 percent of respondents who had a third cooking and heating energy option depended on charcoal, millet stalks, straw and LPG as alternatives. In Figures 5-1 and 5-2, examples of household stocks of cooking and heating energy forms in the communities are shown.

Household stock of millet stalk from previous harvest safely stored in crotch of tree as cooking and heating energy

Location: Azaasi, Kasena-Nankana East District, Upper East Region

Figure 5-1: A stack of millet stock stored as source of energy for cooking and heating
Source: Author's field survey May-July 2012

Figure 5-2: Three-stone fireplace and with stack of firewood for household use
A: Three-stone fireplace in Fakwesi, Atebubu-Amantin District, Brong Ahafo Region
B: Stack of firewood for household use in Sabidi, Atebubu-Amantin District, Brong Ahafo Region
Source: Author's field survey May-July 2012

When households were presented with unlimited choice of energy forms to choose from, respondents indicated a wide variety of energy forms they would have preferred if they had the option. The following discussion shows these preferences, the reasons allocated for these preferences and why these preferred energy forms were not in use. Shown in Table 5-2, a little over 60 percent of all respondents indicated preferring LPG as energy for cooking. This is followed by 26 percent of respondents who preferred charcoal. Smaller proportions of 5.4 percent, 5.4 percent, and 2.4 percent preferred firewood, electricity and kerosene for cooking respectively. When the figures for LPG and charcoal preferences are compared with the principal (first) energy for cooking and heating already discussed (Table 5-1), it may be deduced that quite a substantial proportion of respondents who used firewood and charcoal may willingly substitute it if they had the chance.

Table 5-2: Preferred cooking and heating energy

Cooking and heating energy	% of respondents, N=199
LPG	60.4
Charcoal	26.2
Firewood	5.4
Grid electricity	5.4
Paraffin	2.7
Total	**100.0**

Source: Author's field survey, May-July 2012

A number of reasons were given for these preferences (Table 5-3). The two outstanding reasons were 'easy to use' and 'time saving' indicated by 31 percent and 25.5 percent of respondents respectively. A host of other reasons were given but almost all these responses were permutations between these two main responses and others, such as '*easy to use and clean*', '*easy to use and efficient*', and '*easy to use and effective*'. A detailed list of these reasons is presented in Appendix X. From Table 5-2, LPG was the majority's preferred energy for cooking and heating. It is worth noting that LPG is a modern form of energy. However, respondents' preferences for charcoal is significant, thus the reasons for preferred energy for cooking and heating was further cross-tabulated with the energy options to allocate reasons. The following reasons were given: charcoal was easy to use; LPG was dangerous for use with children at home but charcoal was safe; charcoal was available, healthier, cooked better than firewood, and saved time. It was noted particularly in the communities in the Upper East Districts that a phobia for LPG still persisted. Households could not feel safe with LPG when there were little children in the house, and when houses were built principally of mud and thatch roofs. The cross-tabulation also showed "availability" as the main reason why 5.4 percent of respondents still preferred firewood. Availability as indicated here refers to the physical availability. It is interesting to note that despite the travel distance covered to access fuelwood, an average of nine miles each fuelwood gathering day, some respondents still noted it as "available". Particularly in the communities in the Atebubu-Amantin District, picking of fuelwood was considered part of the daily farming activities. Twigs were gathered from the farms each day at the close of the farming day. The inconvenience of using fuelwood was only mostly acknowledged during the rains when it was difficult to access dry wood and to cook in open kitchens as is normally the case with the use of fuelwood. In the study communities of the Builsa and Kassena-Nankana East, respondents acknowledged the long distance covered by mostly the women to find fuelwood and the effect on the health of the women. However, when respondents were asked to prioritise their energy needs, cooking energy was almost always given the last consideration because "*we can find them (firewood). If they are not available, we can use the straw but there is no alternative option for lighting energy*".

Table 5-3: Reasons for preferred energy source for cooking and heating

Reasons for preferred energy	**% of respondents, N=199**
Easy to use	31.8
Time saving	26.4
Available	8.1
Other reasons	33.7
Total	**100**

Source: Author's field survey, May-July 2012

Preferred meant both 'preferred but not using' and 'preferred and using'. Notably, some respondents were actually using their preferred option especially for charcoal and firewood. When this table is further compared with the primary energy use table, this becomes clearer: for charcoal users, 14.8 percent used it a primary energy and 67.9 percent used it an alternative energy. In the case of LPG, it was not available in all the communities visited. Users had to travel outside their communities to the bigger towns which were mainly the Districts capitals to access them. Thus only 0.7 percent of respondents used LPG as a primary cooking energy.

Table 5-4: Non-use of preferred energy for cooking and heating

Reasons for non-use	% of respondents, N=199
Too expensive	48.2
Energy not available in the area	28.9
Too expensive and energy not available in the areas	8.8
Don't have appliances	7.0
Other reasons	7.0
Total	**100.0**

Source: Author's field survey, May-July 2012

When further questioned why the preferred energy was not being used, two main reasons were given shown in Table 5-4: 48 percent of respondents indicated that the source of energy was 'too expensive', and 28.9 percent indicated that the energy form is not available in the area. For seven percent of respondents, they did not have the appliances that needed to use the energy form, that is, LPG stove and cylinder or charcoal coal pot.

5.3 Energy for lighting

All respondents had a first energy for lighting. However, only 25 percent and 1.3 percent of respondents had second and thirds lighting energy options, respectively, as shown in Table 5-5. For the first lighting option, Chart 5-2 illustrates that the majority 79 percent of respondents used dry cells and light emitting diode (LED) torch or lamp or ordinary bulb torch (See example in Figure 5-3) as the first energy option for lighting. This is a recent rural lighting energy development phenomenon that may need further investigation.

Table 5-5: Proportion of households having first, second, and third sources of energy for lighting

Energy for lighting	% of respondents, N=199
First energy	100.0
Second energy	25.0
Third energy	1.3

Source: Author's field survey, May-July 2012

Over the years, paraffin (kerosene) has been the main energy for lighting in the rural areas. However, from the data received, only 7.6 percent of those interviewed used paraffin as the first lighting source; this proportion was not too different from the proportion using solar - 6.9 percent - which is deemed as unpopular. This was compared to the 2010 Population and Housing Census data on energy use. The census data does not provide segregated data between urban and rural population nor among regions but it is significant that the proportion of paraffin users compares very closely to those using dry cell-and-torch with 17.8 percent and 15.7 percent respectively (Ghana Statistical Services, 2012). The figures for the 2000 Population and Housing Census show significant difference. In 2000, kerosene lamps accounted for 54.9 percent of energy use. Dry cells and torches did not feature at all and may have been probably be lumped with 'other sources' which constituted only 0.3 percent of responses (Ghana Statistical Service (GSS), 2005). It is evident therefore that there is significant developmental and phenomenal change in the use of this energy form over the ten-year period. The reason allocated has been the fact that dry cells-and-torches are safer, brighter, and relatively cheaper for the subsistence lifestyles of the rural dwellers. Another significant reason given was the inadequacy of kerosene supply. In fact, in the Fakwesi study community in the Atebubu-Amantin District, one respondent commented that he had not seen kerosene in the past four years as at the time of interview (June 2012).

A- Locaton: Azaasi, Kassena-Nakana East District, Upper East Region

B- Location: Kore-Alam-Yeri, Builsa Dsitrit, Upper East Region

Figure 5-3: Dry cell-based torch, electricity rechargeable lamp, and dry cell LED lamp
Source: Author's field survey, May-July, 2012

It is also evident that solar energy has made a lot of gains over the last ten years. The 2000 Population and Housing Census Report recorded that solar constituted 0.1 percent of all energy sources for lighting for the whole country (GSS, 2005). Specifically in the Brong Ahafo and Upper East Regions, the proportion recorded was zero percent and 0.1 percent respectively. In 2010, the census report showed that the percentage of solar in lighting was 0.2 percent for the entire country, and 0.1 percent and 0.3 percent for the Brong Ahafo and Upper East Regions, respectively. These in absolute numbers are 693 and 612 in the two respective regions. From the survey, the proportion of respondents using solar as first energy is 6.9 percent. This disaggregates further in a ratio of 0:1:9 respectively between the three Districts - Atebubu-Amantin District in the Brong Ahafo Region, and Kassena-Nankana East and Builsa Districts both in the Upper East Region. The Builsa District appeared to be making gradual gains in adopting solar.

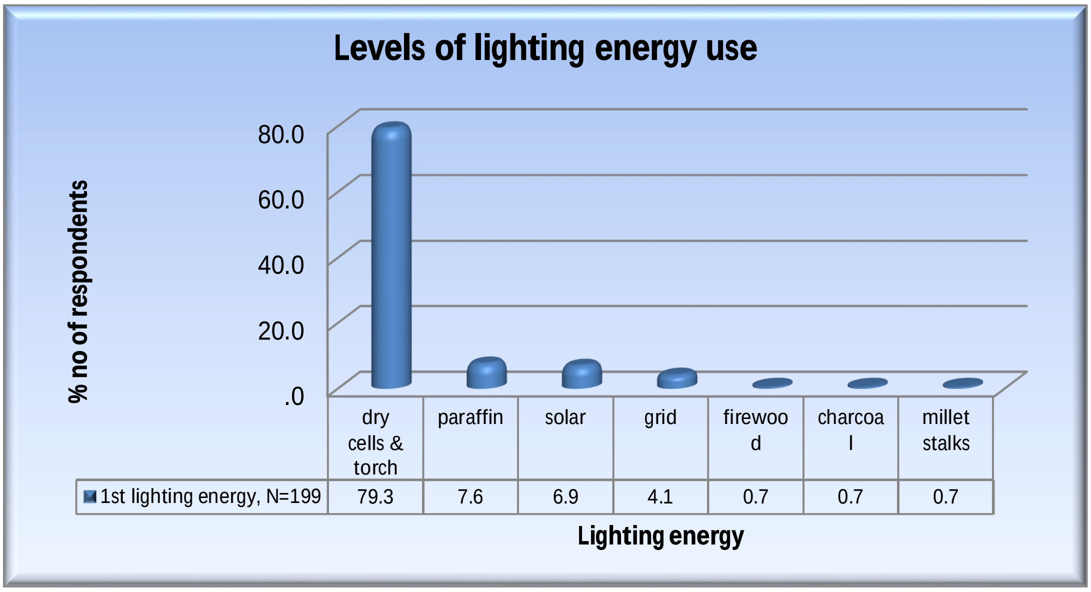


Chart 5-2: Energy for lighting
Source: Author's field survey, May-July 2012

Only 25 percent of respondents had a second alternative energy for lighting, constituting 49 respondents. Out of this, about one-third of the respondents supplemented their first energy for lighting with paraffin, and another one-third supplemented with dry cells with LED torches or lamps. In the two study Districts in the Upper East Region, respondents who were patronising the solar systems through the GEDAP project indicated that they switched from solar to dry cells or paraffin in the event of an operational challenge of the solar units. The proportion of respondents that had access to a third light energy option was much fewer – 1.3 percent of respondents had a third energy option and all used paraffin.

Table 5-6: Preferred source of energy for lighting and reasons for preference

Lighting energy	% of respondents, N=199	Reasons	% of respondents, N=199
Grid electricity	88.1	Easy to use	46.8
Solar	7.7	Brightness and efficiency	21.6
Solar and grid	2.1	Economical	9.4
Dry cells	1.4	Others	22.2
Paraffin	0.7	**Total**	**100.0**
Total	**100.0**		

Source: Author's field survey May-July, 2012

Respondents were further asked to indicate their preferred source of lighting (Table 5-6). The popularity of electricity is clearly depicted in the responses: 88 percent of respondents indicated their preference for electricity. Preference for electricity was the highest was across the three Districts. This is followed by preference for solar by 7.7 percent of respondents who thought that it was wishful to prefer grid electricity because "*the grid will never get here* (to their communities)": these respondents who were in the

Upper East had been exposed to the solar alternative through the GEDAP and therefore also wanted a form of energy they can control. Only 1.4 percent and 0.7 percent of respondents maintained a preference for dry cell and paraffin respectively, due to the cost involved in grid connection as against their income levels. For instance, in Azaasi, a community in the Kassena-Nankana East District, where high tension grid lines and distributor lines and poles had been erected, a respondent commented:

"There is no power in these lines and they have been up for a long time. Even if there was power in them, I need to buy a pole for GHS 120 to connect to my house but I can't afford that at all. It's too much!"

For 46.8 percent of respondents, the ease of usage was the main reason for their preferences; the brightness and efficiency of the light source in comparison to light output from other sources of light and how economical the energy form was the determining factor for 21.6 percent and 9.4 percent of respondents respectively. By economical, respondents made references to both grid electricity and solar photovoltaic. Those referring to grid electricity implied electricity would allow them to save money spent on dry cells. For others, electricity was even cheaper than solar, clarifying why rural dwellers felt cheated when they are not connected to grid electricity: the notion was that the more expensive energy source had been sent to them (rural dwellers) while the cheaper energy was enjoyed in the urban areas. Other respondents also explained economical with regards to the multiple services that it provided - once a household had grid electricity for lighting, that same energy source was able to provide energy for television, radio, refrigeration, and other power-based services. A few respondents however acknowledged the renewable nature of solar and therefore considered it economical. In the 'Others' category shown in Table 5-6, some respondents considered the monthly billing structure for grid electricity use as more convenient than the daily or twice weekly purchase of dry cells. This view contradicts the general assumption that piece meal purchase of energy is convenient for rural dwellers. On the other hand, other respondents expressed their uncertainty as to when the grid would reach them and therefore preferred a decentralised energy system such as solar home system over the grid electricity. The details are listed in Appendix X. An inter-Districts disaggregation of energy for lighting preferences revealed that majority of the 88 percent of respondents who preferred grid electricity were from the Atebubu-Amantin District with 42 percent (See Appendix X). Kassena-Nankana East and Builsa Districts followed with 30 percent and 28 percent respectively. On the other hand, solar preference was higher in Builsa and Kassena-Nankana East Districts than in Atebubu-Amantin District. The percentages of respondents indicating solar are relatively high among the Upper East Districts because the communities studied were among the GEDAP communities and therefore appreciated better the use of solar energy. However, as the statistics show in Table 5-8 below, even households which had solar would prefer a switch to grid electricity if they had the chance but would maintain the solar alternative as supplementary against power outages. Table 5-7 was derived from in-depth interviews with 20 percent of the total number of respondents, comprising a mix of those who already had solar systems and those who had not. As much as four-fifths of this group of respondents would not abandon their systems even when they had grid electricity; they would use them concurrently. In time, when the feed-in-tariff system in Ghana is well established, this could be an opportunity for current solar users who are also connected to the grid to reap the benefits thereof. Those who indicated they would abandon it explained that it would be expensive to keep both and would therefore sell the decentralised systems to others who needed them.

Table 5-7: Intention to abandon the decentralised energy system (solar) with the incidence of grid electricity

Response	No. of respondents, N=40
Yes	9
No	31

Source: Author's field survey, May-July 2012

Following further inquisition why their preferred energy for lighting was not being used, the major reason given was that it was "not available in the area", indicated by 65 percent of respondents (Table 5-8). The second major reason was that it was "too expensive". Here, a financial barrier to accessibility is indicated. For instance, in Wuru in the Kassena-Nankana East District, even though the community could have accessed grid electricity, only the chief's palace was connected due to the lack of utility poles which the rest of the community indicated they were unable to privately afford.

Table 5-8: Non-use of preferred energy for lighting

Reasons for non-use	% of respondents, N=199
Energy not available in the area	65.0
Too expensive	25.7
Have no electricity connection	5.0
Too expensive and unavailable	2.1
Others	2.1
Total	**100.0**

Source: Author's field survey, May-July 2012

5.4 Energy for learning

To examine the role energy plays in human capital development, the energy use for learning was investigated. From Chapter 3.7.4, 98 percent of respondents (195 respondents) had school going children at home. For school going children, it was essential to have a source of light for learning especially during evening and night studies. Even when information and communication technology is far from reach, the ability to learn at night is a basic right for school going children. Shown in Table 5-9, 73 percent of respondents had an energy option for learning for their school going children and teenagers. Only 7.4 percent of respondents had a second energy option for the children and none of the households had a third option.

Table 5-9: Energy options for learning

Energy for learning	% of respondents, N=195
First energy	73.0
Second energy	7.4
Third energy	0.0

Source: Author's field survey, May-July 2012

In the pie-chart shown in Chart 5-3, as much as 72 percent of the respondents indicated that their children learnt using dry cells with LED torches as their main energy for learning. Approximately 12 percent used paraffin and paraffin lamps, and 9.2 percent used solar home units. A little more than six percent of respondents used the grid mainly by charging their rechargeable LED lamps in grid connected communities or in the neighbouring town centres.

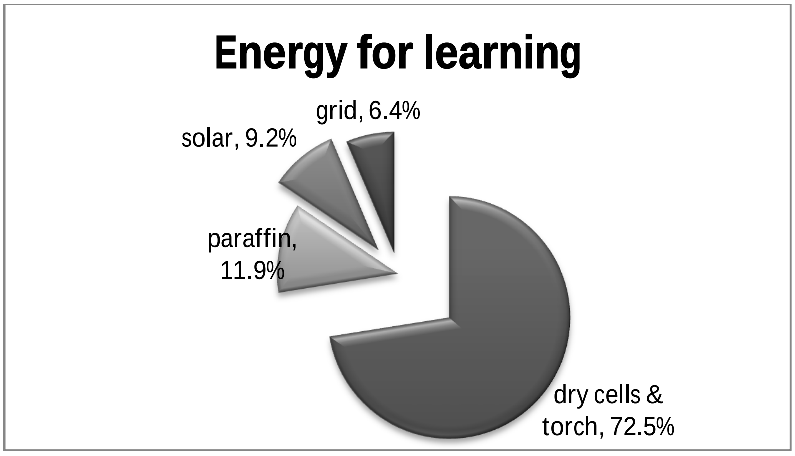


Chart 5-3: First energy for learning

Source: Author's field survey, May-July 2012

For the 7.4 percent respondents who had a second energy option, totalling 14 respondents, those who used solar resorted to dry cells, and those who used dry cells resorted to paraffin when their first option was not available. For their most preferred energy option, 90 percent of the respondents would have preferred to have grid electricity for their school children to learn; about 8 percent also thought solar was a better alternative than their current source of energy for learning. The minority 1.6 percent of respondents maintained a preference for paraffin and dry cells with LED torches. This is shown is Table 5-10. Almost 41 percent of households had these alternative preferences because these preferences were easy to use, 38 percent considered better illumination, and 13 percent were of the opinion that their preference would give them value for money. These responses were concerning the grid. Those who preferred the solar indicated that it was not intermittent like the grid and was more reliable in addition to the fact that it was a renewable form of energy (See details in Appendix X).

Table 5-10: Preferred learning energy and reasons for preference

Preferred learning energy		Reasons for preferred energy	
energy form	**% of respondents, N=195**	**Reasons**	**% of respondents, N=195**
Grid electricity	90.3	Easy to use	40.9
Solar	8.1	Better illumination	37.7
Dry cells	0.8	Easy to use and cost effective	13.2
Paraffin	0.8	Others	8.2
Total	**100.0**	**Total**	**100.0**

Source: Author's field survey, May-July 2012

Nonetheless, as shown in Table 5-11, households were not using their preferences because the majority preference which was electricity was not available in their communities. Other respondents also indicated that their preferred energy was too expensive and they could not afford the initial cost, and that included the initial cost for the GEDAP solar systems.

Table 5-11: Reasons for non-use of preference

Reasons for non-use	% of respondents, N=195
Energy not available in the area	74.1
Too expensive	20.7
Have no electricity connection	4.3
Too expensive and not available in the area	0.9
Total	**100.0**

Source: Author's field survey, May-July 2012

5.5 Energy for ironing

Ironing is perceived as an important energy based activity in the communities visited especially for school going children within the communities. From Table 5-12, 80 percent of respondents had a first energy option for ironing. Only nine respondents (4.7 percent) had a second option and none of respondents had a third option. Chart 5-4 shows the forms of energy constituting respondents' first energy for ironing. Moreover, the 20 percent of respondents who did not have energy options for ironing did not consider ironing an essential energy service and did not iron. About 85 percent of respondents who had a first energy option used charcoal and 10.9 percent picked live coals from burning firewood. Either of these was used with the local box iron which respondents either owned or borrowed from neighbours. A minimum five percent used the grid. These respondents were in Wuru and Nagalikenia, and others went to neighbouring communities with electricity. For instance, respondents in Balansa went to Sandema to iron.

Table 5-12: Proportion of households with energy options for ironing

Energy for ironing	% of respondents, N=199
First energy	80.0
Second energy	4.7
Third energy	0.0

Source: Author's field survey, May – July 2012

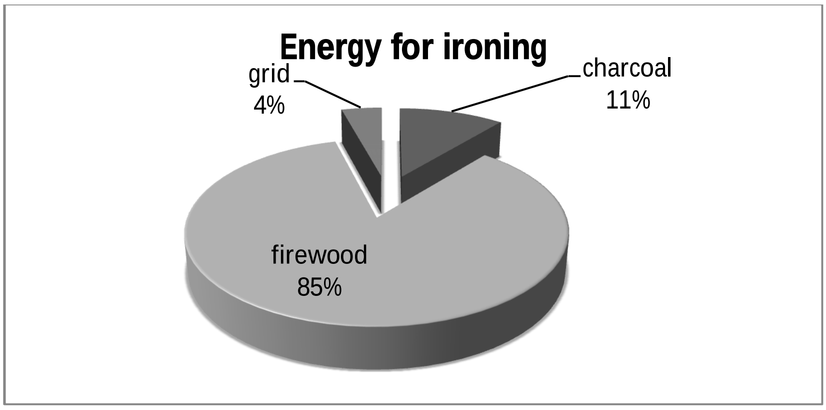


Chart 5-4: First energy for ironing
Source: Author's field survey, May- July 2012

The second option for ironing was either firewood or charcoal. Respondents who used grid for ironing supplemented with charcoal and those that used firewood primarily also substituted with charcoal in situations when there was not already burning firewood for live coals.

Table 5-13: Preferred energy for ironing and reasons for preference

Energy form	**% of respondents, N=159**	**Reasons**	**% of respondents, N=159**
Electricity	92.5	Easy to use	46.2
Solar	5.2	Easy to use and cost effective	11.4
Charcoal	2.2	Easy to use and time saving	10.6
Total	**100.0**	Time saving	9.1
		Effective and easy to use	5.3
		Economical	6.1
		Others	11.4
		Total	**100**

Source: Author's field survey, May-July 2012

Table 5-14: Non-use of preferred energy for ironing

Reasons	**% of respondents, N=159**
Energy not available in the area	72.0
Too expensive	18.4
Have no electricity connection	5.6
Don't have appliances	0.8
Other	3.2
Total	**100.0**

Source: Author's field survey, May-July 2012

Given the choice, once again the highest proportion of respondents - 93 percent - would choose grid electricity for ironing. Among the reasons given, the ease of usage was indicated by 46 percent of respondents as their reasons for their preference. This was followed by eleven percent of respondents who saw their preferred choice as both easy to use and cost effective, and another eleven percent who were convinced their preferred choice also saved time in addition to its ease of usage. The responses are shown in Table 5-13. However, since the communities were not connected to the grid, 72 percent could not use their preferred energy. The next 18 percent said the energy form was too expensive (Table 5-14).

The preference of solar for ironing indicated in Table 5-13 is an indication that there is a section of respondents who assumed that solar had the capacity to be used for ironing, as a direct supplement for grid electricity. These were respondents in communities where solar projects were being implemented. When this data is triangulated with information from key informants, both product suppliers and local project officers, the highest wattage of the solar home systems supplied during the project were 100Watt systems which could not be used for ironing. Impliedly, there is a portion of potential consumers who expect a higher output from the solar systems similar to what grid electricity is able to provide. According to a key informant interview at NEGD, one of major solar distributors in Ghana, the more output demanded, the higher the wattage and definitely, the higher the cost involved. Paraphrasing a statement made during the key informant interview, "*if the customer has money, all specifications of solar are possible but not all are economica"*. Literature shows and important to note that in the past, these unmet expectations have been some of the reasons why rural communities have been disillusioned about solar. Thus without necessary maximum clarity and intense education before the implementation of non-conventional interventions, these disillusions will still persist and affect scaling up of well-meaning projects.

5.6 Energy for other domestic energy purposes

Other energy purposes were identified apart from the routine domestic purposes and this included charging of mobile phone, and operating radio and television (TV). Phone charging has recently become one of the essential energy service activities in rural areas. Keeping mobile phones and instant communication is now an important development phenomenon in the rural areas such that irrespective of levels of poverty that may be indicated in a rural community, this seemly *expensive* technology is used. Thus in an interview with an energy expert of one of the international development banks, it was asserted that technical expertise underestimate the capacity of rural dwellers to pay for modern energy; that if rural households are able to maintain and load calling units on mobile phones, sometimes even more than one per household, then they are capable of paying for modern energy. This was said comparing the average cost of maintaining a mobile phone to the cost of paying for modern energy such as solar or even grid electricity per month. Out of the total number of respondents, 89.9 percent has a first energy option to address these other energy needs, and only nine percent had an alternative energy option. Statistics in Table 5-15 shows the proportion of respondents who used some form of energy for these purposes.

Table 5-15: Proportion of respondents with energy options for other energy purposes

Energy for Other purposes	% of respondents, N=199	Other energy purposes	% of respondents, N=179
First energy	89.9	Radio	67.2
Second energy	9.0	Phone charging, radio	29.1
Third energy	0.0	Phone charging	2.2
		Phone charging, TV, radio	0.7
		TV, Radio	0.7
		Total	**100.0**

Source: Author's field survey, May-July 2012

Shown in Table 5-16, the forms of energy used to attain these services were dry cells, solar, grid electricity, and (diesel) generator. Grid energy was accessed outside of the communities. The main purpose of grid electricity was for phone charging; occasionally respondents had grid-rechargeable LED lanterns that had built-in radios which were charged with grid electricity. Solar was also used for phone charging and occasionally for radio; dry cells were used for operating radios; and generator for operating television which was a seldom occurrence. In addition, at the community level, diesel generator was sometimes used to operate the community public announcement (PA) system instead of the gong-gong, and while it was being operated, community members were allowed to charge their phones for a fee. Respondents who had a second energy option used grid and dry cells.

Table 5-16: Energy use for other domestic purposes

Energy forms	% of respondents who had a 1st energy option, N=179
Dry cells	66.4
Dry cells & solar	16.4
Dry cells & grid	10.4
Grid	4.5
Solar	1.5
Dry cells & generator	0.7
Total	**100**

Source: Author's field survey, May – July 2012

Close to 80 percent of these respondents preferred to have grid for these activities particularly for phone charging because grid charged phones "*charged faster and lasted longer*" (a reason given by respondents). Others wished they had constant power supply for big radio and sound systems, to own television sets, and generally to have their choice of entertainment without restriction. A preference for solar was however maintained by 5.7 percent of respondents - these were solar users who were still benefiting from their investments and insisted that solar was more reliable than the grid. In addition, that was the most available to them. Another 3.5 percent maintained preference for dry cells based on the reason that dry cells made the radio a mobile device; they could easily carry their radios everywhere with them, even to the farm, keeping them constantly abreast with current affairs. The results are shown in Table 5-17.

Table 5-17: Preferred energy for 'Other' domestic purposes

Preferred energy	% of respondents, N=179
Grid	80.1
Solar	5.7
Solar and grid	2.1
Dry cells	3.5
Solar and dry cell	0.7
Grid and dry cell	5.7
Solar, grid, dry cell	2.1
Total	**100**

Source: Author's field survey, May – July 2012

5.6.1 Patterns of energy consumption for rural domestic energy services

The following discussion presents composite timelines of energy-requiring activities in the study communities. These activities are lighting, cooking and heating, ironing, learning, tuning on radio and television viewing. The valid percentages of respondents are presented as percentages of the respective frequencies of the total sample. It provides a better perspective than the valid percentage per time period. This is shown diagrammatically in Chart 5-5, and the specific values are shown in Appendix XI.

Generally, most of the energy consuming activities occurred in the mornings between 06 and 10 hours, and in the evenings between 16 and 20 hours. With the exception of cooking and radio playing, different activities peeked at these two distinct times indicating the extent of energy services needs at these times. Cooking and radio playing (listening to the mid-day News) were the significant features of the afternoon. Cooking and heating is an energy activity that is notable in the morning, the afternoon and in the evening peaking with 47.7 percent, 20.8 percent, and 67.1 percent of respondents respectively at these given time periods. One other distinct feature of radio use was the usage period 'all morning', 'all afternoon', and 'all evening' indicated by respondents. This could not be graphically plotted along the other timelines but a significantly high proportion of respondents were found in these three categories, i.e., 26.8 percent, 30.9 percent and 32.2 percent respectively, representing the first or second majority of respondents under the three distinct time periods. This is an indicator of the consumption of dry cells within the communities. The disposal of these dry cells has environmental and climatic implications though at this stage it may even seem negligible. Respondents indicated that averagely a pair of dry cells was replaced every three days. That means if one radio set per one household is assumed, then in a month, averagely a household uses ten pairs of alkaline cells.

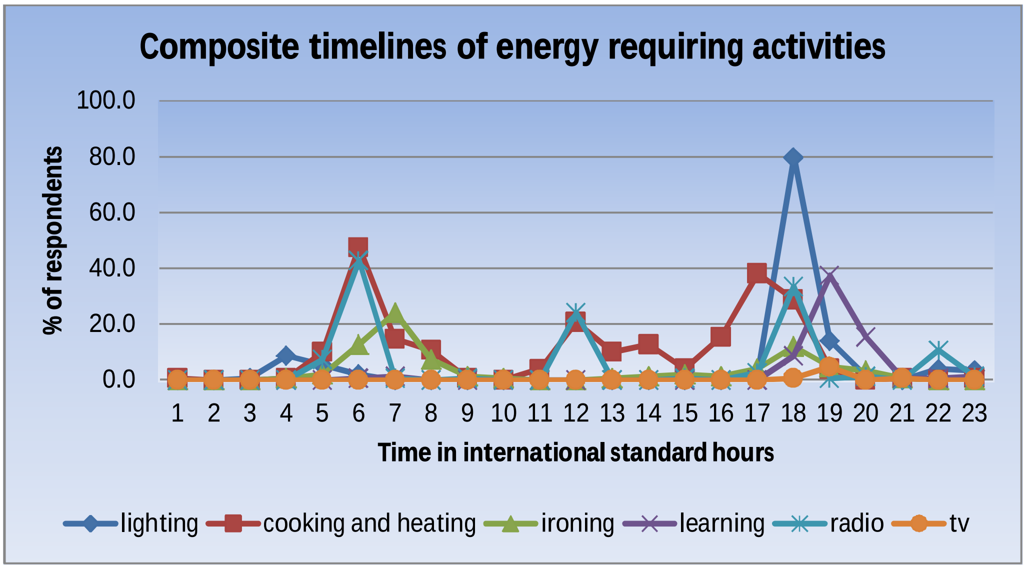


Chart 5-5: Composite timelines of energy requiring activities
Source: Author's field survey, May-July 2012

Lighting peeks with about 80 percent of respondents using it from 18 hours onwards. A little over 14 percent will normally switch on their lights after 19 hours. This is possible because of the almost equal lengths of day and night hours experienced in the tropics. Only 16.1 percent of the total number sampled used some form of lighting in the morning. Those who needed light used it between the hours of 03 hours -06 hours. The peak hours of the morning were 04 hours and 05 hours. After 06 hours, there was enough natural light. Another significant energy based night activity was learning. In total, about 53 percent of respondents (representing the pupils and students in the various households) started learning between the hours of 19 - 20hours. The majority 37 percent start learning from 19 hours. Ironing is also one energy activity that is noticeable in the mornings. Respondents indicated that ironing was mostly undertaken to iron the school uniform of pupils and students. On very rare occasions did the adults iron their clothing. Timelines serve to give a general picture of the energy use pattern in a day and specific periods of high energy consumption. As shown in the above discussion, energy peak periods in the rural study communities follow the general pattern of peaking in the mornings and evening even though peak periods are higher in the evenings. This could serve to guide interventions and the sensitisation of the target beneficiaries on the efficient use of energy, the need to conserve energy or even recharge energy supply as in the case of solar photovoltaic systems, when energy is less needed.

5.7 Energy for undertaking economic activities

This section presents economic activities identified among households interviewed and their energy uses. Of the total number of households interviewed, only 18 percent were engaged in productive activities in the communities that were energy consuming (Table 5-18). Most of the study respondents were farmers, about 83.9 percent, who depended on human mechanical energy using hoes and cutlasses, and (very rarely) on animal power in the communities in the Upper East Region. Very few of these farmers employed energy in the form of diesel for the use of tractor in ploughing their agricultural lands - these constituted only seven out of the thirty-six households which were engaged in energy-based productive activities (Table 5-19).

Table 5-18: Energy options for economic activities

Energy for economic activity	% of respondents, N=199
First energy	18.1
Second energy	2.0
Third energy	0.0

Source: Author's field survey, May-July 2012

Table 5-19: Household energy-based economic activities

Economic activity	No. of respondents, N=36
Commerce – petty trading, convenience shops	13
Agriculture – farming	5
Agriculture and commerce	2
Agriculture processing - shea butter, dawadawa[42]	5
Food processing and vending	5
Light industry – tailoring	4
Cottage industry – milling	1
Commerce and agricultural processing	1
Total	**36**

Source: Author's field survey, May – July 2012

Other activities included commerce – petty trading, convenience shops, solar appliance charging, agricultural processing cottage industry, food processing and vending (chop bar) including fish processing through frying and sun-drying, dress-making, and milling-grinding-pressing undertaken with diesel engine (the multifunctional platform). The solar appliance-charging businesses were subsidiaries of already established convenience mini-shops and of a drinking bar in Kumfia and Fakwesi respectively, both in the Atebubu-Amantin District. In the study communities in the Upper East Region, private owners of solar home systems acquired through the GEDAP charged the mobile phones of community members in their homes not as established businesses but adhoc business activities. Nevertheless, both groups in the Upper East Region and in the Atebubu-Amantin District provided the service at a fee, ranging between GHS0.5 and GHS0.6 per charge. The energy sources used were firewood, charcoal, dry cells (with torch), paraffin, solar, grid, diesel engine (for MFP), and petrol or diesel (for generator) (Chart 5-6). In terms of the number of respondents, 21 respondents of this sub-sample used biomass - firewood and charcoal - for their economic activities, six respondents used fossils for their activities, and three used grid electricity for charging rechargeable lamps and for milling of food stuff in neighbouring towns. One respondent using the MFP and fossils for milling foodstuffs which were later retailed. The remaining five respondents used dry cells and

[42] Soumbala balls, a local spice

torch (to enable late night sales), paraffin, and solar for operating the phone charging business and to operate the drinking bar in the playing of music.

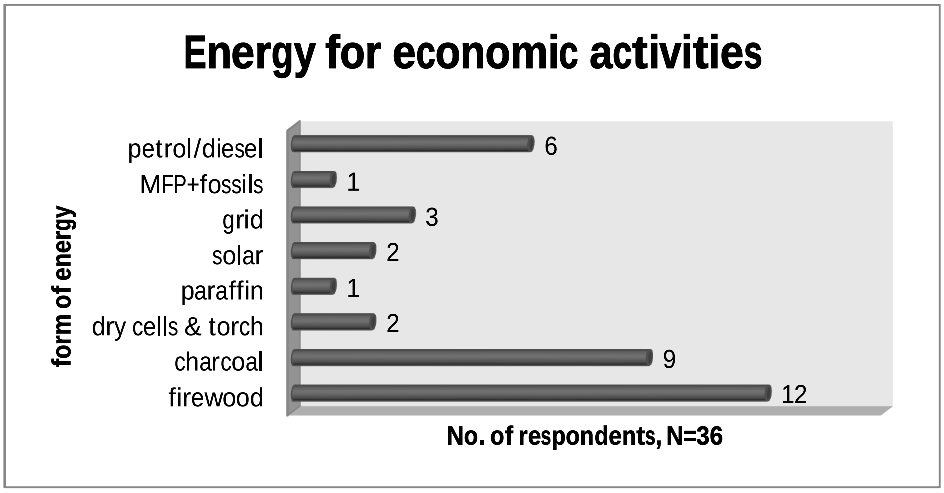


Chart 5-6: Energy for Economic Activities
Source: Author's field survey, May-July 2012

When energy options for the economic activities were sought, only two percent of respondents had second energy options and none had a third (Table 5-18). The food processing industry supplemented firewood with charcoal; those who were engaged in shea nut processing sometimes went to neighbouring towns and used electricity for the grinding aspect of the processing activity instead of manually pounding it; farmers engaged in mechanised farming who used fossil fuels used petrol in the absence of diesel to carry out the agricultural activity. It is worth noting that even though agriculture activity undertaken in these rural communities was generally not modern energy intensive, the agricultural process involved a series of energy intensive processes, viz, land clearing and preparation, harvesting, drying, storage, and processing. In the communities visited, except for the few respondents who depended on tractors for ploughing, human energy and natural 'non-technicalised' energy were used. As already indicated, hoes and cutlasses were used for land clearing; in rare cases, oxen were employed. The land was subsequently burnt as part of the slash-and-burn farming practice. Direct energy from the sun was engaged during harvesting and drying. For preservation, wind energy was engaged; vegetables such as pepper were cooked, dried in the sun and bagged; fish was salted and dried. With the absence of grinding mills, agriculture produce such as cereals were winnowed, pounded and sifted using human mechanical energy. In the Upper East Region, transporting of food stuffs to the market on market days from one community to the other and within communities was either head-carried or drawn on animal-drawn carts.

Energy use for economic activity is economic activity dependent. Chart 5-7 shows that the majority of respondents (18) would prefer using electricity for their economic activity if they had that choice. For instance, the operator of the MFP in Fakwesi in the Atebubu-Amantin District, remarked that, grinding mills that operated with electricity grinded smoother than the MFP which operated on diesel. Again, with electricity he would be able to attach a battery charging unit more efficiently to the engine than in its decentralised fossil-based state.

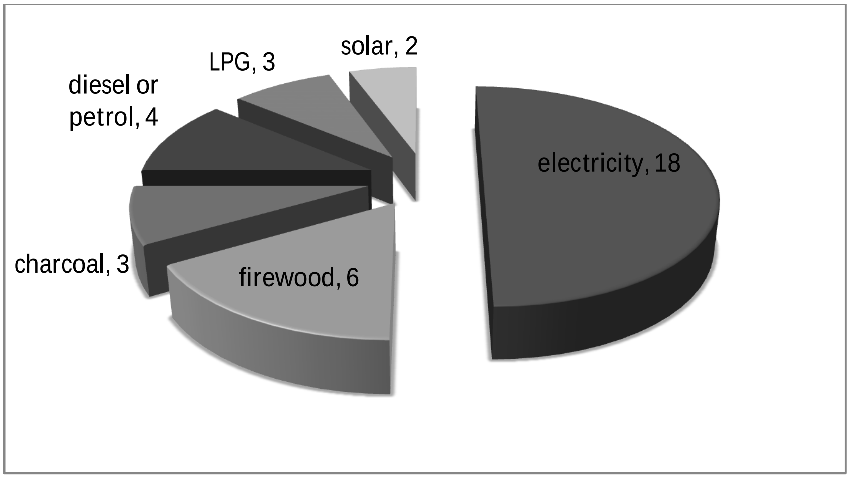


Chart 5-7: Preferred energy for economic activity
Source: Author's field survey, May-July 2012

Table 5-20 presents a list of anticipated livelihood activities and improvement in livelihood activities listed by respondents.

Table 5-20: Anticipated economic activities with improved source of energy

Study Districts		
Kassena-Nankana East	**Builsa**	**Atebubu-Amantin**
Large scale farming	Large scale farming	Mobile phone charging
Hair barbering	Open an electrical works shop	Operate a cold store to sell fish
Operate a convenient shop	Work late into the night	Sale of cold water, drinks, operate a bar
Sale of cold water and drinks	Operate a poultry farm	Baking
Work late into the night	Sale of cold water and drinks	Operate a corn mill
Expand shea butter production		Expand and improve functions of MFP
Operate corn mill		Welding
		Irrigation farming
		Petty trading
		Sale of appliances
		Rent out musical instruments
		Large scale food vending
		Expand tailoring business

Source: Author's field survey, May – July 2012

Dressmakers foresaw that they would be smarter, faster and improve their productivity if they were running electric sewing machines. In a similar vein, fishmongers would have operated cold stores to maintain the freshness of their fish when they were unable to sell out all their fresh fish during the day rather than frying, salting or smoking them for preservation. Those involved in agricultural processing would prefer electricity at some point in the processing – for example, shea butter and "dawadawa" processing required milling at certain points in the processing; petty shop operators could operate for longer hours. Interestingly, almost a third of respondents preferred to use biomass, that is, firewood and charcoal, "*because it is faster"*. The scenario presented by one respondent who was a "chop-bar" (local commercial eating place) operator was that the "*firewood makes a huge fire and is able to cook faster as well as able to support big cooking pots*". What this respondent did not appreciate was the inefficient way in which energy from the "huge fire" was combusted, that the excess heat and flames around the cooking pot were all wasted. In terms of the availability, respondents preferring biomass and fossil fuels indicated that they had access. Notably, they considered the physical access without considering the challenges involved such as the number of hours they might spend to gather biomass. For the remaining 26 respondents, they could not use their preferred energy because the energy form was "*not available in their communities*" (i.e. electricity) or it was "*too expensive"* (i.e. solar and LPG) as shown in Table 5-21.

Table 5-21: Non-use of preferred energy for economic activities (excluding biomass)

Reasons for non-use	**No. of respondents, N=26**
Too expensive	18
Energy not available in the area	8

Source: Author's field survey, May-July 2012

5.8 Summary and conclusion

Tables 5-22 is a summary of the energy use in structure and magnitude of the population sampled. It presents a bird eye view of the effective proportions of respondents who had primary and alternative energy from the analysis in Chapters 5.2 to 5.7. It also shows the preferred energy for the various energy services required by respondents. The responses on energy preference serve as an indicator of respondents' appreciation of alternative energy sources and their own motivation for ownership and use when possible. From the summary table, it is obvious that 100 percent of the surveyed sampled utilised energy services for cooking and heating, and lighting. However the use of other energy services varied. With the exception of cooking, all other activities are to a large extent dependent on electric power. Thus, from Table 5-23, with the exception of cooking and heating, the majority of respondents indicated the unavailability of the energy source as the reason why they are unable to use their preferred energy, which is mainly electricity. This goes to iterate the importance, the multiple role and ripple effects of access to electricity. According to an International Energy Agency (IEA) World Energy Outlook (WEO) 2006 report, energy for cooking is mostly the last to be considered by poor families (IEA, 2006:422). The study showed that the respondents in the Brong Ahafo Region for instance did not seem to acknowledge the challenge of gathering and using biomass for cooking with the exception of the health implications such as backache and the respiratory effects of cooking with fuelwood. This is because it was comparatively easy to find twigs and logs on their farms, and gathering of fuelwood was seen as commonplace in daily farming activity. Most invariably, they visited their farms each day of the week except for cultural taboo days, and each day they gathered enough fuelwood to keep the household supply running. However, for the respondents in the Upper East Region, fuelwood gatherers who were mostly women walked an average of nine miles for each trip of fuelwood search. Their farmlands were located around their homesteads and not within forests or thickets where they could gather fuelwood from. The Region lies in the Guinea Savannah zone where trees are sparsely distributed, and what respondents referred to as the 'bush' were located miles away from the communities. In addition, they were not always able to get the supply from the 'bush' but rather gathered as they walked along. This situation has a toll on the productivity as well as the health of the women. As they rightly indicated, during the farming season, they rarely went to the 'bush' because of the farming demands around their homesteads. They either did these trips *only* twice a week or depended on millet and sorghum stalks as alternatives. Since these alternatives burnt faster than fuelwood, it also meant that they cooked less, further affecting the nutrition of their households. This study confirms the IEA assertion above which will later be seen in the analysis of what energy for which activity respondents considered first in prioritising their energy needs.

The discussion establishes that the traditional forms of energy are the most used in the research communities. One marked finding was the new phenomenon on dry cells and light emitting diode (LED) torches which seem to have gained grounds as energy for lighting replacing the traditionally known paraffin due to the unavailability and the constantly rising costs of fossils fuels. In addition, the LED torches were noted as brighter, safer to use, and are easier to carry along than paraffin lamps. The identified economic activities that were energy dependent relied mainly on biomass. Therefore the main energy supply for household activities both domestic and livelihood were traditional or intermediate and were not sustainable in the long run. Consequently, given unlimited choices, majority of respondents preferred modern forms of energy for all energy services. Grid electricity ranked the highest for all services that were eventually dependent on electrical energy, i.e. lighting, ironing, learning, entertainment and communication, and economic activities, and liquefied petroleum gas (LPG) was the majority option for cooking, even though a considerable number of respondents still preferred to use charcoal for the fear of the risk involved in using LPG. These responses are indicative of how contingent most energy services are on electricity and the reason why its provision is given much eminence over the other energy services. That notwithstanding, an improvement in cooking and heating energy and access to cooking and heating energy require equally important and immediate attention if the current majority source of cooking and heating energy and its negative externalities on users and the environment are considered.

Among all the energy uses, economic activity was the least energy dependent activity with only 18 percent of respondents indicating their use of some form of energy apart from human motive power. The majority of respondents for the study were farmers, constituting about 84 percent of the total sample, who depended mainly on man power to carry out their activities. Economic activity serves more or less as a foundation for improvement and sustainability of energy interventions. In Table 5-23, a summary of reasons why preferred energy was not used is presented. Two outstanding reasons why households were unable to use their preferred energy service were the cost and availability of the energy forms. The implication here is that unless households have a sustainable livelihood with enough disposable income, households will remain in energy poverty for a long while. The communities visited are all basically farming communities which produced basically on subsistence basis. The situation was worse in the Upper East Region where agricultural activity was mainly to provide food for the farming household and portions only sold to meet other pressing household needs such as health or education, or when they needed other dietary supplements such as fish or vegetables. In the Brong Ahafo Region, the situation was different. That Region is generally considered as the food basket of the country. In the study communities, farming was not just subsistence but also an economic activity. Conclusively, even if the modern energy options were available, financial access might remain a challenge. On the other hand, if energy options are available, households may be motivated to find a means of accessing it. This will be further examined in the next chapter where willingness to adopt and pay, and the ability to pay are assessed.

Table 5-22: Summary of energy use in structure and magnitude and preferred energy of respondents

Energy activity	Proportion of respondent who had first energy option (%), N=199	Proportion of respondent who had alternative energy (%), N=199	Preferred Energy (% of respondents) Grid electricity	LPG	Charcoal	Kerosene	Firewood	Solar	Dry cell	Car battery	Fossils	Total
Cooking and heating	100.0	71.1	5.4	60.4	26.2	2.7	5.4	0.0	0.0	0.0	0.0	100
Lighting	100.0	25.0	88.1	0.0	0.0	0.7	0.0	7.7	1.4	0.7	0.0	100
Ironing	80.0	4.7	92.5	0.0	2.2	0.0	0.0	5.2	0.0	0.0	0.0	100
Learning	73.0	7.4	90.3	0.0	0.0	0.8	0.0	8.1	0.8	0.0	0.0	100
Others – TV radio, phone charging	89.9	9.0	83.6	0.0	0.0	0.0	0.0	11.8	4.6	0.0	0.0	100
			Preferred Energy (No. of respondents), N=36									
Economic activity	18.1	2.0	18	3	3	0	6	2	0	0.	4	36

Source: Author's field survey, May-July 2012

Table 5-23: Reasons why preferred energy is not being used

Activity	Reasons (% of respondents) too expensive	energy not available in area	have no electricity connection	Do not have appliances	Other	Too expensive & not available	Too expensive & lack of appliances	Total
Cooking and heating	48.2	28.9	0.0	7.0	6.1	8.8	0.9	100
Lighting	25.7	65.0	5.0	0.0	2.1	2.1	0.0	100
Ironing	18.4	72.0	5.6	0.8	3.2	0.0	0.0	100
Learning	18.1	74.1	4.3	0.0	2.6	0.9	0.0	100
Others – radio, phone charging, etc.	28	63.6	5.9	0.0	2.5	0.0	0.0	100
	Reasons (No. of respondents)							
Economic activity	7	29	0	0	0	0	0	36

Source: Author's field survey, May-July 2012

6 ENERGY SUPPLY AND RESOURCES

6.1 Energy Supply

This sub-section observes the sources of energy in the study communities as well as the resources which are as yet untapped. These are grouped according to domestic energy, community energy and energy for livelihood activities.

6.1.1 Domestic energy

The domestic energy forms identified for cooking, lighting, heating, learning, ironing, and communication activities such as playing radio and charging mobile phones are indicated in Table 6-1.

Table 6-1: Domestic energy supply

Domestic energy service	Energy supply	Source
Cooking and heating	• Biofuel – wood, millet and sorghum stalk, charcoal, cow dung • LPG	• Forests, wayside, farms, community • District capital or adjoining District
Lighting	• Solar PV, generators	• Community, neighbouring towns
	• Hydro-electricity – through re-chargeable lamps	• Community • Neighbouring communities
	• Dry cells and torch	• Neighbouring towns
	• Fossil - paraffin	• Community, neighbouring towns
	• Millet and sorghum stalks	• Farms
Learning	• Dry cells and torch	• Neighbouring towns
	• Battery-box'	• Home-based recycling which joins in a series circuit connection lights of old non-functioning torches and dry cells by a household in the Builsa District
Ironing	• Paraffin	• District capital
	• Charcoal, fuelwood (with box iron)	• Community, forest cuttings
Information – Radio	• Transmitters and Dry cells	• District capital, neighbouring town • Community
Communication – mobile phones	• Solar PV and generators	• Community
	• Electricity	• Neighbouring town, self-owned SHS, neighbour's SHS

Source: Author's field survey, May –July 2012

With the exception of the solar home system and LPG, the majority of sources of energy supply were traditional and unsustainable. Dry cells may be considered as an improvement and a step up the energy ladder from paraffin but they cannot meet the energy requirements of households. Respondents possessing electricity re-chargeable lamps are also a step ahead but the source of energy is not within their control. In the case of a discharge without immediate access to grid electricity, they either fell back on dry cell operated lamps or paraffin.

6.1.2 Community energy

Table 6-2 shows the forms of energy used and their sources in providing community services.

Table 6-2: Community energy supply

Community Energy Service	Energy supply	Source
Streetlight	• Solar PV, generators	• Community
Health Centres – CHP compounds	• Solar PV, generators	• Community
Community Announcement	• Gong-gong	• Local manufacturers
	• Generator and amplifiers	• Fossils
	• Human motion power	• Members of Traditional Authority
Schools	• Solar PV, generators	• Community
	• Natural light	• Sun
Water	• Human power	• Manually-operated boreholes • Human drawers and carriers - boys and girls respectively - from rivers

Source: Author's construct based on field survey, May-July 2012

In the list of energy sources available in the study communities for community services, solar photovoltaic was the only modern form of energy. Health facilities identified in some study communities were the Community-based Health Planning and Services (CHPS) compounds. Some of these operated with solar energy. In Kori-Alam-Yeri, a study community in the Builsa District, the story had been previously different where the community health centre ran on torchlight and paraffin lamps. Maternal mortality was reported as high. It was particularly a depressing situation when labour occurred in the night for expectant mothers with complications. There were no public transportation systems from the community to the nearest hospital which is in Sandema, the District capital, a distance of four kilometres. This trip was normally covered on foot. They testified that the community was yet much peaceful and one could be rest assured that mothers would be delivered of their babies safely. The Headman of the Alam-Yeri community commented,

> *"Now members of the community can be assured that the lives of their women in particular will be safe during unexpected night labour."*

The Balansa community, also in the Builsa District, was a pilot community for the GEDAP solar streetlight project. The community recommended the streetlight to be located close to the community boreholes to allow the women to safely fetch water in the night (See Figure 3-4). Before then, there had been incidences of snake bites in the night as the women went to fetch water. 'Under the streetlight' had also become a place of communal gatherings in the evening. The solar streetlight also served as a community clock. One lady respondent asserted,

> *"The solar streetlight has become a clock for us. Sometimes we are not sure what time it is in the morning when we wake up and want to go and search for firewood. When we see the streetlight is still brightly on, then we know it is still too early. When it is dim*

or off, then we know it will soon be sunrise or about 5a.m. So then it is safe to move out".

On the contrary, communities that did not have streetlights did not feel safe travelling between communities in the night. As community members indicated, carrying torch or paraffin lamps along in the night did not give them a sense of security because the brightness of the torchlight or the paraffin is limited to a certain radius beyond which one is in total darkness. To confirm the situation, it was observed when the Author and her research team left the communities late in the evening that the roads were deserted and the only form of illumination was that of the vehicle used. Solar again provided educational energy services. In Kori-Alam-Yeri, certain sections of the primary school had solar energy which allowed the children to study in the evening. In the remaining study communities, the schools depended on natural light for studies and thus their evening learning capacities were hindered.

Announcements in the communities were made using the traditional gong. In Fakwesi and Kumfia in the Atebubu-Amantin District in the Brong Ahafo Region, Traditional Authorities occasionally operated generators and amplifiers especially in announcing community communal works. However this was fossil fuel dependent and "there was not always enough money to run it" (Interview with Unit Committee representative – Kumfia, 20th June, 2012). One of the means used to generate funds for fuel was to allow community members to charge their mobile phones at a fee whenever the generator was running. The generator was also hired out for private funerals in the communities. Furthermore, drawing of water for household purposes was a manual exercise. Some of the study communities in the Upper East Region had manually operated boreholes. In all the study communities in the Brong Ahafo Region, water was fetched from the streams and rivers. The irony of one situation identified was that the Pru River which run through Sabidi one of the study communities, was treated and pumped to supply water to Atebubu the District capital, and its neighbouring communities. The pumping station was located at Sabidi, while the Sabidi community itself drew unprocessed water directly from the Pru River. In Figure 6-1, children are seen head carrying water from the river side. Even at that early age, it was not uncommon to see the girls bearing the loads of basins of water while the boys just walked in front unburdened. When briefly interviewed, the young boys asserted that the boys drew the water from the stream and the girls had to carry it home. An alternative energy powered source of water provision will definitely be in the interest of these young girls of school-going age.

Figure 6-1: Children carrying water drawn from stream

Location: Sabidi, Atebubu-Amantin District, Brong Ahafo Region

Source: Author's field survey, May-July 2012

6.1.3 Livelihood activities

Livelihood activities identified in the study communities were agricultural, commerce and service, and light industrial activities. Energy supply for these activities and their sources are shown in Table 6-3.

Table 6-3: Energy supply for livelihood activities

Livelihood Activity	Energy supply	Source
Agriculture	• Fossil fuel – diesel or petrol • Sunlight, atmospheric heat • Firewood • Wind • Human power	• District capital • Sun • Farms, forest • Community • Community – household and hired hands
Commerce and service:		
Petty trading	• Hydro-electricity, • Dry cells for playing radio • Wet cell and dry cell batteries	• Neighbouring communities • Community • Purchased from neighbouring communities
Fish mongering	• Sunlight, • Biofuel - firewood, charcoal	• Sun • Farm biomass from the community , forest cuttings, way-side
Solar phone charging	• Solar PV, generators, • Hydro-electricity	• Community • District capital, neighbouring community
Drinking bar	• Solar, generators	• Community
	• Fossils	• District capital; retailers in neighbouring communities
	• Musical equipment, generators	• Community
Light industrial activities:		
Dressmaking	• Sewing equipment, human power • Box iron • Charcoal, wood fuel	• Community • Local charcoal manufacturers, community • Community, forest cuttings
Dawadawa (Soumbala balls) and shea processing	• Human labour	• Community – households and hired hands
	• Biomass	• Forest cuttings, way-side, farm waste
Grinding and grain milling	• Diesel engine (multifunctional platforms) • Fossil	• Community based development program • District capital
Cassava processing ('gari')	• Grinding and dewatering equipment (MFP), human power • Biomass	• Community • Farmlands, forest

Source: Author's construct based on field survey, May-July 2012

Agriculture

The main energy resource for agricultural activity was human power. The clearing of the land engaged the local service known as 'by-day' where farmhands were employed and paid daily wages, or was undertaken by the households themselves. In the study communities in the Districts in Upper East Region, it was found that households rarely used animal traction for their farm work because not all households owned cattle and hiring was expensive for them. Agricultural production therefore was limited to subsistence production. The farming households that used tractors got their supply of fossils from the District capital. The drying and burning of cleared weeds engaged direct heat energy from the sun.

Agricultural processing in the study communities in the Upper East Region involved cracking of shelled legumes such as groundnuts, beating of shelled legumes such as beans, and cereals such as millet and sorghum for the de-shelling process. Maize also went through a similar process of beating but was rarely grown in the Region due to poor weather conditions. Rice is also beaten to obtain the paddy and subsequently pounded to remove the husks, and strained with the aid of the wind to separate the husk and the bran from the kernel. The cracking, beating and pounding processes were all manual activities. For storage and preservation purposes, sunlight and wind energy are used. The households had local silos where cereals could be stored in their unprocessed states for the year. Transporting agricultural produce from the farms to the homes was normally done by human carriers since the farmlands were around the homestead. Transporting agricultural produce to the market centres also engaged head-carriers or load-bearing animals, typically the donkey. Not all families had the load-bearing animal facility. Figures 6-2 and 6-3 depict these processes.

Figure 6-2: Traditional storage system in the Upper East Region and agriculture processing
Source: Author's field survey, May-July 2012

Figure 6-3: Manual and non-technicalised agricultural processes
Source: Author's field survey, May-July 2012

In the Brong Ahafo Region, the case was slightly different. Most farm produce were sold to middle men who conveyed the produce from the hinterlands to the urban areas. These buyers came with tractors which carried the hand-harvested produce from the farm to the main town and cities. However, the proportions that was for the subsistence of the farmers and their households were carried as head-loads from the farms to the homes after each visit to the farm. Tuber crops such as cassava, yam and cocoyam were harvested from the roots and further stored in the earth to preserve it from drying. Cereals, particularly maize and beans were harvested, dried and stored in traditional silos. The traditional silos were of different sorts in the southern parts of the country. These were cribs or barns. Pepper was sold as fresh vegetables or was boiled, dried and bagged to preserve it over a longer period of time for the market. Most vegetables such as garden eggs, okra and tomatoes had to be sold out in the fresh state due to the lack of preservation and storage methods. Consequently, during bumper harvests, the farmers were forced to sell at rather low prices to middlemen-and-women to save themselves from losing their investments that could result from postharvest loses. The farmers were exploited but they did not have better alternatives.

The agricultural processes described in both study regions show extensive use of human power and traditional processes which could be enhanced to increase productivity and improve livelihoods if alternative and modern or even intermediate energy services were available. For instance, in the Upper East Region where the soil structure is characterized by thin topsoil, the possibility of animal traction in ploughing could improve agricultural productivity. While households in the Upper East Region could not produce enough for themselves, their counterparts in the Brong Ahafo Region were mostly at the losing end because products had to be sold cheaply at the farm gate to prevent postharvest loses. This iterates a point made earlier in the theoretical discourse that energy development can well serve a needed technological development. As Brugger (1986) (quoted in Diaw, 1994) suggests, if the necessary technology is not available - and in this case decentralised energy -, there could be an appreciable propensity that middle women and men [a typical market phenomenon in Ghana] operating as exogenous factors could siphon the potentials of the local economies to their own economies, developing and creating growth there at the expense of the origin of the potentials.

Commerce and services

In the communities in the Atebubu-Amantin District, petty trading was common. The least distance between the communities and the closest town and urban centre Atebubu, which was also the District Capital is 20 kilometres. This necessitated that the communities provided for themselves a basic level of self-sufficiency through individual establishment of mini kiosks and convenience shops. In the night these shops used torchlights and dry cells which enabled them to trade late into the night. Shop operators indicated their shops could stay open till 11p.m. In another situation found in Nagalikenia, the trader depended on the neighbouring community that had electricity for energy dependent activities such cooling water and drinks. Fish mongers in the communities in the Atebubu-Amantin District preserved the remaining fish after the day’s sales through salting, drying or frying. Solar phone charging depended on energy from individual solar home systems, and drinking bars used generators and fossils purchased from neighbouring towns to cool their drinks and play music, as well as solar home systems for lighting purposes and also to charge the mobile phones of community members. The energy systems for commerce and service activities, with exception of solar, did not seem efficient for the energy services required and therefore productivity was not optimum for each of the services.

Light industrial activities

From the table, the only decentralised energy system enhancing light industrial activity was the MFP which had significantly enhanced the production and productivity of the cassava processing industry as well as household milling of cereals and nuts. In addition to the conventional grinding component, the system also had a presser for cassava processing.

Figure 6-4: The MFP and Cassava processing in Fakwesi
Source: Author's field survey, May – July 2012

These activities were formerly either conducted manually as in the case of cassava processing, or undertaken in District capital in the case of milling of cereals and nuts. Cassava processing for instance initially took about two weeks to be carried out. With the MFP, the same output was produced in one week, saving the women involved about 50 percent of their time. Moreover, it saved the women from travelling almost 38km to Atebubu (from Fakwesi) to process food as was previously the case. Figure 6-4 shows how the MFP and its accompanying presser have enhanced cassava processing. Even though by design the MFP could be configured to couple a de-husker, a battery charger which could in turn be used for charging mobile phones, and a blade sharpener that could sharpen the hoes and cutlasses of farmers, none of these energy functions and services were installed or operating at the time of field survey.

Figure 6-5: Light industrial activities in communities in the Upper East Region
A: Seamstress ironing with box-iron under a baobab tree in Wuru, Builsa District
B: Shea butter processing in Akurugu Daboo (Atosaale), Kassena-Nankana East District
Source: Author's field survey, May – July 2012

All the other forms of energy for light industrial activities which were identified were traditional. Even the roasting of the crashed cassava into the final product called 'gari' was done using biomass though the fireplace is more enclosed to increase energy efficiency and reduce combustion as shown in the background of third plate of Figure

6-4. Figure 6-5 also shows a seamstress ironing with the local box iron on an improvised ironing board and shea butter processing on a three-stone fireplace in two study communities in the Upper East Region.

The sustainability of energy systems depends much on the ability of individuals to maintain them, and where provided by utility services or private investors, the ability to pay for the services provided to keep supply constant. Energy services cannot continue to be provided as a social good. It becomes therefore imperative that consumers have a means to support the service they would enjoy. For instance, in the case of the GEDAP promoted solar systems, farmers were paying off their loans from their farm earnings. In this case, the actual sustainability of the project and the systems can be ascertained after loans have been paid off, and after the fifth year when consumers have to replace their batteries and inverters. At the same time energy services are fundamental for economic growth. It is important that energy service provision is rightly packaged to include a component of productive uses to ensure the appropriate and productive usage. All livelihood activities identified were energy based. Clearly an improvement in the supply of energy will improve the productivity of the economic activities as witnessed in the case of cassava processing in the Atebubu-Amantin District. As discussed in Chapter four, it is reported for instance that even though the country boasts of 72 percent electrification, only about 50-60 percent of households in electrified communities are actually connected (Energy Commission, 2012:31). Cases where connected rural houses have sometimes only one incandescent bulb for the whole house are reported as not uncommon. By implication, most rural houses do not optimise the use of modern energy.

In the case of the development of agriculture, while mechanised farming is not recommended in the communities in the Upper East Region due to the soil structure, other energy enhancing technologies such as solar irrigation and solar drying could be promoted. The MFP for instance has been proven to have worked except for technical challenges encountered with regards to finding and replacing mechanical parts which was reported as expensive (Author's field survey 2012; Inkoom, 2009). Hence, it could be useful for agricultural processing activities such as shea-butter and dawadawa processing, and the milling of cereals for domestic use. Appropriate agricultural processing or preservation could boost the rural economy. It was also evident that without the appropriate agricultural processing, farmers are exploited by wholesalers in a situation that should have rather brought more gains to the farmers and their farming communities.

6.2 Energy resources identified for decentralised supply

6.2.1 Solar

In the Upper East Region, the biggest energy resource identified is solar. The temperatures at the time of the study were within the range of 35°C and 40°C. The Region receives daily solar radiation levels of 4-6kWh/m2 and has sunshine for all months of the year with the highest radiation levels being recorded between March and June. It has very low solar diffuse radiation of rate of about 32 percent (Refer Solar map of Ghana, Map 4-1).

On the other hand, the Atebubu-Amantin District lies within a relatively high solar diffuse radiation zone, with radiation levels of 36 – 40 percent. Daily solar radiation levels are between 3.1-5.8kWh/m^2 (Omane Frimpong, 2013). However, from the field survey, two individuals were identified in Kumfia and Fakwesi who were using solar home systems commercially. Moreover, the GEDAP's off-grid electrification with solar photovoltaic component had been extended to the Sene District which borders the Atebubu-Amantin District and is within the same climatic and ecological conditions. It is therefore plausible for this corridor of the Atebubu-Amantin District to also be considered for solar applications. The Atebubu-Amantin District experiences the double maxima rainfall and therefore solar irrigation for dry season farming may not be as eminent as in the study Districts in the Upper East Region. However when solar is applied to the abundant water resource identified in the study communities (See Chapter 6.2.4), solar water pumping will be a potential to improving the potable water supply challenge identified in the communities. The solar water pumping system is economical to maintain (http://www.ext.colostate.edu/pubs/natres/06705.html[43]) and could serve as a source of income for the community; this income could also be used for the maintenance of the system. New Energy, a water and energy non-governmental organisation (NGO) based in the Northern Region of Ghana has installed over 100 of such water systems in a number of communities which formerly depended on hand pumps the in Northern Region. Water production levels are reported to have increased significantly: the ordinary borehole with a hand pump could produce three to five litres of water per minute but with the solar water pump it produces 15 cubits of water every hour which is equivalent to 250 litres per minute (Interview with Energy Development Practitioner, New Energy – 28th May,2012. Tamale, Ghana).

Requirements of solar water pumping system

From technical literature, the least Peak Sunlight Hours (PSH) needed for the location of a solar water pumping system is five to six hours. The District experiences mean monthly temperatures ranging between 30°C – 24°C. There is no specific data on the number of hours of sunlight for the Brong Ahafo Region or for the District in question. However, data exist for Kumasi in the Ashanti Region and Tamale in the Northern Region, the two Regions bordering the Brong Ahafo Region. An approximate average may be struck to estimate the average hours of sunshine for the Brong Ahafo Region. It is estimated that Tamale has an average sunlight hours of eight hours a day, while Kumasi is estimated to have 5.4hours a day. An average between the two gives 6.7 sunlight hours per day (See Appendix XVI) which can be estimated to the PSH for the Brong Ahafo Region. When the photovoltaic modules of the pumping system is well maintained, i.e., kept clean, securely mounted and protected from strong winds, lightening and hails storms, and from falling objects such as tree branches, the system is expected to have a lifetime of between 20 -25 years[44]. An important precondition will be the availability of water reserve tanks to store water for the days of the year when the PSH is lower than the technical required average of five to six hours.

6.2.2 Biogas

Biogas presents an energy option for the energy poor communities of the Upper East Region, in a scenario where income levels and availability of energy resources may not allow resources such as liquefied petroleum gas (LPG) to be easily accessible. One cubic metre of biogas is shown to be an equivalent of 1.50kilograms of firewood

[43] http://www.ext.colostate.edu/pubs/natres/06705.html (Accessed 11/12/2013)
[44] http://www.ext.colostate.edu/pubs/natres/06705.html (Accessed 11/12/2013)

(Practical Action and Bates, 2007:5). The biogas option could reduce significantly the time spent in wood fuel gathering thereby saving time for the women to be involved in other productive activities, and at the same time reduce the pressure on natural wood resources. In addition, the slurry derived can be used as fertiliser. The Upper East Region is among the three Northern Regions of Ghana where cattle-rearing is the dominant type of animal husbandry. The figures on animal population shown in Table 6-4 were obtained from the Agriculture Departments of both the Kassena-Nankana East and Builsa District Assemblies.

Table 6-4: Livestock population in the Kassena-Nankana East and Builsa Districts

Kassena-Nankana East District			**Builsa District**	
Livestock	**Population 2010**	**Population 2011**	**Sandema Cattle Census 2009**	**Sandema total livestock 2009**
Cattle	22,126	23,232	8,770	110, 263
Sheep	34,891	36,635		
Goat	67,689	71,073		
Pig	16,606	17,436		

Source: Departments of Agriculture, Kassena-Nankana East and Builsa Districts, 2012

The cattle population shown under the Builsa District is for the whole of the Sandema zone. The District did not have updated and detailed livestock information except for the 2009 cattle population of 8,770 and total livestock population of 110,263. Given a total human population of 5,955 in Sandema as at the year 2010 (Population and Housing Census, 2010) and assuming a specific average household size of Sandema as 4.5 persons[45], it is estimated that each household has an average of 6.6 cows. This is illustrated below:

$Ps_{(2010)}$ = Total population Sandema (2010) = 5,955
Hhs = Average household size Sandema = 4.5
$Pc_{(2009)}$ = Total cattle population Sandema (2009) = 8770
Average number of cattle per household $= \frac{Pc_{(2009)} \times Hhs}{Ps_{(2010)}}$
= 6.6 cows

Source: Author's estimation

The calculation cannot be applied to the communities in the Kassena-Nankana East District. Information gathered from the Agriculture Department shows that the cattle are concentrated in Biu, Kologo and Naga, three rural communities located in the southern section of the District (Refer to Map 3-3) further away from the communities of study. This was compared with data gathered from the field. Only four percent of

[45] In 2000, the District average household size was 5.2, and that of the Sandema zone was 4.3. In 2010, the District average household size is given as 5.5. Information is unavailable on the total number of urban households in the District, where the Sandema zone is considered in totality as the urban zone, having a total population of more than 5000 persons. Specific information is also unavailable for the average household size of Sandema. The Author therefore assumes an increment of +0.2 persons following from the positive addition to the general average household size of the District. Even though there could be a possibility of a - 0.2 decrease, it is assumed that with recent upward surge of urbanization, +0.2 is more plausible.

respondents in the District were engaged in the animal rearing, specifically goat and chicken, as a secondary economic activity to farming.

The technical input requirements of a biogas digester are (i) the availability of feedstock, which is either animal waste or human waste, (ii) high temperatures ranging between 30°C and 40°C needed for the anaerobic process, and (iii) water to dilute the waste into slurry (Practical Action and Bates, 2007). In a study on biogas in rural Uganda, it was estimated that a household with between five to ten cows could produce a minimum of $2.5m^3$ of gas which would be adequate for lighting and cooking for an average household size of six (Otim et al., undated). On face value, all three technical requirements seem to be met in the study Districts of the Upper East Region. The actual situation is assessed in the subsequent situational analysis.

Situational Analysis

- The estimated number of cows per household is 6.6 cows. However in the communities visited in the Builsa District, very few households owned cattle and those who had did not have significant numbers. In Kori-Alamyeri, one respondent remarked:

  > *"A strange disease attacked the animals and we lost most of them. We do not have agricultural extension service that could help us save the animals",* (Ateebiik Michael, Kori-Alam-Yeri).

  Again,

  > *"...during the rains, because we (the community) lie in the Volta Basin, the floods from Burkina flooded our lands, drowned and killed most of the cattle and sheep*", (Salifu Balusa, Kori-Alam-Yeri).

  The maximum number of cows that could be counted per household was three. The type of animal husbandry practiced was the pastoral type where the animals were taken to the field to graze. Dung for manure was therefore gathered from the field.

- Moreover, due to the impoverished nature of the farmlands, the farmers would prefer to use cow dung obtained both from their kraals and collected from the fields as manure for their farms, and would not sacrifice that for energy development. In an in-depth interview with 40 selected respondents, a little over two-thirds would not like cow dung to be used for energy production (See Table 6-5).

Table 6-5: Whether respondents prefer cow dung to be used for energy production

Response	Yes	No
No. of respondents, N=40	12	28

Source: Author's field survey, May – July 2012

When knowledge that the slurry produced is more suitable as manure is successfully imparted, this position of the community might change. However, there are other cultural inhibitions. Cow dung was also used as binding material used for plastering houses, and as feedstock which through anaerobic process generated maggots which were in turn used as feedstock for household poultry (See Figure 6-6 and Figure 6-7). In some parts of the Kassena-Nankana East District, it was also used as a source of fuel to start fire. In other parts of the same District but different tribal group, one community, Wuru, blatantly said that that part of the District did not use cow dung to cook except as manure and as building material. The respondents had disgusted expressions on their faces. In Kore-Alam-Yeri in the Builsa District, respondents asserted that cow dung was sparingly used for cooking because of the stench that was emitted during the combustion process. They were not very enthusiastic with a biogas idea. This obviously had aversive implications for suggesting biogas as energy for cooking.

Figure 6-6: Cow dung used as farm manure and as binding material in house construction
Source: Author's field survey, May – July 2012

Figure 6-7: Cow dung processed for poultry feed
Source: Author's field survey, May-July 2012

- The Region records the highest temperatures in the country with an average of 31°C and with a range of 40 – 21°C. The temperature requirements for biogas could thus easily be met.

- One major challenge for the successful implementation in the Districts is the availability of water. The Central Institute of Agriculture Engineering in Bhopal, India, has developed a modification to the fixed-dome biogas digester to address the situation where water is a challenge (Practical Action and Bates, 2007:3). This design allows undiluted cow dung to be used. It generates 50 percent more biogas for each kilogram of dung loaded into the system and does not require slurry drying time before it can be used as a fertilizer. The design modifications are an increase in the bore of the inlet feed, a greater reinforcement of the chamber to withstand the higher gas pressure, an enlarged slurry chamber outlet, and a smooth widened outlet channel to streamline the flow of the slurry. With this modification, the biogas option may be possible in the study communities in the Upper East Region. It is necessary however that a more comprehensive study is done to access its feasibility especially with regards to social acceptance.

- Possible carbon gain - Even though methane (CH_4) is produced, the burning of the gas as fuel for cooking and in some cases for electricity reduces the amount of greenhouse gases emitted otherwise generated by the raw dung. Hence, environmental-wise, biogas seems a laudable option.

Conclusively, even though biogas is perceived as an energy option for communities in the Upper East Region, other factors may militate against its success. A more detailed feasibility study will prove the extent to which the potentials can be used to mitigate the constraints or indicate if it is an option to consider at all.

6.2.3 Rice husk and groundnut shells

The MFP by the original design in Ghana uses fossil fuels to operate. Recently, KITE, a not-for-profit energy development organisation in collaboration with Christian Aid and other organisations have been exploring the possibility of using rice husk or groundnut shells through a gasification process as fuel for MFP operation in Jana, a community in the Northern Region of Ghana. When this is successful it could provide an alternative fuel for the implementation of the MFP in three Northern Regions of the country where rice (Amanor-Boadu 2012), and groundnut production are the highest, and consequently a possible consideration for the study communities in the Upper East Region. Rice and groundnut production in the two study Districts are shown in Table 6-6. The MFP has been useful for agriculture and agricultural processing activities in the agricultural communities in the Brong Ahafo Region including two of the study communities – Fakwesi and Kumfia. It would be all the more useful when all its complementary components such as blade sharpener, rice de-husker, and grinder are installed. The results of the feasibility may also indicate the viability or otherwise of biomass gasification as an alternative decentralised energy option for two of the study communities in the Atebubu-Amantin District which are already operating MFPs - there may be the possibility of exploring the drying and gasification of wet biodegradable waste that is generated from the wet agricultural waste in these study communities.

Table 6-6: Rice and groundnut production in Upper East Region study Districts

Crop	Kassena-Nankana East District		Builsa District	
	Production 2010 (MT)	Production 2011 (MT)	Production 2010 (MT)	Production 2011 (MT)
Rice	39504.6	33149.2	25513	22975
groundnuts	17046	6147.5	10997	11639.8

Source: Department of Agriculture, Kassena-Nankana East and Builsa Districts, 2012

Furthermore, both rice husk and groundnut shells could be compressed into briquettes. Briquetting is the process to improve the characteristics of biomass as a renewable energy resource by densification. Thus less volume of biomass will be needed for the same amount of energy output (GIZ-HERA, 2011). In a study by Yahaya and Ibrahim (2012) into the development of rice husk in Nigeria, it was found out in a water boiling test that while one kilogramme of rice husk-gum Arabic briquette and rice husk-starch briquette took fifteen minutes respectively to boil two litres of water, 1.2 kilogramme of firewood used 21 minutes to boil the same amount of water. It also showed that the briquettes had superior combustion properties over firewood giving off pale yellow to pale blue flames. Additionally, briquettes support a clean environment by helping to dispose of the waste from rice and groundnuts. They also reduce the pressure on forests, and are therefore carbon dioxide (CO_2) saver both in preserving trees to absorb the atmospheric CO_2 and reducing the incomplete combustion that is associated with firewood. It will save women the time spent from gathering fuelwood, and it is economical and affordable (Yahaya and Ibrahim, 2012; Ahiduzzaman, 2007).

The estimation in Equation 6-1 is based on a study in Peru using Oryza rice species (Assureira, 2002). The same species of rice is cultivated in Ghana. From the 39504.6 metric tonnes of rice produced in the Kassena-Nankana East District in 2010 (Table 6-6) an oil equivalent of 2,495 tonnes of oil equivalent (toe) could be produced. Similarly, 1611toe could be produced in the Builsa District.

Equation 6-1: Estimation of rice briquettes production in study Districts in the Upper East Region

F1	1900 kilotonnes of the Oryza spp = 380,000 tonnes of husk			
F2	Converting metric tonnes into kilotonnes			1kT = 1000MT
	KNE 2010 (MT)	KNE 2011(MT)	Builsa 2010 (MT)	Builsa 2011 (MT)
(metric tonne)	39504.6	33149.2	25513	22975
(kilotonne)	39.505	33.149	25.513	22.975
	The equivalent in tonnes of husk based on F1 will be as follows			
tonnes of husk	7900.92	6629.84	5102.6	4595
F3	If 380,000 produces an equivalent of 120,000 tonnes of oil equivalent (from Practical Action Report), then for			
	7900	6629.84	5102.6	4595
Toe	2495.03	2093.63	1611.35	1451.05

Source: Author's estimation

where F1, F2, and F3 are formulae and toe is tonnes of oil equivalent
1 kilotonne (kT) = 99.93 tonnes of oil equivalent (toe)
1 toe = 0.010006692kT

Equation 6-2: Estimating the proportion contribution of briquettes to the total energy consumption of UER

Woodfuel consumption – Upper East Region (UER)	= 574 kilotonnes
	= 57361.61toe
Average firewood consumption per user per year in Ghana	= 0.76
Average firewood consumption in UER	= 43594.82 toe
Proportion of energy derived from briquettes in Builsa and Kassena-Nankana District as proportions of energy consumed from firewood in UER	= 4.8% and 3.3%

Source: Author's estimation

Ghana Energy Statistics (2000 – 2008) estimates that the total energy consumed from woodfuel in 2008 is 16400 kilotonnes (Energy Commission, undated: 37), which is equivalent to 1638903.25 toe. Data is unavailable on the specific proportions of firewood consumption per administrative region as a proportion of the total firewood consumption of the country, much less of the Districts. A study by C4 EcoSolutions estimates that the total woodfuel consumption of the Upper East Region is 574,000tonnes per year (C4 EcoSolutions, 2012:4), which is equivalent to 57361.61toe. It is further estimated that the average firewood consumption per user per year is 0.76toe. Compared to the woodfuel consumption of 57361.61toe, this gives an average of firewood consumption in tonnes of oil equivalent as 43594.82 for the Upper East Region (UER). The Medium-Term Development Plan of both Districts for the period 2010 -2013, indicate that 66.5 percent of Builsa District (Builsa District Assembly, 2010) and 76 percent of Kassena-Nankana East District (Kassena-Nankana East District Assembly, 2010) rely on firewood.

Evaluated against the energy from briquettes that could be produced in Builsa and Kassena-Nankana East Districts from rice husks in 2011, the energy produced in tonnes of oil equivalent from both Districts would be 4.8 percent and 3.3 percent respectively of the total energy consumed from firewood in the Upper East Region (See Equation 6-2). By implication, given the current figures, rice briquettes can replace 4.8 percent and 3.3percent of the energy consumption in firewood in the two Districts. Briquettes can therefore serve a supplementary energy supply for 4.8 percent and 3.3percent. On the other hand, if the Districts for instance targets 25 percent fuelwood replacement with briquettes, then an increased access to rice husk will be necessary to produce equivalent amount of briquette. Nonetheless, a further detail feasibility study is needed to show the exact extent to which briquettes will support the energy supply in the District and therefore the rural communities.

6.2.4 Water

Water from the tributaries of the Volta draining the Kassena-Nankana East District was a great irrigation asset for dry season farming for communities within the catchment area of the Tono Irrigation project. However, for communities in the Builsa District, access to the waters from the Volta was sporadic occurring during the wet season when the Volta overflowed its banks and when the floodwaters from the Burkina Faso Dam were released. Dry season farming was not practised in the District. Together with the high solar potential in the Region and in the District for that matter, solar water pumping for irrigation purposes could be considered to give these farming communities who otherwise rely solely on the single maxima rainfall another opportunity of farming within the year to boost their productivity. Also, the section of Atebubu-Amantin District studied in the Brong Ahafo Region was well drained. The communities had access to the River Pru and the River Tamfe which could be possible potentials for small hydropower system. The Rivers have great volumes often overflowing their banks during the rainy season and cutting off the study communities which all lie in the same corridor of the District. The Pru River for instance has been harnessed to provide drinking water to Atebubu, the District capital.

Consideration for small hydropower system for study communities in Atebubu-Amantin District

Small hydropower is a local energy resource, which can be harnessed from small rivers and can produce power of up to 10MW[46] . Small scale hydropower can be further subdivided into mini hydro (usually defined as <500kW) and micro hydro (<100kW) (IEA Small Scale Hydro Annex). A micro hydro power is the small-scale harnessing of energy from falling water, such as steep mountain rivers[47]. It does not require a dam or storage facility to be constructed but rather operates on the 'run of the river'. Even though the District is well-drained, it lacks the sufficient gradient required for small or micro hydro systems. The physical characteristics of the Atebubu-Amantin District showed that the topography is fairly flat and undulating with no significant hills. Thus the rivers in the District have sluggish flow leaving behind volumes of alluvial deposits. Furthermore, the rivers dry up quickly during the dry season. The conditions of the drainage system of the area do not make it suitable for consideration for micro hydro systems.

6.3 Summary

This Chapter attempted to answer the question, 'How are the energy needs of rural households being met?'. The key components of the Chapter in addressing this question were sources of household energy supply and energy resources identified in the study communities that could be harnessed to improve rural access to energy both for domestic, community, and livelihood activities. The communities in the Builsa and Kassena-Nankana East Districts depended mainly on traditional energy sources for all activities spanning domestic to economic, other than electricity which was occasionally accessed from neighbouring communities and the phenomenal dry cells and torch which was quickly replacing paraffin. A few households had also participated in the GEDAP solar project and therefore benefited from this energy service. The situation was similar in the Atebubu-Amantin District, with the exception of the MFP which added value to agricultural produce and enhanced food processing. From the energy resources identified, a number of possible decentralised energy systems can be developed to address both the social development and economic growth needs of the rural communities studied. These included solar for solar photovoltaic, dryers, irrigation, and water pumping to improve community water supply; animal waste for biogas; rice husks and groundnut shells for the biomass gasification and development of briquettes; gasification using biodegradable waste; and animal power for animal motive power. An indicative feasibility analysis showed that not all the resources identified may be potentials in the communities in which they are found either due to

[46] http://www.small-hydro.com/about/small-scale-hydrpower.aspx. Accessed 04/03/ 2014
[47] http://practicalaction.org/simple-ideas-micro-hydro. Accessed 04/03/ 2014

the physical characteristics of the communities or due to cultural and traditional inhibitions. When any of these must be developed, an important consideration is the ability to use the decentralised energy option productively in addition to its domestic uses. The main idea is that the energy option is able to sustain itself and promote economic growth and development in the target communities. Moreover, the supply of energy itself could be a source of livelihood to members of the community as in the case of rice briquette production.

7 DETERMINING THE PRECONDITIONS NECESSARY FOR THE IMPLEMENTATION AND SUSTAINABILITY OF DECENTRALISED ENERGY SYSTEMS

7.1 Rationale

The implementation of development projects goes beyond the capital and technical input of the executing and implementing agencies to include a number of social factors and inputs from the intended beneficiaries. Implementation is successful when there is an appreciable level of acceptability, ownership and involvement of the beneficiaries. The implementation and sustainability of alternative energy sources particularly in the rural areas have been challenged over the years. Due to their unconventional nature, their implementation is often met with certain forms of resistance intended and/ or unintended from diverse angles. This section of the report looks at the implementation and sustainability of decentralised energy systems from three perspectives – the household and community, the energy system environment which are both internal and at the micro-level, and the external preconditions emanating from the macro governmental and international levels.

7.2 Household decision making process on adopting a form of energy

Household energy decision making is influenced by a myriad of factors, evaluated and analysed by the actors in the decision-making process until the final decision is taken. This information was generated from in-depth interviews conducted with 20 percent of the total sample studied, corresponding to 40 households. The enquiry sought to find out the actors in the decision-making process, their levels of involvement and the types of consultation made, the key issues considered in the decision-making process, and also given the rural environment which is known to be communal, the effect of the community on household energy decision-making. For respondents who had previous or current experience of using decentralised energy systems, the enquiry was made in retrospect.

7.2.1 Actors and the consultation process

Respondents indicated that all members of the household are eligible actors in energy decision-making though at different levels. The consultation process was found to be a three step process conducted on two levels – a household discussion which could involve the entire household or selected members of the household, further consultation conducted within the neighbourhood, and a final decision making point. The field responses showed that for the majority of households, the initial consultation involved all household members. Further consultation was done either by observation or through interaction with other community members. The final decision was however taken by fewer members of the household.

7.2.2 Key considerations

Respondents were asked what key issues they considered or would consider before a decision on adopting an alternative energy is made. The essence was to understand the level of involvement and commitment, and the thought processes that influenced the adoption of an alternative energy. It also revealed respondents' expectations of potential sources of energy. The issue of availability of energy forms was foremost during the quantitative enquiry determining why preferred energy for various energy services was not being used (Refer Chapter 5). With the exception of cooking fuel, more than 50 percent of respondents for each of the other investigated energy services indicated unavailability as the major reason why they were not utilising their preferred energy. The fundamental assumption therefore to the question on key considerations was that the alternative energy is available. In Table 7-1, a summary of these considerations are shown. Multiple indications of the key considerations were possible (See details in Appendix XII). Issues related to cost dominated respondents' considerations. These spanned the first cost, mode of payment, and sustainability and maintenance cost which respondents referred to as "later cost". More than half of the respondents (22 respondents) considered this a key issue. Following that, the next outstanding issue was the convenience or the ease of use of the new suggested DE system compared to the existing energy form they were using, indicated by ten respondents. Other important considerations mentioned were the benefits and disadvantages, usefulness, and operationability among others. Only two respondents considered the productive usage of the new energy form. One respondent was even careful to consider the executing agency as a main issue, to determine the authenticity of any such projects for the deployment of the alternative energy systems. This cautiousness is a result of past experiences of failed low quality deployed energy systems.

Table 7-1: Key considerations before adopting

Consideration	No. of respondents (households), N=40
Affordability – first cost	12
Convenience or ease of use compared to current energy form	10
Mode of payment	6
Sustainability and maintenance - later cost	4
Others	25

Source: Author's field survey, May-July 2012

7.2.3 Convinced of workability

In addition, a majority of respondents wanted to see the new system 'demonstrated'. "*Seeing is believing"*, the respondents remarked. From past experiences of failed systems, the fear of the unknown level of risk, and from the inherent need of value for money, the respondents were cautious and wanted to see that newly introduced systems would be used by a category of 'trusted' persons to be convinced of the workability of the systems. Prahalad (2005) from the Bottom of the Pyramid concepts suggests that "*the poor are resilient ... and value-conscious consumers who themselves present a huge market and* *also cause innovations, products, services and business models"*. Out of 40 respondents, the majority 22 respondents therefore would want to see a certain number and category of neighbours using the decentralised system to convince them of the workability of the systems. The average number of neighbours needed as convincing proof was 1.8 neighbours, ranging between one and five, and the categories of neighbours included ordinary neighbours, and opinion leaders such as the Assemblyman, Unit Committee members, the Chief, and elders in the community.

These responses were however not valid proof enough to show an interest in decentralised energy systems. There were respondents who had neighbours using solar home systems and even then did not own one. It can be inferred that there is a myriad of reasons why a respondent will adopt a decentralised energy system or not. This cuts across financial, individual interest, energy use service required, and the extent to which others users can convince him or her.

'Through demonstrations and testing'

In the first place, the information about the multifunctional platform (MFP) project came from the District Assembly. We were told the MFP would help the community in food and agricultural processing and to generate income. This made the project convincing enough. Secondly, this was new thing but the project implementers demonstrated its workability. They worked in the community over a long period of time and then we the potential investors had to go through an application and selection process before we were selected and given the bid.
Response from Owusu- Anane, MFP owner and operator, Fakwesi, Atebubu-

Box 7-1: Value perception of alternative energy of rural dwellers

The issue of value perception was keenly discussed with two key informants – a development practitioner and an energy development financier. According to literature, rural dwellers lack the perceived value of alternative energy and therefore are not responsive to such proposals. The two development agents expressed contrary opinions.

Development Planning Practitioner, Department of Planning, Kwame Nkrumah University of Science and Technology, Ghana – 31st May 2012:

"They (rural dwellers) are hesitant to adopt rather than not having a perceived value. The rural people are more practical than us. They deal with real economics. We (urbanites) deal with theoretical economics. If you go and you tell a rural person that this or that technology is very good (introduce a technology to the rural areas), that it will give him or her light for his or her poultry farm, improve his or her business, etc., the important question they will be asking you is the economics of it – how much will it cost? If the parts break down where can I get them? Just as was in the case of the introduction of tractors in the agricultural sector in the Northern Region of Ghana, farmers were comfortable sticking to the well-known Maxwell Fergusson (MF) brand than any other of the new brands which all failed. A farmer would prefer an old MF even if it is 20 years old because the spare parts are easily available. Thus, the perspective of the ordinary rural dweller is, how simple the technology is, how sustainable, and how they can maintain it. *He doesn't want a fashionable technology; he wants a* ***functional*** *technology, technology that he can easily own,* not to be entirely dependent on external technical backstopping all the time and more so as the foreign currency exchange keeps appreciating. If they have to consistently import parts and they cannot manufacture them locally, then it is a problem. That is the bottom line. They have very good perceptions, they want to modernise, but they are afraid of technology that will take them halfway and leave them. Nobody wants to have light for just one night and end up being a laughing stock of neighbours who did not buy the new technology. Consequently, they are hesitant to adopt technology; they know the values but they are afraid!"

Energy Expert I – African Development Bank (AfDB), Tunis, 3rd April 2012:

The financier agreed that 'lack of perceived value' is one of the reasons why the poor will not adopt a new energy technology. This is further elaborated:

"This is especially so because of the issues of technology which the providers fail to address. For example, solar suppliers fail to present the truth of the energy capacity to the people such as threshold of power. The rural people are made to assume that the power provided can for instance light all bulbs, power televisions and fridges, etc. There is not enough education for the consumer to have the clear picture. Secondly, grid electricity in most African countries are wrongly priced and highly subsidised and so solar comes out as expensive. Consumers appear to get more value from grid than from solar. Consumers are not told they have to replace the battery every 3-5 years, they are not told the invertor will have to be replaced every now and then, all in addition to the initial investment. They are not also told that the guarantee covering the product does not cover these replacements. The inconvenience related to the new technology appears quite higher than they know of. Consumers feel they are not getting value for money. From another angle, consumers who are sure of receiving the grid some time later place little value on renewables as against the perceived value of those who know they will not be reached. For the latter group, the value overshadows the possible disadvantages."

Source: Author's field survey - Key informant interviews: April 2012 (Tunis); May-July 2012 (Ghana)

7.2.4 Willingness and ability to pay the initial cost

Willingness to pay and ability to pay are consumer assessment tools used in demand analysis to assess the effect of price changes on (potential) consumers. They employ both quantitative and qualitative tools of assessment. While analysis of the ability to pay shows whether or not the consumer has the final capacity to finance the commodity, in terms of willingness to pay, the decision to pay is influenced by other factors apart from his or her financial capacity.

Willingness to pay the initial cost

Table 7-2 shows that 28 out of the 40 respondents were willing to pay the first cost of a decentralised energy option if the cost was three, four or five times their current cost of energy. Another six respondents would rather pay for only up to three times the cost of the current energy expenditure. However, five respondents indicated that they would pay less than three times or would not be willing to pay at all.

Willingness (and ability) to pay also depended on the stream of income of respondents - majority of whom were farmers - and how these incomes were received. One respondent remarked:

> *"We are willing to pay three times, four times or five times. If it this happens after March, we'll pay monthly until we are done so we'll need about 1 year. This because we do seasonal work and after the March is the planting season so there is no extra money available."* (Yaw Donkor, Kumfia – Atebubu-Amantin District)

Table 7-2: Willingness to pay an equivalent cost of household's current cost of energy

Payment scenarios of equivalent household current cost of energy	**No. of respondents, N=40**	**Length of instalment wished (years)**	**No. of respondents, N=40**
only 3 times	6	bulk payment	1
up to 4 times	0	< 1 year	8
up to 5 times	0	1 - 2 years	28
3 or 4 times	1	3 years	2
all three scenarios	28	10 years	1
none of the above (<3 times or not at all)	5		
Total	**40**		

Source: Author's field survey, May-July 2012

In addition to cost, respondents' willingness to pay is influenced by the priority given to energy. Energy needs compete with general household needs for the same financial resources. Respondents were also asked to prioritise general household needs on a scale of one to five in decreasing levels of priority among the following household needs: funeral, education, marriage ceremony, water and energy.

Table 7-3: Prioritisation of common household needs

Rank	**% of respondents, N=40**				
	Energy	**Funeral**	**Education**	**Marriage**	**Water**
1^{st}	2	0	27	5	6
2^{nd}	11	6	8	5	11
3^{rd}	13	7	3	9	8
4^{th}	6	15	0	8	10
5^{th}	8	12	2	13	5
$\sum(1^{st}: 3^{rd})$	26	13	38	19	25
$\sum(1^{st}: 2^{nd})$	13	6	35	10	17
$\sum(4^{th}: 5^{th})$	14	27	2	21	15

Source: Author's field survey, May-July 2012

From Table 7-3, about two-thirds, that is, 27 of respondents had education as the first priority. Energy competed with water for second priority position with 11 respondents. Further comparing the combined number of respondents for the first three priority levels, education again ranked first with the highest number of 38 respondents. Energy still competed keenly with water on the second priority position with 26 and 25 respondents respectively. When the first and second priority levels are compared, water displaces energy with four more respondents. On the other hand about one-third of respondents (14) would place energy in the fourth and fifth priority positions. A number of reasons were given for this prioritisation. For respondents who gave top priority to the energy, that is, priority levels 1 to 3, energy was intended for economic activities. Some of the activities desired were the setting up dressmaking shop, sale of cold drinks, and sale of more cooked food per day. For others, the need to see and move around in the night was preeminent; others saw it as necessary for survival, to make life comfortable and help kids learn at night. For those who did not see the need to prioritise energy, energy was simply not a priority in life. Remarks such as "*once there is life it can always be taken care of*", "*it* *can be done gradually", "we can survive without it", "it is a luxury", and "it can be considered when some money is left (surplus income)"* were made. The last remark was made in reference to cooking energy, showing again how improved cooking energy is least prioritised. An even more unexpected response was made by a respondent who even though was user of a decentralised energy system – a solar home system – gave 'energy' the least priority level 5. He indicated that all other important and pressing needs must be taken care of first. It also shows why a long-term payment plan is important to them (See Table 7-4). The reasons for other priorities are presented in Appendix X.

Ability to pay the initial cost

Assessing the study communities' ability to pay will be done in three ways:

- An analysis of respondents' specific responses of their ability to pay,
- Through an analysis of the respondents' responses to emergency situations, and
- An analysis of respondents' income and expenditure including a comparative analysis with indicative cost of decentralised energy systems

Respondents were asked specifically how many times their current expenditure on energy they would be able to pay for a new improved form of energy. Current cost of energy implies the combined energy expenditure for lighting and cooking. Respondents indicated they were able to pay under diverse circumstances. Respondents were given the option to indicate if they could pay two times or four times the current cost of their energy. While majority of respondents responded within these limits, a few others indicated they could only pay below the minimum limit. Majority of respondents also indicated their desire for the payment to be spread over an extended period of time. The results are shown below.

Table 7-4: Respondents' responses of their ability to pay an equivalence of their current expenditure on energy

Ability to pay	**No. of respondents, N=40**
Yes	40
No	0
2x	6
2x spread over a period	2
4x	0
4x spread over a period	0
2x and 4x	7
2x and 4x spread over a period	18
<2x spread over a period	4
<2x, needs a loan and repay in instalments	1
Already have decentralised energy systems for which they paid more than GHS1000 as initial instalment	2
Total	**40**

Source: Author's field survey, May-July 2012

Shown in Table 7-4, twenty-five of respondents, representing the majority indicated their ability to pay two times or four times the current cost of their energy for a DE. However

18 of these 25 respondents would like the cost to spread over a period of time. Eight respondents could pay only two times. Five out of the 40 respondents indicated their inability to pay within the given brackets - they could pay less than two times their current energy expenditure; one of these respondents needed a loan to repay in instalments.

However, other factors influenced the decision. These are assessed under respondents' responses to emergency cases, and an analysis of respondents' income and expenditure including a comparative analysis with indicative cost of decentralised energy systems.

Table 7-5: Extra emergency expenses

Experience with emergencies	**No. of respondents, N=40**
Yes	34
No	6
Extra emergency expenses	**No. of respondents, N=34**
Funeral	15
Funeral and health	13
Funeral and invitation to in-laws	2
Health	2
Poor harvest or a fatal disease among reared animals that results in their death	2

Source: Author's field survey, May - July 2012

Household energy needs compete with unexpected emergency situations for the same financial resources. Shown in Table 7-5, 34 out of the 40 respondents accented to having emergency situations that required emergency financial commitment. Outstanding among the emergencies were funeral and health. Others were poor harvest, disease among animals, and even invitation to visit in-laws.

Table 7-6: Household priority between an emergency situation and energy investment

Priority	**No. of respondents, N=34**
Emergency situation	28
Energy	3
Both	3

Source: Author's field survey, May - July 2012

Generally, respondents indicated that these incidents were not frequent. However, in Table 7-6, majority of respondents indicated that they will give premium attention to emergency situations against considering an energy option given that both situations occurred at the same time. *"People first; energy is not life*", "*Funerals are part of culture that must be maintained"*, "*it is more important to respond to emergencies than energy; it (energy) is important to address but not as much as an emergency"*, and *"…because with the current form of energy we are still surviving*", are some remarks made by respondents to support their argument of giving more priority to other matters than energy.

Again, the level of priority awarded the situation may be dictated by the bigger extended family depending on the kind of situation, over which the individual household could have total control or otherwise. For example, in the case of funerals, the extent of relationship of the household with the deceased determined the extent of its involvement and whether or not the situation could be ignored or postponed in favour of other pressing issues. One respondent remarked, *"It (funeral) is necessary but not by-force to attend"*. The level of priority also depended on the relationship and/ or the dependence of the household on the extended family. Although the rural family system in the Ghanaian context is normally known as extended, some households had some levels of independency and therefore would not oblige to every cry of the extended family system. Thus another respondent remarked, *"...some others can take care of it (funeral)"*. Table 7-7 shows that for almost two-thirds of the respondents, the priority of an emergency situation was determined by the respondent himself.

Table 7-7: Prioritisation of emergency situations

Prioritisation of emergency situations	**No. of respondents, N=34**
Prioritised by households	22
Prioritised by the extended family	7
Prioritised by both household and extended family	5

Source: Author's field survey, May-July 2012

Of particular importance to the study was the household's reaction to emergency situations. This aids in guesstimating their financial situation, their ability to pay, and how they could react to an unexpected decentralised energy system promotion programme, if only the household highly prioritised energy needs. Table 7-8 shows the actions taken by households to salvage emergency situations. Out of the 34 respondents who experienced emergency situations, 19 respondents representing a little more than half of the respondents had their own financial resources they fell on. They supported with cash at hand (emergency situations are not necessary single household situations; the communal and extended nature of rural households obliged respective households to assist in extended family issues such as funerals and illness), relied on their savings, or sold some of their reared animals. Respondents in the communities in the Upper East Region mostly sold their livestock to salvage emergencies. The remaining 15 respondents relied on external financial resources – borrowed from friends or other members of the family or from the bank, borrowed from trading partners[48], relied on remittances, or sought government's help if the emergency was a disaster such as floods or fire outbreaks. About a tenth of the respondents would 'help in kind'. By implication, for almost one-half of the respondents, financial aid could not be highly certain of. The external resources could not be highly dependable. Triangulating this data with data received from the quantitative survey reveals a certain amount of inconsistency. From the quantitative data analysis, respondents' reactions to emergency situations indicated 68 percent of respondents saved, about seven percent did not save but sold agricultural produce either animals or crops to remedy the situation and 25 percent borrowed from different sources in times of

[48] This borrowing arrangement was identified in the communities in the Atebubu-Amantin District in the Brong Ahafo Region, where farmers or charcoal producers traded with their clients who are also the middle men or women, such that in times of dire financial need, they borrowed from these clients, referred to as trading partners who took more of either the farm products or the charcoal in a sort of batter trade. When the items for batter were not ready, the trading partners could lend the money for a period of time and redeem these products on their next visit to the farm gate.

emergency (See Appendix XIV). Therefore even though the quantitative data indicate a more positive ability-to-pay, the in-depth qualitative interviews show that there are a lot more people who are unable to pay.

Table 7-8: How households react to emergency situations

Actions	No. of respondents, N=34
Help in cash	8
Rely on savings	6
Sells some of his animals	5
Borrow from friends, other members of family, from the bank	8
Help in kind	3
Borrow from working partners	2
Rely on remittances	2
Seek government help through the Assemblyman if it is a big disaster	2

Source: Author's field survey, May-July 2012

What some experts think

To gain a better understanding of rural households' ability to pay, key informant interviews with financiers, development agents, community workers, direct implementers and researchers on rural households' ability to pay were conducted. The following are some of their remarks.

An energy development financier in an interview remarked:

> *"The rural areas are not so poor but we offer them the wrong package and we expect them to pay for the wrong package."* (Energy Expert I, 3rd April, 2012, AfDB – Tunis)

The financier argued that the mobile phone technology has extensively penetrated the rural market and users are even so able re-charge their phones with pre-paid credit. Therefore rural households are able to pay for improved energy.

An energy development practitioner based in Northern Ghana reflected:

> *"If rural households have the same low level of income as it currently is, they will maintain their energy consumption patterns. However, with improved livelihoods and levels of income, their attitudes and behaviours will change. For example, a group of women charcoal producers who participated in savings supporting project stopped producing charcoal when their income levels changed. One woman commented that it used to beat her conscience whenever she cut trees for firewood but there didn't seem to be an alternative."* (Energy Development Practitioner, SNV - Tamale, Ghana, 12th June 2012)

The remark from this key expert confirmed that of another energy expert who strongly hypothesised that until rural incomes changed, energy for cooking which protracts energy poverty in rural developing communities will never be changed, *(Brew-Hammond, 21st May 2012, Accra).*

Another energy and water development expert based in Northern Ghana observed:

"...an understanding of the price points that people are willing to pay in relation to that particular energy service is important – this is something that is often missed because we place a higher premium on the lighting than people actually do in the villages. When you drive through – and I have done a lot of research work across the country - the rural attitude towards light is the same: the vast majority of rural dwellers are not going to sell their grandchildren to get the light. It is important to know the price point they are prepared to pay otherwise you end up with a situation where it looks like they are not responding and do not appreciate it, but how do they value it? What is the utility to them? In the same way I will not buy a Mercedes, for some of them, the solar light with panels or whichever decentralised energy system are fantastic but the prices are absolutely bizarre." (Energy Development Practitioner, New Energy - Tamale, Ghana, 28th May 2012)

Income and expenditure analysis

Information on income and expenditure was based on 70 percent of the total sampled household. Out of the 139 respondents, only 66 percent saved. The average monthly household expenditure[49] of households interviewed which is approximated for the average monthly household income was GHS419. This is compared to the average monthly income saved, which is GHS111. It is out of this same savings that all the financial implications of emergencies are addressed. The data exhibited extreme outliers. Therefore the data is grouped into three, showing very low savings, moderate savings and high savings. The remaining 34 percent of respondents who did not save responded to emergency situations by borrowing from friends, family, and the bank. From Table 7-9, the greater 73 percent of respondents had the least monthly savings of about GHS 13 per month. This group of respondents may not be able to purchase an alternative decentralised energy system outright, when their monthly savings is compared with the cost of the GEDAP SHS, and the improved firewood and charcoal cookstoves as examples from the field study. In addition, the values recorded in the study communities in the Upper East Region were extremely lower than in the Brong Ahafo Region. For respondents who received remittances, the average amount of remittance per month was GHS10. The average monthly energy expenditure was GHS40. For the sake of analysis, this is compared to the cost of improved energy for lighting and cooking, the technologies which were being subsidised for the poor and rural areas at the time of the research. These were the GEDAP solar home system and the improved charcoal cookstoves. The expenditure figures indicated above are even higher than national figures. The Ghana Living Standards Survey Five (GLSS) 2005/2006 which is the latest survey on living standards in Ghana indicates that rural localities have an average annual per capita expenditure of GHS458 which translates to GHS1.20 per person per day (Ghana Statistical Service, 2007). Assuming an average household size of five, the monthly expenditure per household will be 180GHS, which is lower than that recorded for expenditure of the study sample. It may be inferred that generally a financial scheme may be necessary is order to promote decentralised systems in the rural communities.

[49] Expenditure is used as a proxy to income because income figures did not exist and could not easily calculated especially in the study communities in Builsa and Kassena-Nankana East Districts

Table 7-9: Income and Expenditure Analysis - Statistics

Statistics	**Amount**			
Average monthly income	-----			
Average monthly expenditure	- 419GHS for total sample - 241GHS for study communities in Builsa and Kassena-Nankana East Districts - 679GHS for study communities in Atebubu-Amantin District			
Average monthly energy expenditure	40GHS			
Average energy expenditure as a percentage of total expenditure	9.5%			
GEDAP solar home system monthly instalment	25GHS (system cost a maximum of 600GHS to be paid over a period of two years)			
Improved firewood cookstoves	130GHS - upfront cost of device			
Improved charcoal cookstoves	28GHS and 8GHS – upfront cost of device for large and medium sizes respectively			
Cost of charging mobile phone	0.5 GHS per charge Frequency of charge per week – 3 times			
	Average cost of charging phone per month – 6GHS			
Saving				
Percentage of respondents who save	66.4%			
	Total average (GHS)	Low savings (GHS)	Average savings (GHS)	High savings (GHS)
Average amount saved per month	111.00	12.58	197.86	1250.00
Mode	1.00	1.00	100.00	750.00
Standard deviation	296.00	16.57	125.22	661.44
Minimum	0.05	0.05	100.00	750.00
Maximum	2000.00	50.00	500.00	2000.00
% of respondents (N=139)	100	73	22	5
Remittances	**% of respondents (N=139)**			
Receive	10.7			
Give	26.8			
Both	4.0			
None	58.4			
Total	**100**			

Source: Author's field survey, May-July 2012

Energy expenditure

The energy expenditure analysis is drawn from the quantitative household survey. The average energy expenditures for the various energy sources are indicated in Table 7-10. Comparing the average monthly energy expenditure to for example the monthly instalments for an electricity providing system, for example the solar home system (SHS), and a cooking device without considering the life spans of the devices involved showed that at a given time, the consumer will pay at least GHS 53, that is the monthly cost of the SHS and the upfront cost of the cooking devices because cooking device were not being sold on credit. When the SHS is combined with the improved firewood cookstove, a more challenging cost is arrived at, that is, GHS 155. Even though most appropriate for rural use, the cost of improved firewood cookstoves deters even suppliers from producing it. Again the charcoal cookstove is not desirable because the rural dwellers consider the recurrent cost of charcoal.

Table 7-10: Monthly energy expenditure

Energy source	Average monthly expenditure (GHS)
Firewood	22
Charcoal	21.6
Car battery charging	33.2
Dry cells	9.6
LPG	50.4
Petrol or diesel	39.2
Paraffin	20.0
Grid electricity	12.8
Solar system	5.6
Average monthly energy expenditure per household	40

Source: Author's field survey, May – July 2012

Drawing inferences from the variables considered above, it may be said conclusively that the ability or the willingness of study respondents to pay were influenced by a myriad of factors. Considered exclusively, the variables suggest that respondents were able and willing to pay. This appeared ironic for respondents in communities where solar home systems were being promoted and deployed at the time of field survey. This is because the monthly cost of the systems was more than the equivalence of 2.5 times their monthly expenditure on lighting. Thus, as the energy expert indicated, an understanding of the price points at which (rural) consumers are willing to pay is important in assessing their responsiveness towards an energy option. Moreover, without an appropriate targeted financing scheme, the combined cost for lighting and cooking is beyond the financial capability of the respondents.

The second variable brings out the realities more clearly when almost three-quarters of respondents indicated that emergency situations will be first prioritised over investment in a new form of energy. While this does not appear extraordinary, the extraordinary element is the fact that the main emergency situation identified is funeral, which transcends beyond individual household funerals to that of the extended family and of the community. Almost two-thirds of respondents relied on their own financial resources to salvage emergency situations. This explains why these 'emergencies' will be considered over energy investment. The remaining one-third relied on external resources which could not always be reliable. Among common household needs, energy competed keenly with water for the second place priority. Drawing inferences from these two variables, it may be inferred that energy development was not a topmost priority for most respondents on a general basis. Thus, respondents may have a willingness to pay for a better energy option, and assume that they are able to pay but in reality, a number of factors affect their ability to pay. Their ability to pay cannot be conclusively indicated.

It may also be inferred from the experts' contributions that the supplier could play a role in improving rural willingness to pay. The quality of service offered, and identifying what energy service is needed through participatory energy planning could boost the willingness to pay, while improved levels of income through improved livelihoods increases the ability to pay especially of cooking fuels which are mostly compromised for other energy services.

7.2.5 Willingness to adopt and energy needs prioritisation

Dissemination of alternative decentralised energy systems in the past has suffered failure for a number of reasons. Even so with the conventional form of energy, that is, electricity, reports of the Energy Commission (2012) indicate that expected productive use and therefore economic growth did not materialise. From key informant interviews, one sector expert remarked,

> "*A clear understanding of the needs of the households is necessary. And the assumption about what is needed may be completely different from what they really need in terms of what they want to use the product for.*" (Energy Development Practitioner, New Energy - Tamale, Ghana, 28th May 2012)

This section of the research sought to find out the willingness of the target group themselves, without any form of coercion, to adopt a decentralised form of energy or not. It protracts the essence of participation and therefore ownership of the energy option being received, so that intervention would not appear to have been imposed on the target group. Two development experts interviewed both hailing from the Northern parts of Ghana and with extensive knowledge of the rural energy landscape of that corridor used solar energy to make their points: for most rural communities in the Northern parts, solar energy as a decentralised form of electricity was seen as an inferior form of electricity offered to them as compared to the grid enjoyed by urbanites:

> *"(Rural) people see solar as some form of electrification, but an inferior form of electrification. They want it but they want something more. They want the grid. If it is ignored that the people have their own expectations and strategies, then investments in decentralised energy will fail."* (Energy Development Practitioner, New Energy - Tamale, Ghana, 28th May 2012)
>
> *"Grid electricity is useful, it is more modern. Rural dwellers assume that bringing solar to them is more like dumping another form of energy which is not good enough on them. They consider themselves as also fit to enjoy what the city people are enjoying. It is important to keep in mind that almost all the rural people have relatives in the cities and the interaction between the rural people especially from the three Northern Regions and the cities is very intense – in* ***almost every village, even the remotest***[50] *you find that people have relatives in the cities so they are well aware of the benefits of grid electricity",* (Development Planning Practitioner, Department of Planning, KNUST, Ghana – 31st May 2012).

An enquiry was made into respondents' willingness to adopt a decentralised form of energy given the scenario that there was no possibility of accessing grid electricity in the next five, ten, and fifteen years. The responses are indicated in Table 7-11.

[50] With a lot of emphasis

Table 7-11: Willingness to adopt DE over a period without a future possibility of grid connection

Scenario - unavailability of grid electricity in years	Number of respondents willing to adopt, N = 40
10 or 15	1
15, 10, or 5	24
Already adopted	9
Not ever	2
Cannot decide	4
Total	**40**

Source: Author's field survey, May – July 2012

From Table 7-11, almost three-quarters of respondents were willing to adopt and about one-fourth had adopted some form of DE for electricity given the scenario that there would be no possibility of grid connection in the next fifteen, ten or five years. Two respondents however stated that they will never adopt it – for one respondent, decentralised energy systems were costly and his household was financially constrained; for the other, the household would move out to a community where the grid was available.

Table 7-12: Willingness to adopt if electricity would be available in 5 years and 3 years

Scenario (years)	Response		
	Yes	No	Non-response
Five, N=40	27	9	4
Three, N=40	21	15	4

Source: Author's field survey, May – July 2012

When the question was turned around and respondents were asked if they would still adopt DE granted that scenario that that grid connection was certain to be available in the next five years or three years, as shown in Table 7-12, 27 and 21 respondents (including the nine who had already adopted) respectively said they would adopt for various reasons:

- because they needed the DE system desperately; they did not beforehand know about it and had not benefited from its usefulness
- to undertake economic activities – one respondent explained that he was already using generator and dry cells to run his local business, patronises solar phone charging, and the multifunctional platform for milling, stressing the importance of DE for economic activities,
- to lessen the burden of going to the farm or the bush almost every day for firewood – this response indicates that some respondents had other expectations apart from electricity, of improved cooking energy,
- *"because improvement is necessary now, not later"*, and
- because the torch light is not bright enough: '*sometimes the kids hurt themselves in the dark'*, and *'sometimes there are snake bites'*.

On the other hand, 9 and 15 respondents respectively would not adopt because they would "*rather wait than do double spending", and "the period is short and worthwhile* *to wait because the grid illuminates better than solar*". Four respondents in both cases did not respond and were strongly pessimistic of any possibility of their communities having any grid connection within the time period of the scenarios presented and therefore would not even contemplate the possibility. The results of both questions show that a majority of the respondents were willing to adopt a DE. It also shows that for about a third of the respondents, having an alternative energy was not an urgent need.

Energy needs prioritisation

This variable is intended to give an idea of which energy needs are more important to the rural dwellers in the communities studied. It is relevant in knowing which alternative and decentralised energy option will be most acceded to when the various options are presented. Again, limited access to cooking energy which is one of the key exhibits of energy poverty, and which also has negative externalities on the global environment and the vulnerable group of women and children is shown in literature as an energy access improvement option which is least prioritised. The extent to which this situation is true in this study is sought. Additionally, respondents' inclination and optimism towards economic growth is sought. On a scale of 1 to 5 in decreasing priority, cooking, economic, lighting (domestic) and learning, ironing, radio and television and phone charging energy needs were ranked by respondents. The responses are shown in Table 7-13.

Table 7-13: Prioritising energy needs

	No. of respondents, N=40							
Rank / Energy need	1	2	3	∑(n1:n3)	4	5	Non-response	Total
Cooking and heating	13	13	5	31	4	4	1	40
Lighting and learning	27	7	4	38	1	0	1	40
Economic	7	3	12	22	5	3	10	40
Radio, TV, phone charging	3	13	12	28	9	0	3	40
Ironing	5	0	2	7	3	17	13	40

Source: Author's field survey, May –July 2012

Among the energy needs, lighting was the most prioritised, given the first rank by 27 respondents. The first three priority positions, 1 -3, in order of decreasing priority is keenly competed for by the energy need for lighting and learning, and cooking and heating with 38 and 31 respondents respectively. Some of the reasons given in support of energy for cooking and heating were '*food is necessary for survival – "yere ye ayi, yere nom mpampa" - literal translation is "we are doing a funeral and even during that mourning time, we are eating thick porridge" (traditionally, when one is in mourning, one does not eat.); "cooking so that the women will be free".* In the case of lighting and learning, the ripple effects on other energy services were indicated.

Energy for telecommunication follows closely with 28 responses. Economic need takes the fourth position. For these 22 respondents, some of the reasons given were "*to generate income and for survival", "it is the most important because I ran a drinking bar. Any other energy investment will come later", "more income means better life"*. Compared with the quantitative interviews, among the total number of 199 respondents interviewed, only seven applied some form of mechanisation in their farming activities. These depended on fossils which was available in the big towns and District capitals, or retailed in the communities and could be bought once they had the financial means. For economic energy need, the most anticipated energy based economic activities were electric power home-based economic activities (See Table 5-20). Thus once energy for lighting was assured, it invariably implied to respondents that energy for economic activities could be secured. For one respondent, cooking was both a domestic and economic activity because she operated a "chop bar" (local restaurant) from where the family was also fed. Therefore even though cooking was ranked 1st, she remarked *"to be able to sell more and make more money"*.

Five respondents ranked ironing first: these respondents had LPG for cooking and heating and solar for lighting, radio, TV and phone charging, but solar could not power an iron so a source of power for ironing was priority. Others assumed that once they had power for ironing, it would be the same source of power for lighting and learning and other electricity based activities. This confirms an observation by a rural energy expert based in Northern Ghana interviewed:

> *"If it (the decentralised energy system) is brought (to the people), they will take it anyway but it will not meet their needs. For example, basic lighting – the assumption is that you need a certain level of brightness. As development practitioners, we calculate the basic lumens needed, and the equivalence to candle lights, among others assuming that they also need the quality of light we need but it is completely different. You need a bright source of light if you want to read but if you need it for general orientation, then you don't need a bright light. So there were times I saw that when people put on the light, they will put a card board in front to shield off some its brightness. They need something more than just light."*
>
> (Energy Development Practitioner, New Energy - Tamale, Ghana, 28th May 2012)

From the discussion above, it is noted that rural communities are rarely aware whether or not they are within the master plan of electrification. Even when they are informed through General Assembly meetings of the District Assembly, they could not be totally expectant. Unfortunately, that had been proven as true as in the case of Nagalikenia, Azaasi and Akudugu-Daboo in the Kassena-Nankana East District, and Fakwesi and Kumfia in the Atebubu-Amantin District. These communities were proposed to be connected to the national grid, electric poles were erected in the communities and in the case of Nagalikenia, some houses got wired but after more than four years later after a change of government, their communities were still not connected to the grid. The bodily language of respondents willing to adopt showed that they had outlived their patience. This is a peculiar situation of the developing world, where national spatial political interest even influences access to grid electricity. National policies and an ardent policy of implementation remain critical issues in ensuring improved access to energy and it is unfortunately one of the areas where nothing ever seems to happen and it is seemly difficult to get political buy-in.

Respondents' willingness to adopt can be said to be dependent on their ability to pay. The two variables are mutually dependent. The research results show that even though a substantial number of respondents indicated their willingness to adopt, they had not adopted although their communities had been introduced to some form of decentralised form of energy. Even though the perception of energy development practitioners and experts or rural response to decentralised energy may have been developed from years of experience, a slight contrast is seen to be emerging when compared with the study respondents' willingness to adopt. Thirty-four out of 40 respondents were willing to adopt some form of DE if they were not going to be connected to the grid in the next five, ten or fifteen years. In addition, it may be referred from Chapter 5.3 that as much as 31 respondents out of 40 respondents indicated that they were going to keep their DE systems even when their communities were eventually connected to the grid. By implication, the perceptions of people were gradually being altered as DE was being more appreciated than previously. Thus, with an improvement in informational dissemination and a gradual removal of that barrier, the perceived resistance from the rural communities may be removed.

Regarding the prioritisation of energy needs, the competitiveness of energy needs for learning and lighting, and that for cooking and heating is in congruence to the previous impression that energy need for lighting overshadows energy need for cooking and others. It may be inferred therefore that even though energy need for cooking is highly prioritised, given the respondents' ability to pay, lighting energy need may overshadow cooking need. From the economic energy needs indicated and the reasons allocated, it may be inferred that if the rural communities had energy dependent economic activities or had such potential, then energy could be useful and applied productively to improve the economic growth status of the communities. However without such, the productive application of energy will be negligible.

Again, some energy planning implications may be inferred from the case where some respondents highly prioritised ironing over other energy needs. The rural folks expect more from energy than lighting. Lighting itself might be the least expected with respect to the lumens produced except probably for school going children. However, the other possible applications and services of energy particularly electrical energy are more important to them. If assertion by the rural energy expert in Northern Ghana is true, then the rural communities do not just want light but rather more functionality from electricity. Thus it is not uncommon to see individual rural houses with only one lighted bulb in grid connected village communities. Moreover, it is generally observed from development practice that rural households prefer dim coloured light bulbs. Notwithstanding, as village communities become more developed, their energy needs graduate and may consequently demand higher energy capacities.

7.2.6 Socio-cultural factors, socio-cultural acceptability, conflict of usage, aversion to new technology

A fourth set of preconditions considered were socio-cultural factors, socio-cultural acceptability, conflict of usage and aversion to new technology. Energy resources identified within the communities were cow dung, crop residue, agricultural waste and water. Even though cow dung can be classified among agricultural waste, it was isolated as a well-known source of energy production and also because literature indicates a level of resistance to its use. The study attempted to find out if there were social restrictions to the use of the potential energy resources identified. With the exception of cow dung and specifically in the Builsa District and in Wuru community in the Kassena-Nankana East (KNE) District, there were no social norms or values restricting the use of these potential energy resources. In the Builsa District and in Wuru community in the Kassena-Nankana East (KNE) District respondents vehemently despised the use of cow dung. In the same KNE District, the tribes in Azaasi and Akudugu-Daboo comfortably used the dung for cooking while the Sisala tribe within which Wuru falls prohibited it. The energy resources were identified to have other potential uses. Apart from being used in its unprocessed state as cooking fuel, cow dung was also used as feedstock through anaerobic process to generate chicken feed, as manure, and for building and plastering (Refer Figures 6-6 and 6-7). Crop residue was used in its unprocessed state as fuel, roofing material, fodder for cattle, and as mulch; water (natural drainage) was a source of fishing, used for irrigating gardens and farms, and for a range of domestic activities. Even though majority of respondents were willing to have the potential energy resources developed, a significant proportion of study respondents consequently had reservations due to these other potential uses (Table 7-14). There were some relevant differences in the responses from the communities in the Upper East Region and the Brong Ahafo Region respectively. For instance, the energy resources were basic livelihood factors for communities in the Upper East Region and the opportunity cost of using the resources were higher – the fertility of their farmlands depended on them due to the poor and impoverished state of their soils. In addition, the resources were not in abundant quantities. On the other hand, with the exception of water, resources identified in the study communities in the Brong Ahafo Region were mostly considered as waste and usually disposed-off.

Table 7-14: Willingness of respondents to allow potential energy resources to be developed

Location of respondents	Number of respondents, N=40			
	Yes	**No**	**Partially**	**Total**
Study communities in Builsa and Kassena-Nankana East Districts	9	12	5	26
Study communities in Atebubu-Amantin District	11	2	1	14
All communities	20	14	6	40

Source: Author's field survey, May –July 2012

Again, in the communities in the Brong Ahafo Region, the communities had neither cattle nor the dung. In a few cases, crop residues were used for roofing and that was typically found in Sabidi which was mainly a northern tribe settler community; none of the respondents lived in thatch-roofed houses. Limited amount was used as mulch, and as roofing for crib barns. Again due to the relatively fair availability of woodfuel, crop residue was not used as fuel substitutes in these communities. Corn stover, groundnut shells and beans pods were usually burnt to dispose them off. Chicken droppings were used for pepper farming on a small-scale basis. Respondents who were partially willing for potential energy resources to be developed (Table 7-14) wished for some of the resources to be used and others not to be: for example they wished for water resources to be used to generate electricity but not cow dung. Appendix XV provides a summary of the reasons respondents gave in affirmation or otherwise of the use of the potentials for energy.

In conclusion, it is unsafe to assume that socio-cultural inclinations would be the same in a given geographical area. Tribal differences within the same district must be taken into consideration in order to prevent wholesale implementation of projects that would be accepted by one group and rejected by the other.

7.2.7 Final decision

A critical evaluation of the myriad of factors discussed above leads to the final household decision on whether or not to adopt a decentralised energy option. From Chapter 7.2.1, the actors in the decision making process are involved in a funnel shape, from a broader initial discussion base to a narrower final decision-making stage. The actors identified for the final stage were the household heads, man and wife, men in the house, and the entire members of the family. These are indicated in Table 7-15.

Table 7-15: Final decision making on new energy system

Decision maker	**No. of respondents (households), N=40**
Head of household (male)	23
Entire family	6
Household head (female)	2
Men in the household	4
Man and wife	4
Son	1
Total	**40**

Source: Author's field survey May –July, 2014

Table 7-15 depicts a male dominance in the final decision on household energy decision as the heads of households indicated by more than 50 percent of interviewed households. One particular respondent from the Upper East Region who indicated 'men in the house' emphasised the exclusion of the wife saying, "*a discussion with the brothers excluding the wife*". Some schools of thought have argued that this has been the reason why cooking energy, the most pertinent energy issue in the rural areas has not received much attention; neither have alternatives received acceptance in these areas. This is because the household energy decisions are made by men *'who do not care how they eat or how food gets on their table'* (a view expressed by an energy development practitioner, Netherlands Development Organisation (SNV), Tamale, during a key informant interview, 12th June, 2012). Another key informant of the northern heritage in Ghana asserted,

> *"Of course we say the man takes the decision. In taking the decision, if the woman happens to be a market woman or a salaried worker where she interacts with other women, and she gets to know that so and so has got some new lighting system and they say it's good, then she will inform the husband. So the decision will emanate from the woman but the man will take the final decision to adopt or not to adopt. But in few families where women earn and contribute largely to the family income the women can*

decide but it is normally considered in Northern Ghana disrespectful even if the woman earns money to take the decision".

(Development Planning Practitioner, Department of Planning, Kwame Nkrumah University of Science and Technology, Ghana – 31st May 2012)

In taking the final decision, even though generally respondents indicated that decisions were not influenced by their communities, from the assessment of the factors that they considered, it may be concluded rather that their assessments of factors and their decision-making process are affected by their interactions with their communities but their final decisions are not either forced or resisted by their communities. Again, it was also observed that where the energy decision would not negatively impact on community development, the community and its institutions did not prohibit anyone from improving their energy source or use. Therefore in Fakwesi and Kumfia both in the Atebubu-Amantin District, two individuals were operating solar home systems, the services of which are well patronised by the communities but the acquisition of systems was based on individual households' final decisions. On the other hand, even if an individual wanted to explore wood resources, e.g. charcoal production, using modern, appropriate, and energy efficient production methods, the kind of wood resources that could be harvested will be constraint by what the community and its institutions will approve or not. Thus in the Upper East Region, some traditional authorities prevented the harvesting of economic trees for charcoal production. In Kumfia in the Atebubu-Amantin District, "*krayie*" (rosewood) which was previously harvested for woodfuel was at the time of the study restricted because the economic value of the tree as building material for railways had been discovered. In addition, the influence of modern energy access on development and the modernity it connoted prevented the individual household decision on it from being prohibited by the community. For example, a community that had the MFP - either owned by a group of rural investors or individual investors - served as a social capital and a symbol status for the community among its neighbouring communities (Inkoom, 2009; Author's field survey, May-June 2012). Typical information sources included neighbours, opinion leaders such as the Assemblyman, social and economic associations such as farmers' associations, youth associations and women's associations. The Traditional Authority was also useful in disseminating information. In the Upper East, the information flow was from the sub-chief to the various landlords, who further passed the information to their various quarters; in the Brong Ahafo Region, the chief's linguist either goes round with a gong-gong and announces, calls for a general assembly and announces, or uses the community Public Address system. One other important channel of information in the Upper East communities was the market. In the communities visited, typical of both urban and rural communities in the Upper East Region, market days were periodic, occurring every third day. Community members moved across districts to participate in the market days of the bigger towns. The study communities in both study Districts participated in both the Navrongo market and the Sandema market days. These were moments of intense interaction which transcended beyond the economic aims and served as a place of social interaction and word-of-mouth information dissemination.

The process described in the forgoing discussion is illustrated diagrammatically below.

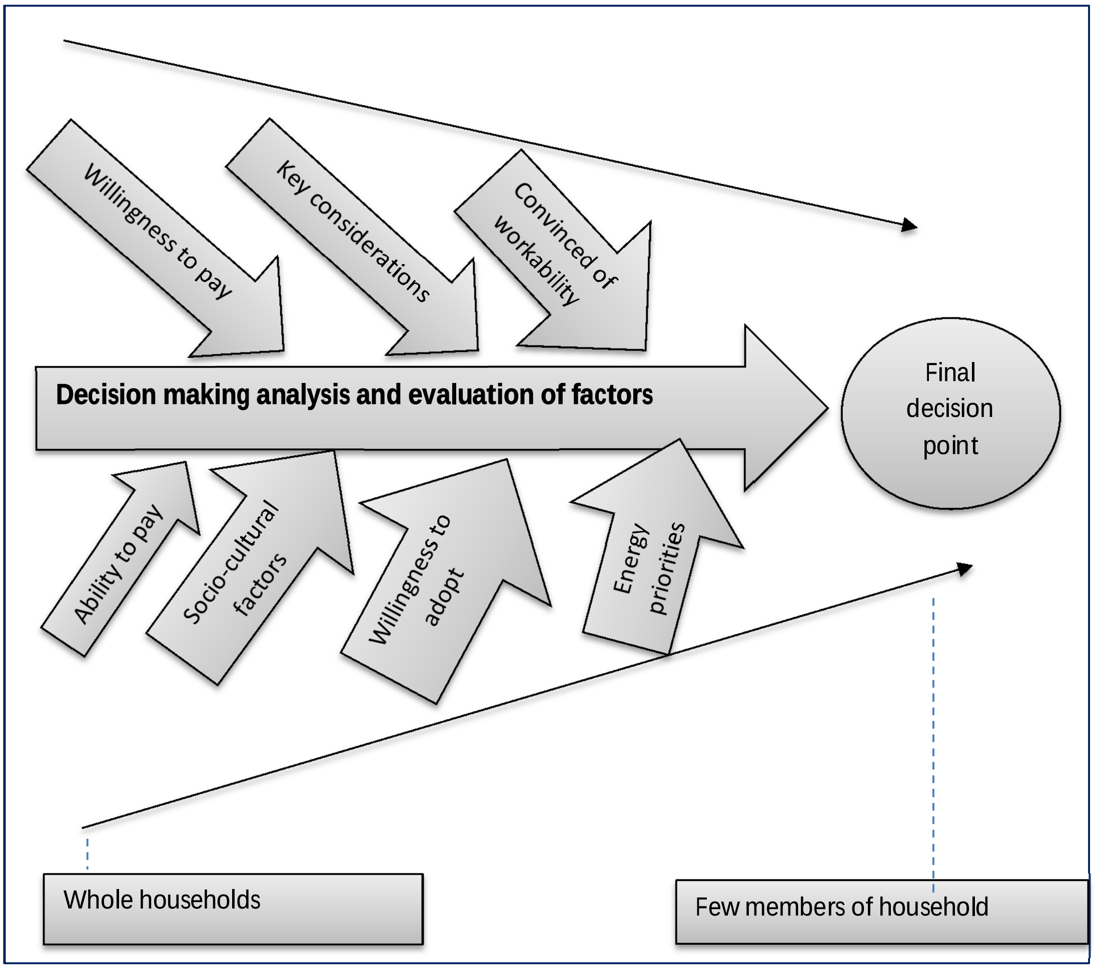


Figure 7-1: **Household energy decision making process**
Source: Author's construct

7.3 Preconditions emanating from the energy system environment

7.3.1 Components, characteristics and organisation of the rural energy system – energy resources, institutions, organisations

The traditional energy system consisting of the traditional fuels of firewood and charcoal is highly unregulated. The system is not regularised under any particular government Ministry or District Department. Individuals who are actors in the system take decisions based on their individual discretions. The production of these fuels as well as the sale is unregulated. Information on the system was gathered through interviews with charcoal producers, officials at the District Assembly, energy experts, and through field observations.

Figure 7-2: Charcoal depot and export

A – Achimota charcoal, Kumfia – Atebubu-Amantin
B – Charcoal truck leaving Atebubu-Amantin District
Source: Author's field survey, May-July 2012

7.3.2 Institutions in the traditional energy system

The traditional energy system consists of firewood and biomass gatherers, transporters, charcoal producers, (large scale) buyers, middlemen and women, and retailers (small scale traders).

Fuelwood gatherers and transporters

There are 2 kinds of firewood gatherers:

i. Main business gatherers – gathering of fuelwood as a main business. These sell firewood on a large scale to major food vendors and cottage industries.
ii. Small scale gatherers – these gather fuelwood for use at home either as a separate activity in the case of women in the communities in the Upper East Region, or as part of their farming activity in the case of farmers in the communities in the Brong Ahafo Region. The excess which is not immediately needed is sold. Small scale gatherers transport the fuel as head load or on their bicycles (Figure 7-3), doubling as both gatherers and transporters. Large scale gatherers hire tractors to move it from the bush to the buying centres.

Figure 7-3: Bicycle transport in Kumfia from farm to the house

Source: Author's field survey, May-July 2012

Charcoal producers

Figure 7-4: Charcoal production at home

Source: Author's field survey, May – July 2012

The three study communities in the Atebubu-Amantin District are well-known charcoal producing communities, whereas isolated individuals were involved in the activity in the study communities in the Builsa and Kassena-Nankana East Districts.

The charcoal production process involves a number of actors who play important roles in the process but have minimal influence on the pricing of the end product. Production is carried out in the bush. In most rural cases, wooded land is purchased from a land owner. When producers have exhausted the wood resources, the land is returned to the owner. There are often informal payment arrangements between the landowners and the lessees. The wood cutting and gathering process (that precedes burning in the case of charcoal production) as well as the packing of the charcoal into sacks involves extra labour. Family hands are usually used, but for large scale production, hired hands are necessary. At the sale centres and sometimes in the bush, large scale buyers export firewood or charcoal in trucks to the large towns and cities such Bolgatanga, Kumasi, Accra and Tema. In Figure 7-2, a charcoal depot in Kumfia, and a loaded truck leaving the Atebubu-Amantin District can be seen. In the Upper East Region, similar to what generally occurs in the Northern parts of the country, the road side is the marketing point for most gatherers of firewood and producers of charcoal (Figure 7-5).

Within the study communities in the Upper East Region, the purchase of the firewood and charcoal for household domestic use was found to be common due to the growing scarcity of wood. On the contrary, in the Brong Ahafo Region, firewood was not bought; on rare occasions, community members bought charcoal or gathered from the remains of the mounds at the farms either as part of the reward for assisting in bagging charcoal or simply as goodwill from the charcoal producers. Individuals also burnt charcoal on mini-scale just for home use. In Figure 7-4, a little girl was seen already socialised into charcoal burning in Kumfia – the activity was taking place in the family backyard farm, with parents sitting in the main compound and looking on.

7.3.3 Formal organisations

There are no formal associations for producers or buyers. Producers and buyers deal with each other on individual basis. In the Upper East Region large charcoal markets were found in the big towns and cities. These were stock piles created by middlemen and women who gathered a number of bags from here and there and eventually loaded them into trucks to the cities. In the words of an energy expert interviewed, "*all rural stakeholders along the supply chain are poor*, *while the middlemen and women gain the most"* (Energy Development Practitioner, New Energy - Tamale, Ghana, 28th May 2012).

7.3.4 Price determination

Prices are determined by the market forces of supply and demand. There is no government regulation in that regard. As a result, there are price variations between the different Districts determined by the market forces and by informal trade associations whose decisions are determined by these forces. The key determinants of supply are the wet and dry seasons, and in recent times, the easy availability of woodfuel. In the Brong Ahafo Region[51], the cost of the land concession is also factored into the price. Again, individual producers and their clients are able to bargain out prices. Sometimes the market women (and men) seem to have a very high influence on the final price as they are more organised. '*There are normally few of them, so three or four of them who normally buy from a particular place may collude and insist on the price they want to buy it'* (Energy Development Practitioner, New Energy - Tamale, Ghana, 28th May 2012) and the producers tend to agree with them but the producers are not obliged to take it. It is rather a bargaining process. The main inputs in the pricing equation for producers in the Upper East Region are labour, and the cost of carting the wood fuel from the bush. These have no fixed rates; rather 'it is an estimation of what they think their labour is worth' (Energy Development Practitioner, New Energy - Tamale, Ghana, 28th May 2012). They do not buy the wood; neither do they buy land for fuelwood gathering or charcoal production so the cost of land concessions is not applicable as in the case of production in the Brong Ahafo Region.

Figure 7-5: Temporary firewood depot on the Sandema-Navrongo link

Source: Author's field survey, May-July 2012

[51] An energy expert asserted that in Donkokrom in the Eastern Region cutting of firewood is very organized because land owners sell the concession to charcoal burners for the number of months the wood will be harvested for charcoal burning. The practices, he asserted is gradually infiltrating into the Northern parts of the country even though to a large extent they cut trees directly from the natural forest (Source: Expert interview with Amadu Mahama, New Energy, Tamale-Ghana, 28th May 2012). The practice is therefore more familiar with the Southern parts of the country than with the Northern parts.

In districts where charcoal production is prominent such as in the Atebubu-Amantin District, the District Assembly have set up tolling systems that taxes the producers as well as the buyers who visit the Districts to export the products in trucks (Interview with District Official, Atebubu-Amantin District, 19th June 2012; Amaka-Otchere, 2006). On the other hand, the production activity had not been regularised by the District Assemblies in the Builsa and Kassena-Nankana East Districts. In both Districts in the Upper East Region, the production had been banned by both the District Assembly and the Traditional Assembly. The sale and hewing of firewood was nonetheless grossly permitted as this remained the main source of fuel for cooking and heating. A key official at the Kassena-Nankana East District pointed out that "*on market days which fall every three days, one can see donkeys carrying loads and loads of firewood from the communities in the forest areas to the market*", (Interview with District Official - Kassena-Nankana East District, 5th June 2012). The study also found out that woodfuel, especially charcoal was more expensive in the study Districts in the Upper East Region than in the Brong Ahafo Region. While the cost of the 50kg jute bag was priced GHS 5 in the study communities in the Brong Ahafo Region as farm gate price, the same was between GHS10 and GHS14 in the communities in the Upper East Region. This may again be attributed to the scarcity of wood in those communities in the Upper East Region.

It can be concluded that the informality of the rural energy system environment has implications for planning the woodfuel sector and infusing it into a sustainable energy plan that is based on woodfuel. It is acknowledged internationally that woodfuel will continue to be part of the global energy mix especially rural energy mix for a very long time into the future. The inequalities in the exogenous flow of woodfuel from rural areas to meet urban demand are contributory to the persisting and accelerating energy poverty in the rural areas. As currently the case in the urban settlements, access to electricity does not necessarily mean minimal use of woodfuel. Therefore, without a sustainable woodfuel supply plan, improving access to electricity alone may not address the issue of energy poverty in the rural areas.

7.4 What are the external preconditions influencing energy development in the rural communities?

Political and institutional barriers

In Chapter four, government's national provision for rural energy development was discussed. The chapter concluded that policy-wise, government policy on renewable energy demonstrated a commitment to rural energy development. The government's commitment to current international drive on ending energy poverty also demonstrated a rural energy development pathway. However, among the various options, solar energy for lighting is the most developed. Wind, small-hydro systems, off-grid electrification and other appropriate technology for cooking energy such as improved cookstoves, biogas and the development of briquettes have over the years been principally piloted or are still at the feasibility study stages. While rural communities show some level of scepticism with alternative sources of electrical energy and also have financial and sometimes cultural challenges in the use of modern energy for cooking, the gradual but slow pace of government in the development and promotion of alternatives does less to improve access to energy in such rural communities. As a consequence, economic growth and development is retarded.

The following emerged in an interview with an energy expert of a key multilateral financial institution:

> *"On the government side, the Ministries of Energy (of African countries) have planning responsibilities; they care for energy development at both the rural and urban levels even though somehow they are bit biased to bigger transformation rather than smaller. My view is that the on-grid business will grow much faster than the alternative rural energy development and this is very clear when one looks at the countries' energy and development plans and strategies."* (Energy Expert II, AfDB - Tunis, 18th April 2012)

Political barriers may also be identified where interest groups both from the demand and supply side have interest above more cooperative and systemic interest and tend to frustrate initiatives (Key informant interview with Brew-Hammond, 21st May 2012, Accra). In relation to that, institutional barriers were also identified. In the experts' opinion, this may probably be the strongest barrier. The argument that was raised was that if organisational structures existed, it sets forth a system and procedure in the development and promotion of decentralised energy in the rural areas. In all the districts studied, there were no separate district energy development plans, neither were there special incentives for energy investment. All such incentives were initiated at the national level. The DAs had very low lobbying power or rather did not have the urge to lobby for alternative energy as compared to grid electricity.

External development funding

While governmental support wavers, a macro external factor also impedes decentralised energy development in the rural areas of the developing world. External financial institutions have structures and systems that discourage development outside the bracket of on-grid electrification. In Chapter 4.3.6 it was evident that the government relied mostly on external funding for developing the energy sector. As shown in the input by an energy financial expert in the quote below, multilateral institutions may be contributory to the current state of rural energy development.

> *"Rural and even non-rural energy development is many times a question of available financing. There are countries in Africa where is it difficult to do energy projects. For instance, Country X is a very small country with about 500,000 inhabitants. The amount of money they can have from the Bank (a multilateral financial institution and regional development bank) every three years is so small they couldn't do any energy project: a generation project is impossible, neither is a transmission plan possible. Many times, these countries find it difficult to obtain financing because of their project situations: even bigger international financing institutions do not allow them to get financing from anywhere. So (from my economic background), I believe that inequalities will remain ...because of the way*

financing is structured which favours more the bigger than smaller countries which have smaller population". (Energy Expert II, AfDB - Tunis, 18th April 2012)

In Ghana, this is evident in the implementation of the GEDAP project. Amadu (2012) in an assessment of the financial allocations of the project points out that, out of the USD 210 million committed to the project, only USD27million (about 12 percent) has been allocated to the promotion of off-grid decentralised solutions, with the remaining geared towards strengthening the traditional grid-based state-owned electricity supply agencies. It is important to note that the GEDAP is a multi-donor funded project involving the World Bank-International Development Agency (IDA), Global Environment Facility (GEF), African Development Bank (AfDB), Global Partnership on Output-based Aid (GPOBA), Africa Catalytic Growth Fund (ACGF) and the Swiss Agency for Development and Cooperation (SECO). By implication, all the partnering donors are party to this financing logic.

Cost of decentralised energy systems

Another key issue that confronts the dissemination of decentralised energy systems in the rural areas is the cost component. With development and improvement over design and input components over the years, the price of decentralised energy systems particularly solar has been geometrically falling (Renewable Energy World.Com, 2104[52]; Interview with Adu-Asare, solar energy expert and representative of Association of Ghana Solar Industries (AGSI), 21st May 2012; UNDP 2011). Yet, even at the recent prices, the costs are deemed high for rural dwellers. Without external financial support systems, the rural dwellers are unable to purchase the systems. One government representative remarked in an interview:

> "*If the government could have a scheme where renewable would be treated as the grid and people would pay the lifeline-, but we do not have that system. When it comes to renewable energy, the high cost is part of the problem. If you sent it to the rural areas, and there is no subsidy, the rural dwellers are unable to pay. Over the years, the government has provided solar systems to a number of rural communities and all of them have been subsidised but the government does not have a clear policy on what is subsidised and what is not. All of them have been project based".* (Government Energy Development Official, Energy Commission, Ghana, 25th July 2012)

In the opinion of another energy financial expert, subsidy should be a vital input from the government side to promote and sustain decentralised forms of energy at the rural level. Reference is made to the breakthrough of renewable energy in developed countries such as Germany and Denmark where government subsidies have played a major role. The expert iterated that subsidies do not necessary have to be announced but can be fed in indirectly through the following mediums:

- *Grid could be highly priced while Renewable Energy (RE) is promoted - there is a subsidy.*

[52] http://www.renewableenergyworld.com/rea/blog/post/2009/08/retail-solar-price-drop-accelerates-new-record-lows-reached. Accessed 27th May 2014

- *Introducing an RE tax in the electricity bill - there could be a cost factor in the grid power billing such that the consumer using RE will not pay but the one who does not use RE will pay this cost factor,*
- *Duty free and tax free for importing companies and ensuring that the discount goes to the consumer and not redirected, and*
- *Introducing and promoting the hybrid form of energy where individuals using solar for example will feed it into the national grid and will be credited.*
  (Energy Expert I – African Development Bank (AfDB), Tunis, 3rd April 2012)

Up until the time of field study, the government of Ghana had in place tax exemptions for renewable and decentralised energy systems in terms of import duty exemptions and Value Added Tax (VAT) exemptions. A complete decentralised system such as solar system consisting of the panel, inverter, regulator and battery, would not attract VAT. However, constituent parts of the system with the exception of the generator component attracted VAT but not import duties. In a number of interviews with solar distributors, this schedule did not seem to be well understood resulting in continuous rift between the regulators and the importers. The government's outlook is such that when the systems are eventually locally (in-country) produced, then there will be no exemptions on imports.

In relation to this, from the supplier view point, limited finance and weak financial environment also hinders the development of alternative energy sector. One major private solar supplier in Ghana who has active presence in the three Northern Regions remarked that 'there are no guarantee rates but this is what will attract investment. With guarantee rates, the banks can be well assured of regulatory support and can risk giving for example as much as USD20,000 for solar investment, spread over a period of say 10 to 15 years: the logic may be to compare this transaction with the application for car and home loans, that is, similar amount over similar repayment duration', (Alternative Energy Supplier I – NEGD, Accra, 5th July 2012).

Regulation

The regulatory system mandates the Commissions to regulate among other things the quality, imports and pricing of renewable and decentralised energy systems. This does not always favour the private sector which is the major actor in the supply and distribution of decentralised energy. One supplier who served as a key informant described the situation as an antagonism from the Energy Commission and the Public Utility Regulatory Commission (PURC), citing an example where suppliers and distributors were once required to charge 8 cent/kW for solar energy supply. To the supplier, this meant a loss because at that rate, a huge difference existed which was not budgeted for, (Alternative Energy Supplier I – NEGD, Accra, 5th July 2012).

Technology failure and availability barrier

The unavailability of the technology was also identified as a barrier to implementation. This is also directly related to informational barrier. This was an issue raised by a key stakeholder in the solar industry in the country who made a fundamental remark in a discussion: "*We talk about the technology but where is it?*" (Adu-Asare, Solar Energy

Expert, 21st May 2012). When interests are whipped up, there is a hitch in distribution when the technology is unavailable. The propagation of liquefied petroleum gas (LPG) suffered a similar fate when after an appreciable level of acceptance was achieved at the rural level, there was acute shortage, reversing the whole process and resulting in a further plunge into the consumption of woodfuels. In a similar vein, solar is most talked about but the availability is limited. In the communities studied in the Brong Ahafo Region, only single individuals were using solar. These were acquired through individual initiatives outside the communities and even outside of the District. The members of the communities testified to the useful of the systems as they benefited from the phone charging service in the least. However, majority of respondents did not know how they could access the system for themselves.

Furthermore, technology failure either as a result of industrial defect or importation of inferior commodities has been the cause of disillusionment and major scepticism about decentralised energy systems in the rural settings. In this respect, the solar expert further remarked that "the technology must also be protected from failure because when it fails it is a blow to the industry" (Adu Asare, Solar Energy Expert, 21st May 2012). While all technologies have acceptable rates of depreciation, failure with decentralised systems such as solar and biogas and the unavailability of immediate technological support has been a barrier to the promotion and acceptance of DE systems.

In summary, even though alternative and decentralised energy solutions are accorded the efficient energy development path for remote rural areas, governments seem to have a greater commitment towards on-grid electrification than alternative energy. By implication, the internal in-country issues that are within the local control militate against the promotion and development of decentralised energy. Internal preconditions can be controlled or manipulated; even the socio-cultural pre-conditions can gradually be improved through consistent conscientisation and modernising the application for rural dwellers who contrary to popular assumptions, like to be identified with modern trends. Political will and other in-country issues can be improved by a willing government. The external preconditions are however out of the control of the local development agent. The most challenging aspect of the external preconditions is the external funding, that is, influencing the dominant logic of external development funders to suit the development priorities of the country. Funding decisions and priorities remain the prerogative of funders. However, the counter effect of this external precondition could be minimised to achieve desired results when the internal preconditions are effectively tackled.

7.5 Management systems and capacities necessary for effective functioning of decentralised energy systems

7.5.1 Technical backstopping

The effective management of decentralised energy systems is a critical element for their sustainability. Decentralised energy systems require decentralised management capacities that can be easily accessed by users.

Technical base

Due to the fact that most decentralised energy systems are operated on new technologies which though appear similar to general mechanical and electrical applications and operations, require certain levels of expertise that may not be necessarily present in the rural communities. An alternative energy supplier remarked:

> *"The fact that there are local electricians and mechanics does not necessarily mean they can just be co-opted in to the after-sales-service to work on the systems. NEGD for example has stopped using flooded batteries because the local mechanics simply serviced them by opening them and refilling them with electrolytes of car batteries, which broke these batteries down completely because they have different specific gravity. Subsequently, we had to seal the batteries and label them as not to be opened or discharged."* (Alternative Energy Supplier I – NEGD, Accra, 5th July 2012)

The capacity of local potential technical resource to handle after-sale-service is essential. Data on the technical base situation was elicited from interviews with District officials, community interviews, and interviews with dealers and suppliers of decentralised energy installations. The study Districts in the Upper East Region indicated that when communities reported technical faults on their systems, the reports were sent to Accra, the national capital[53]. In a cross interview with a few of the major suppliers of decentralised systems in country, suppliers indicated that their overheads are greatly increased when after-sales-service was delivered from their base stations. For one supplier "installation is not a problem at all but servicing costs the company a lot. Sending a service team of two personnel from Accra to Tamale to fix a USD20 problem costs about USD1200," (Alternative Energy Supplier I – NEGD, Accra, 5th July 2012). To salvage the situation, dealers who double as the local main retailers and who operate from the major towns in the Districts sometimes with a regional sphere of influence, have been trained for this purpose. However, this technical expertise is also not easily accessible by the rural communities. It therefore appears that much more localised community-based expertise will be more helpful.

In the study communities in Builsa and Kassena-Nankana Districts, there was no such effective technical base, particularly regarding electricians. Only mechanical apprentices in the form of bicycle repairers were identified. One significant remark made in all communities visited was that there were no technical jobs in the communities so the young apprentices normally worked in the neighbouring towns which were the District capitals. In both Kumfia and Fakwesi in the Atebubu-Amantin District where MFPs were being operated, the operators indicated that all technical assistance were called for from Atebubu, the District capital, which was 28km and 37km from Kumfia and Fakwesi respectively. In all cases, the operators had to pay for the transport fares of the technical persons in addition to their service charge. In Sabidi, a key informant remarked that "there are no fitters or mechanics; people are just explorative and will attempt to help others

[53] The national capital, Accra, is at the southernmost of the country. The distance between the two locations is approximately 845 kilometres.

when there are problems with motorbikes". Notably, decentralised systems such as the MFPs were income generating activities and therefore the cost of repair and maintenance could be factored into the operating cost and charges. However in the case of privately used decentralised system such as solar home systems in Builsa and Kassena-Nankana East Districts, this implied extra cost to owners.

Receptiveness to new ideas

The District officials and community opinion leaders were optimistic that the assertiveness and willingness of the young people in the communities to learn presented a possible technical potential. In KNE District, the optimism was based on the past recent turn out for a rural technology and technical training of the youth in the development of farm implements. In the communities in the Atebubu-Amantin District, the MFP installation process had involved the training of local people in the maintenance of the platform. Further discussions showed that although the youth were receptive to new ideas and technology and some had been trained, they did not operate in the communities due to the inadequate clientele base and also sometimes due to the lack of the appropriate energy services which tended to impede their work. For instance, a discussion with the Fakwesi platform operator indicated that technical assistance for routine maintenance was sourced from the Atebubu township because trained technical hands were not in the community due to the inadequate business opportunities in the community. In Kumfia, an opinion leader indicated that a trained electrician had left the community and resided in Atebubu due to very low demand for his services in the community. Apart from these cases stated it was difficult for the Researcher to identify vivid technical enthusiasm in the communities. In the communities in the Builsa District, the youth were either engaged in the Sandema Township or were farming. Communities in the Kassena-Nankana East District exhibited some technical inclinations such as electrical, masonry, and fitting. This could be attributed to their closeness to Navrongo. In the communities in the Atebubu-Amantin District, the Researcher's impression was that the youthful population, especially the young men, were enthusiastic about farming and charcoal production. It is possible that the younger youth of school going age especially those who were in the Junior Secondary School will be more technically inclined as was noticed with the group of school children (and their parents) who tried the "battery-box" (See Table 6-1). They also displayed a lot of enthusiasm for the introduction of new ideas and new technologies since they were more exposed to the fast moving technological world through their interactions when they visited the town centres. However, the communities could also loose this potential set of technical minds if the communities do not serve as good business propositions for them.

Training cost and suppliers' overheads

One key issue which seems to persist with training for technical after sales services is the cost component. Suppliers try to protect their overheads from soaring, and government programmes rarely factor in the cost of maintenance in projects costs. Another major private investor and supplier thus lamented:

> "*There is no maintenance contract. We've done most of these projects and we ask for an extension of the contract, a small monthly retainer fee so that we can just do routine maintenance such as cleaning the panels, checking for wire connections to see cables are well connected, etc. but no government will do that. So one day the client's light goes off, they call a local technician and with just his local expertise, the technician replaces it with an AC (alternating current) bulb instead of a DC (direct current) bulb, or he does the wrong connections, or opens the battery the wrong way and damage it resulting in system collapse and solar is given a bad name."* (Alternative Energy Supplier I – Wilkins Engineering, Accra, 5th July 2012)

Conclusively, even though technical activities could not be identified in the communities themselves, there is basis for training. It may be plausible that the young persons who are involved in the activities and yet working in the major towns could be recruited and trained. With the exception of the cases stated in the communities in the Atebubu-Amantin District, the opinion leaders that in the communities in the Upper East Region indicated that the communities served as "dormitory" to the these young people working in the major towns.

7.5.2 Financial support system

Finance has been identified as one of the key barriers to the promotion of DE systems. Comparatively, DEs are expensive to the consumers than the conventional grid. The same apply to cooking energy where improved woodfuel cookstoves are financially inaccessible to rural communities where woodfuel consumption is tremendous. As part of the research, the microfinance landscape of Districts of study was examined to identify the financial assistance available or otherwise for the promotion of decentralised energy systems. These rural banks were identified: Builsa Community Bank (BUSCO) in the Builsa District, Naara Community Bank and Sirigu Rural Bank in the Kassena-Nankana East District, and Yapra Rural Bank, Agricultural Development Bank (ADB), and Sinapi Aba Microfinance in the Atebubu-Amantin District. The selection of the institutions was done according to their availability and prominence in micro-financing in their Districts. For those in the Upper East Region, their past and current involvement in deployment and financing of DE systems was also a criterion. Four out of the six financial institutions interviewed had previously invested into the energy sector. These were the three institutions in the Upper East Region, and the ADB and the Yapra Rural Bank in the Brong Ahafo Region (Atebubu-Amantin District). The three institutions in the Upper East Region and the Yapra Rural Bank were involved in the deployment of solar systems under the GEDAP under an agreement between the mother rural bank - the Apex Bank - and the executing agencies of the GEDAP. The ADB was the local funding support during the implementation of the MFP in the Atebubu-Amantin District, which was executed by the UNDP. Apart from these specific investment activities, the financial institutions had not been involved in any other energy investments. The Builsa Community Bank though was considering in its Strategic Plan to partner with certain DE suppliers in Upper East Region to undertake renewable energy projects.

Funding support

With the exception of the above mentioned specific energy investments, all the MFIs interviewed granted mainly microfinance loans and trader loans. It seemed ironical that farmer loans were unpopular with these MFIs which operated in predominantly farming communities. However, across discussions with all the MFIs in both study Districts in the Upper East Region and in the Atebubu-Amantin District, this was the case due to the high risk involved in farming activities such as crop failure and the low loan recovery rate. For instance, in an interview with ADB, the case is mentioned of a farmer who intentionally set his farm to fire to implicate crop destruction by a fire outbreak when in actual fact the farmer had already harvested and sold off his crops before setting the land to fire, just to evade loan repayment. In the Kassena-Nankana East District, a District official asserted that in 2011, the rains stopped very early resulting in drought dry conditions and subsequently, the massive burning of rice fields due to fire outbreaks.

Table 7-16: Interest rates of financial institutions

Bank	**Interest**	**Remark**
Yapra Rural Bank	Trader loan – 34% p.a. Farmer loan – 34% p.a.	Interest rate application is Amortisation or at Reducing Balance
Agriculture Development Bank (ADB)	Agriculture loan – 16.95% Personal loan – 24% (Amortisation) Commercial loan - 27%	Agriculture loan requires 25% lien or fixed deposit as collateral Collateral base lending in the form of Treasury Bills/Fixed Deposits, Bonds charge on inventory, Building collateral Interest application on personal loan is Amortisation
Sinapi Aba Trust	3.3% per month for all loans, that is, Group Guarantee Funding, Farmer loan	In the special case of dealing with *farmers*, the farmer must have <u>another</u> income generating <u>business</u> which will take care of <u>off-season loan repayment</u> The alternative is the <u>Bullet type of payment</u> – the loan is given for a farming-and-harvest period of three months and then the total loan and interest is paid off in a single lump sum Interest application is Amortisation or Reducing Balance
Naara Rural Bank (subsidiary Sirigu Rural Bank)	Salary loan – 25% Agriculture loan – 26% Commercial or trade loan – 26% Construction loan - 30%	Straight line interest rate applied on salary loans; Amortisation or reducing balance on all the other loans
Builsa Community Bank (BUSCO)	Salary loan – 25% Business or trade loan – 28% Agriculture loan – 27% Construction loan – 30%	Straight line interest rate applied on salary loans; Amortisation or reducing balance on all the other loans

Source: Author's field survey, May – July 2012

The ADB for instance only gave farmer loans with a 25 percent lien or fixed deposit as collateral. It can be inferred that if farmer loans which under normal circumstances should be considered as economic loans were considered as high risk and thus were rarely given out, then support for individual energy investment could be less expected. This was only possible with civil servants and salaried income earners whose salaries were administered through the Banks.

Loan repayment

Loan repayment was expected in cash and not in kind. In past, when farmer loans were granted, the MFIs accepted loan repayment in kind. It was recorded by the ADB that repayment rate of agricultural loans was less than 25 percent in 2012 (the year of interview), and even less than 22 percent in 2011; for personal loans the rate was 87 percent, while for commercial loans, repayment was less than 50 percent.

Institutions interest in future energy investment

Further to the involvement of the financial institutions in past energy programme, it was enquired if the institutions will be interested in investing into decentralised and alternative energy supply for their surrounding rural communities either through supporting a chain of retailers or supporting the consumers directly through long term loans. The responses are shown in Table 7-17. With the exception of Sinapi Aba Trust, all the other MFIs interviewed had a level of interest in investing into energy. However, it was only the Builsa Community Bank in the Bulsa District and the ADB in the Atebubu Amantin District which were certain of such future investment. The Yapra Rural Bank in the Atebubu-Amantin District and the Naara Bank in the Kassena-Nankana District were interested not as sole investors but as part of a programme like the GEDAP.

Table 7-17: Interest in future energy investment

Bank	**Level of interest**		
	Very interested	Interested but with conditions	Not interested
BUSCO	√		
Naara		√	
Yapra		√	
ADB	√		
Sinapi Aba			√

Source: Author's field survey, May – July 2012

Some prime considerations for the MFIs that were 'very interested' were:

- Value for money: The economics of it, that is, the efficiency of whatever energy project which is being introduced such that the products will not fail consumers which will consequently result in the default in repayment.
- Win-win case: the project is beneficial to all, that is, the bank, the supplier, and the community. For the bank it should be good business; for the supplier, there should be enough guarantee, guaranteeing the worth of the project and enough technical support for addressing technical issues and retrofitting when there is a problem; and for the community it should entail a livelihood improvement.

- Accessibility: the communities must be accessible to ensure that loan applicants and their applications can be assessed and for loan recovery, to keep the overheads of the loan administration at the barest minimum. This condition was overly stressed by the Yapra Rural Bank, which even though operated in the Atebubu-Amantin District, saw it viable to be involved in energy project in communities in Sene District, a neighbouring District, rather than the study communities due to the rather poor accessibility to that corridor of the Atebubu-Amantin District. Thus from the supplier viewpoint, physical access to communities is a necessary precondition to energy access for communities.

Excerpt on the GEDAP deployment and funding process as a proxy for energy investments

The financial support component for the beneficiary communities of the GEDAP was designed as an improvement over past failed programmes. The following were observed in the funding process:

- The creation of a project office for the energy deployment project in the collaborating rural bank – the project officer employed was selected from the beneficiary community by the community.
- Awareness creation to propagate enough information about the alternative energy – this was done through the Chiefs and sub-chiefs and the local radio stations.
- The message – this had to be convincing enough. For instance, the members of the communities were admonished to consider how long it might be before they had electricity; that it could not be easily predicted when the grid would reach them; that solar would make it possible for them to also enjoy light and be enlightened.
- Location of applicant – The applicant was required to be within the area ear-marked for the project.
- Opening of account with the bank – the interested beneficiaries were required to open bank accounts with the rural bank. A key caution was to ensure that the account was not opened with the minimum balance. This was necessary to prevent a misunderstanding when the applicant's financial contribution was deducted from the accounts. Again, the applicant's contribution was not taken until installation of the energy system was approved.
- Funding arrangement:
    - The applicant contributed an initial 10 percent
    - The local rural bank contributed 20 percent
    - The (Association of Rural Banks) ARB Apex Bank – the mother rural bank through which donor funding was administered contributed 80 percent
- Subsidy - there was a subsidy component in the cost of the system, a grant which lowered the cost to the consumer. Therefore the initial ten percent paid by the consumer was based on the subsidised cost. The payment to the supplier was however the actual cost. The funding approach adopted was the output-based approach where donor funders executed payment only after installation had been verified and confirmed by an independent agent.

- Repayment - The rural bank paid the suppliers on behalf of the beneficiaries so that the beneficiaries repaid the bank. After the initial ten percent deposit, the rest of the cost of the facility was paid in instalment over a period of 24months at an interest rate of 28 percent per annum for both farmer-beneficiaries and non-farmer-beneficiaries alike. The project officer noted that at the initial stages people were collecting the facility for a one-year repayment period but they were not able to honour it. They could mostly honour the repayment within two years so the repayment period was adjusted. Compared to the interest rates shown in Table 7-16 above, the project interest rate was comparable to the prevailing rates of the microfinance institutions, with the exception of the rates of the Agriculture Development Bank in the Atebubu-Amantin District.
- Accessing the applicant's ability to pay - Project officers did the beneficiary screening. It was also necessary to obtain a certain number of beneficiaries within a community. However, installation was done on a first-come-first-served basis. When a community had understood and wanted the product, a request from the community was sent to the rural bank. The project site was inspected to check if the requirements expected of the beneficiary were met – e.g. that the beneficiary's house had metallic roofing.
- After installation, an inspection was initiated by the mother bank - Apex Bank. When all criteria were satisfied, the Apex Bank paid the 80 percent component including the grant component in addition to the 20 percent from the local rural bank.
- Identification of suppliers: The customers were connected to the suppliers through the bank to effect installation but all payments were direct transactions between the bank and the suppliers.

It may be inferred from the discussion that the financial landscape for the deployment of alternative energy was not all conducive. While suppliers did not have guarantee rates from the banks to ease their transactions, the interest rates, the types of loans, collateral required and even community accessibility hindered the diffusion and acceptance of alternative and decentralised energy forms in the rural communities. However, when projects were administered as in the case of the GEDAP, suppliers had the assurance of being promptly paid, and the MFIs were more certain of loan recovery. From the discussion on micro financing, the interest rate such as that offered by ADB on personnel loans is a deterrent. Individual application for financial support may require a collateral security or a consistent source of income which is administered through the financial institution. This situation is likely to delineate the rural communities as outliers. The deployment of DE system under an output-based scheme such as the GEDAP appeared more feasible. Without a financing and repayment model such this model, it is difficult for ordinary farmers such as those studied to obtain and repay loans under the then prevailing interest rates. The microfinance institutions in the Upper East Region and the Yapra Rural Bank in the Atebubu-Amantin District, through the GEDAP off-grid electrification project, had had an experience with the output-based model. In the respect that the GEDAP repayment and loan recovery was successful, these institutions would

have leverage in providing credit support for the dissemination of DE systems in rural communities.
The seasonal nature of farmers' income was a challenge. Changes in weather conditions could be a catastrophe for any financial plan of the farmer, and unsettling for microfinance institutions and DE retailers who were business and profit oriented. In addition, the more remote the rural communities, the less their opportunities of being served my microfinance institutions who wished to minimise their overhead costs. Thus physical access to rural communities is an important precondition.

7.6 Conclusion

The deployment, acceptance and sustainability of decentralised energy systems are affected by certain preconditions at the household level, the energy environment, and a milieu of external factors. The household factors culminate in the value identified in the decentralised energy systems which are alternatives to the conventional energy forms rural dwellers would have ultimately wished for, their ability, and their willingness to pay which can also be influenced by the external preconditions through subsidy provision. Due to the tag given decentralised energy systems as alternatives to the conventional, the preconditions identified have equal weights in how they affect deployment, acceptance and sustainability. Without identifying and understanding those at the household level, external injections are unsuccessful, and without the external support, households' willingness to adopt, ability and willingness to pay will be hindered because supply will be hindered.

In consonance with the proposition by Christensen (1997) on disruptive technologies, the management of DE systems at the micro rural area requires local and localised management systems and capacities. Their management cannot be lumped together with the macro level management. Even the individual rural settings have individual peculiarities which need to be taken into consideration in planning. Although from the foregone analysis it may be desirable to further decentralise technical backstopping even from the regional level to the district level where they are most accessible to network of rural communities, cost and funding remains a challenge. A business model that adequately incorporates this cost factor may be useful. It is also evident that local financial institutions deemed it risky to be involved in energy financing with the rural consumers based on their income earning structure. Until decentralised systems are effectively integrated and infused into the country's energy supply mix, this withdrawal may persist from both the demand and finance sides – the rural consumers are not committed to pay and financial institutions are consequently not prepared to take the risk. It may also be important to avoid adding the face of the government to programmes to prevent the 'commons' mentality that is usually linked to government interventions.

8 DISCUSSION - THEORETICAL AND CONCEPTUAL INFERENCES FROM EMPIRICAL DATA

8.1 Rationale

The goal of this study was to examine how decentralised energy options can be harnessed to improve the socio-economic development of rural areas. A number of specific research objectives were derived to address this goal. The findings reported in Chapters four to seven are discussed in the light of the research objectives and the theoretical framework within which they were situated to identify convergences and departures.

8.2 The socio-economic energy needs of the rural household and how these are being met

The research question was examined under the concepts of accessibility, availability and affordability developed by international energy development agencies, which were also emphasised in Prahalad's (2005) concept of the Bottom of the Pyramid, as well as in Christensen's (1997) Disruptive Technology.

The working definition for accessibility is "the fundamental energy requirement for any group of persons forming a household and eventually living in a living space referred to as their community, and which include sufficient energy for lighting, cooking and some form of livelihood". The Energy Development Index developed by the International Energy Agency (IEA, 2012) considers energy as a domestic consumable, for community service, and for productive use. The estimated threshold level of electricity consumption for rural households is assumed at 250 kilowatts-hour (kWh) per year, calculated on the assumption of five persons per household (idem.). This is the minimum requirement for a floor fan, a mobile telephone and two compact fluorescent light bulbs for about five hours per day. From the quantitative study, only 9.5 percent of respondents were identified to be using solar home systems, and 4.1 percent used grid electricity and grid electricity services for the charging of re-chargeable lamps. The solar systems that were being used by respondents could not power a floor fan, and provided approximately 77kWh per year at eight peak sun hours per day given that the angle of tilt is five degrees. This translates to as low as 0.21kilowatts-hour per day, which is almost one-third of the estimated threshold level of electricity consumption. By implication, the sample studied fell below the minimum of 250kWh per year, the situation being worse for the 88.3 percent of respondents who did not use the solar home system or its equivalent.

In terms of cooking, fuels identified were basically biomass utilised over traditional three-stone cookstoves with energy efficiency of nine percent (Essah, 2002) with pockets of respondents (15 percent) using the traditional coal pot which uses charcoal with efficiency between eight percent and fifteen percent (Ecofys, 2006). This falls woefully below the IEA minimum efficiency requirement of improved wood and charcoal stoves that is 40 percent greater than a three-stone fire (See Table 8-2), and its definition of energy access which in terms of cooking energy meant 'less health harmful, more environmentally sustainable and energy efficient biomass cookstoves such as biogas systems, liquefied petroleum gas stoves and advance biomass stoves'. In the discussion, the IEA noted that households did not distinguish energy use as part of micro-enterprise conducted within the home. The same was observed in the field study. For instance, micro-enterprise activities such as food vending were undertaken on subsistence level to provide supplementary income for the household. Even though food vending was a productive activity, its energy use could not be distinguished from the energy use of the households because the households invariably took their dinner from the same source, unaccounted for. From the study, ten of the potential indicators of energy access as defined under the Energy Development Index could be estimated. In Tables 8-1 and 8-2, these are shown.

Table 8-1: Dimensions of Energy Access in study communities

Dimension	Potential Indicator	Results of empirical evidence
clean cooking	Percentage of households having an efficient stove that meets minimum requirements for indoor air quality	1.4 percent used LPG stoves
	Percentage of households that cooks with modern fuels	1.4 percent
	Percentage of income or expenditure spent on cooking fuels	i. About 53 percent of respondents did not spend on cooking fuels ii. 3.3 percent of expenditure in the case of those who spent on cooking fuels - The figures contained here cannot be concretely said to be solely expenditure on cooking fuels because for respondents undertaking home-based energy based economic activities, the quantities and the expenditures could not be disaggregated.
	Number of household electricity connections	4.1 percent grid electricity and grid electricity service – 8 households 9.5 percent, that is 19 households using off-grid electricity - solar
energy for public services	Percentage of hospitals and schools with minimum level of electricity supply and percentage of villages with street lighting	- 1 community out of total of 10 study communities with solar streetlights - 4 out of 10 communities have CHP centres that operated on solar energy - 2 out of 10 communities with solar power for lighting in schools
productive use	Percentage of businesses with equipment common for their sector that consumes modern energy	53 percent which is 8 out of 15 businesses identified used alternative modern energy, e.g. generators with diesel instead of electricity, solar instead of electricity. The business operators indicated their productivity could increase significantly with grid electricity Individual households using solar systems, that is, 7.6 percent also provided solar phone charging services in the communities
	Percentage of farms with minimum availability of advanced mechanical power	4.2 percent, that is 7 out of the total number of farming households (167 households) practiced mechanised farming. These were all found in the study communities in the Upper East Region

Source: International Energy Agency (2012) and Author's data analysis, 2014

Table 8-2: Total Energy Access in study communities

Energy service	Minimum standard	Results from the study
Lighting	• 300 lumens at household level	• For the users of solar lights interviewed, the LED produced 150 lumens per watt (Amogpai, 2011). Most lights were of 5W, giving a minimum of 750 lumens per household
Cooking and water heating	• 1kg woodfuel or 0.3kg charcoal or 0.04kg LPG or 0.2litres of kerosene or ethanol per person per day, taking less than 30 minutes per household per day to obtain	• In the study communities in the Upper East Region, average woodfuel use per person per day was 0.34kg, supplemented with crop residue. The average distance covered to access woodfuel was 9miles, an equivalent of 2 hours 15 minutes. • In the communities in the Brong Ahafo Region, woodfuel use was beyond the minimum standard of woodfuel and charcoal.
	• Minimum efficiency of improved wood and charcoal stoves to be 40 percent greater than a three-stone fire in terms of fuel use	• None was identified - the traditional three-stone cookstove and coal pots (very rare) used had efficiencies of ≤9 percent and (8-15 percent) respectively.
Cooling	• Food processors, retailers and households have facilities to extend life of perishable products by minimum of 50 percent over that allowed by ambient storage. • All health facilities have refrigeration adequate for the blood, vaccine and medicinal needs of local populations	• Local preservation methods such as such drying, boiling and frying were used • The CHPS compounds were only equipped to handle minor health issues in additional to maternal delivery and were not capacitated to keep a blood bank. Vaccines could be preserved for a maximum of two days in ice chest. The compounds had refrigerators but not freezers. Vaccines were normally kept at the main health centres where there was relatively constant supply of electricity.

Source: Practical Action (2010; 2012) and Author's data analysis, 2014

Table 8-2: Total Energy Access in study communities (continued)

Energy service	Minimum standard	Results from the study
Information and communications	• People can communicate electronic information beyond the locality in which they live • People can access electronic media relevant to their lives and livelihoods	• Mobile phone usage was common among respondents. 32.1 percent used personal mobile phones and the remaining 67.9 percent communicated electronically through commercial mobile phones • All respondents had a form of electronic media, that is, radio, mobile phones, TV
Earning a living	• Access to energy is sufficient for the start-up of any enterprise	• Access to energy was insufficient within the communities for enterprises which were energy dependent. The source of energy was mainly outside the communities which constraint physical access
	• The proportion of operating costs for energy consumption in energy-efficient enterprises is financially sustainable.	• Due to the physical access constraint, the cost was relatively high to enterprises. Thus the proportion of operating cost was financially unsustainable

Source: Practical Action (2010; 2012) and Author's data analysis, 2014

The table above served as a guide to determining energy access. Generally, accessibility to energy for cooking, lighting, and productive use was poor, and even poorer in the study communities in the Upper East Region than in the Brong Ahafo Region. Considering the requirements of the energy development index, the results of the study indicated that energy needs of rural communities were not adequately met and access fell below the international minimum requirements. The case witnessed in the research can be called extreme inaccessibility.

Energy availability is defined as when the household is within the economic connection and supply range of the energy network or supplier (Brew-Hammond 2010:2292) and when there is a technical possibility to use it (IEA, 2012). From the field study, certain sections of Wuru and Nagalikenia communities in the Kassena-Nankana East (KNE) District were within economic connection and supply range with a technical possibility to use it but unaffordability and a combination of financial, technical and political challenges within the implementation chain – from the Central Government through the Utility Agencies to the executing agencies were major hindrances to connection and therefore only eight households out of the total of 36 households interviewed in these two communities were connected to the grid. In Akudugu Daboo and Azaasi, poles had been erected and lines had been laid according to the minimum requirement of the Self Help Electrification Programme (SHEP) five years earlier before the time of the field work but the lines had not been connected to the grid. By implication, even though some respondents indicated they could not afford the extra cost of extending the lines to their homes, respondents who were in the financial position to do so were also constrained because there was no connection to the grid. This affirms that the technical possibility to use is an important factor in defining availability.

Both affordability of access and affordability of consumption were deficient in the study area. Need plus affordability equals demand. Even though need was identified, there was lack of affordability and therefore there was no resulting demand. The working definition for affordability is when the household is able to pay the upfront connection cost and the usage cost. Komives et al. (2005) quoted in AfDB (2011) suggests a threshold of five percent of total expenditure as a determinant of affordability of basic electricity for poor households, that is, the monthly recurrent expenditure. From the study, those connected to electricity on the lifeline tariff paid a maximum of GHS7.85 per month for the lifeline maximum of 50kWh consumption per month which was 2.3 percent of their monthly expenditure. However, for communities which were on the verge of being connected to the national grid (that is, Azaasi and Akudugu Daboo) or partly connected to the grid (Wuru), the requirement of an upfront cost of GHS120 for an access pole and wiring was beyond the financial capacity of households. Similarly, the solar home systems which were being deployed through the Ghana Energy Development Access Project (GEDAP) at the time of the field study cost at the minimum GHS600 which was expected to be paid back in 24 months. The average cost of GHS25 per month which was 10.4 percent of the monthly expenditure was beyond the means of majority of respondents. The average monthly household expenditure[54] was GHS241 in the communities in the Upper East Region, and GHS697 for communities in the Brong Ahafo Region.

Conclusively, the equation, that is, *Need + Affordability = Demand,* hypothesised by the Author (section 2.5.2) is relevant. The threshold of five percent suggested by Komives is also relevant. It is also relevant that off-grids systems should be demand-driven as suggested by Kaundinya, et al. (2009) quoted in UNCTAD (2010). In addition, on-grid systems within this remote rural context can also said to be demand-driven. Therefore, even though both accessibility and availability parameters may be satisfied, without affordability, energy poverty among rural communities such as those studied will persist. The Author also assumed 'demand' as substantive and expressed as a preference. However the results of the study are showing that without affordability, "preference" will be invalid as a determinant of demand. Respondents indicated genuine preferences for modern energy but the topmost limitation was cost of the modern fuels. It is right to conclude that poverty is a barrier to energy access. Practical Action (2012) adds to the relationship by indicating that lack of access to energy services is also a barrier to poverty reduction. The relationship between income and energy access is cyclical. Improved incomes will lead to increased energy access, and improved energy access makes available

[54] Monthly expenditure was used as a proxy for monthly income because the respondents especially in the Builsa and Kassena-Nankana East District did not have records of their earnings. Being mostly purely subsistence farmers, it appeared that they consumed all they produced, and only sold portions out for immediate income to be able to take care of emergencies.

a lot of opportunities for development which are energy based and therefore leads to improved incomes. In the Author's opinion, the starting point should be improved access to energy. This is where the key issue of subsidies becomes relevant; and to that effect, the relationship between productivity and technological progress as defined by the production theory finds its relevance. While the government or any engine of development cannot dispense money to rural communities in a bid to improve incomes, energy access can be improved through subsidies. Combined with an initial productive use programme, rural incomes can be improved resulting in a higher demand for energy for more productive and economic use. Brew-Hammond (2010) argued that since availability and affordability are interrelated, government subsidies targeted at making energy more affordable to the poor might in effect cause utility providers to reduce its availability as it will be unprofitable to them. This is contentious. On the one hand, subsidies are not necessarily cost to be borne by the utility provider but paid by the government to the utility provider on behalf of the beneficiaries. On the other hand, one project officer on the GEDAP remarked*: "the people in the village know darkness and now they have tasted light. They do not want to go back to the darkness"*. By implication, the "people" would put in a financial effort to retain the modern lights. If this phenomenon is true, then government subsidies for both grid and off-grid electricity can be programmed for a period of time, and then withdrawn gradually.

Furthermore, in the Energy Development Framework, the discussion within the broad categories of household and community considers both access to modern fuel and appliances as dependent on each other, that is, a person has adequate access only if they have access to both. It is further acknowledged that in respect to both access to energy and access to appliances, there is also progression. In discussion with respondents on the use of LED torchlights, a progression was observed from candle and/or kerosene to ordinary torchlights and then to the LED torchlights, or sometimes a leap from kerosene to LED torches. It is interesting though that the progression from kerosene was in most cases coerced as a result of the unavailability of kerosene. Generally, in the Northern Regions of Ghana, where torchlight is "every adult's companion" as one key informant described it (Expert interview, New Energy Tamale, 28th May, 2012), the change to LED torches marks the progression because they are brighter. In communities where solar energy had been embraced, a further progression from LED to solar lanterns and to solar home systems was observed. In terms of appliance, not much progression was identified overall with the exception of respondents using who had adopted solar systems and consequently moved from storage cell radio or battery powered television (TV) sets to solar powered radios and TVs. These respondents nonetheless continued using their storage cell radio which could be carried along while the solar appliance was left at home. Therefore there was progression but the old was retained for its benefits.

8.3 What are the available options for decentralised energy? What potentials exist for energy development?

The concepts of accessibility, affordability and availability are also applied in another dimension in defining the product options that should be produced for a market such as the rural market. Thus Prahalad (2005) in his discussion of the Bottom of the Pyramid propounds that to create the capacity to consume, the 3A's must be satisfied, that is, affordability without sacrificing quality or efficacy, access considering both distribution patterns for products or services as well as distance, and availability because demand decision is based on cash they have at hand at a given point in time because they cannot differ buying decisions. Adu-Asare, a solar energy expert in Ghana interviewed reiterated the issue of availability when he discussed the availability barriers with the question "*We talk about the technology but where is it*?", (Key informant interview – 21st May, 2012). Notably, availability as discussed by the development agencies and as discussed by Prahalad had some differences. While the development agencies concentrated on being within the economic connection and supply range and having the technical possibility to use it, Prahalad emphasised on the distribution efficiency based on the fact that demand cannot differ buying decisions. He suggests that innovations that are not mainstream products so that even though they may not satisfy the mainstream market, they may be appropriate for base of the pyramid. The study showed that across all energy services, rural dwellers preferred and wanted to enjoy what the urban dwellers are enjoying. Thus, while Prahalad's assertion is true, an important factor is the ability of the innovation to fulfil certain needs which the poor consider as modern.

Value is an important factor. For instance, in an attempt to find an enabling environment where energy plays a major role in the livelihoods of the poor, Practical Action (2012) observes that energy access alone is no guarantee of an improved livelihood. Rather, reliability, quality, and cost of energy supplies are critical success factors to enterprises – but only when coupled with access to markets, social networks, and a business proposition that has sufficient demand. In a similar vein, the World Bank emphasises that low cost energy technologies can be developed without compromising quality (World Bank, 2010). In the GEDAP case, even though whole communities were not found to have purchased the solar systems at the time of the study, for those who did, the services they enjoyed and the quality of the service were important factors for the success of solar promotion in rural communities. In the empirical studies, the majority of all respondents both for the quantitative household survey and the qualitative in-depth interviews indicated value as the key consideration for a preferred energy resource other than what they were then using for cooking, lighting, and economic activities. Some of the descriptions of "value" were convenience in the use of the energy source, efficiency, operationability, durability, time saving, and brightness.

The possibility of available options for decentralised energy was also examined from the endogenous development theory. The endogenous development theory emphasises on focusing on localities and their resources, territoriality, and the participation of all necessary actors. As Todaro and Smith (2011:91) put it, the problems of poverty, inequality, low productivity in both agriculture and industry, imbalances in economic opportunities, and unemployment have domestic potential solutions. In determining the available options for decentralised energy systems, the empirical study indicated limited options. Fundamentally, solar energy was the most available cutting across study Districts in both the Upper East and Brong Ahafo Regions. Other options were District specific, viz, water, cow dung, and rice husk. Observed from Christensen's concept on Disruptive Technologies (Christensen, 1997), the development of these options will not be within mainstream energy development but it suffices the market that needs it, that is, the remote rural market. Reiterating a submission by the World Bank (2010, in Practical Action, 2012), the adoption of low-cost technologies at the design or planning stage can reduce investment costs by 20-30 percent without affecting the quality of energy services. From Christensen's definition of technology and innovation, this study adopted a definition of innovation to mean emerging concepts or options. The research findings did not indicate any new technically feasible option (ethanol gel was identified but the cost involved deterred even implementing agencies from targeting the rural areas; the peri-urban communities were economically a more desirable market). More significantly, the model of implementation and execution appears to be the most important way of introducing and making DE effective as economic growth energy option. New technologies developed in the Western world such as hydrogen and fuel cells, infrared, wind, etc., are unpopular even in urban centres let alone in rural areas; they cannot simply be applicable in the target remote rural communities.

The economic growth theory was also used to assess available options and potentials existing for energy development. The Economic Growth theory indicates that technological progress is the most important factor that moves the production possibility frontier (PPF) forward, causing economic growth among all the components of economic growth. Energy, and in the context of the study, decentralised energy plays a dual role by affecting economic growth and acting as a component of economic growth. It facilitates capital accumulation indirectly as a socio-economic infrastructure, and at the same time plays the role of technological progress. In an in-depth interview with a section of respondents, respondents acknowledged that an injection of some form of energy would cause improvement in their economic activities or allow them to undertake diversified economic activities. For a given economy, the decision on how much to invest in either capital or consumer goods determines how fast economic growth will occur. Energy has the advantage of again playing the dual role as both a capital good and a consumer good, that is, an investment in energy could result in both growth and consumption. Drawing from the endogenous development theory, decentralised energy, uncovered as a local potential, could be a catalyst for interactions between territories both urban and rural. The production of decentralised energy itself locally could be a major economic venture. For instance, the possible production of rice husk briquettes could be a high income yielding employment activity.

Practical Action (2012), based on this identified that the impact of energy access on livelihoods may be achieved through creating new earning opportunities not possible without energy access; improving existing earning activities in terms of returns by increasing productivity, lowering cost and improving the quality of goods and services; and reducing drudgery and releasing time to enable new earning activities. From the empirical data, only 18 percent of households were engaged in energy-based productive activities. Agriculture, which was the principal economic activity undertaken by 83.9 percent of households was non-mechanised, utilising human power for almost all the process, and using natural non-technicalised forms of energy. Due to the absence of some form of processing and preservation of produce which could be facilitated by energy, exogenous outflow through trading was high. As Brugger (1986) quoted in Diaw (1994) cautioned, smaller economic areas with high levels of potential, as a rule, could have their destinies determined to a high degree by outsiders. Urban traders (middlemen-and-women) siphoned the rural capital in the form of primary agricultural produce at very low prices, rendering the farmers poor while enriching the traders. An energy expert in an interview subsequently remarked that "*all (rural) stakeholders along the supply chain are poor, while the middlemen and women gain the most"* (Energy Development Practitioner – New Energy, Tamale, 28th May, 2012). However, improved forms of energy could ensure value addition: agricultural processing (industries) could be facilitated with improved and appropriate forms of energy which could prevent the incidence of high postharvest loses and the consequent need to sell at low prices to the urban traders.

Again, the study showed that woodfuel was exported from the rural communities to the urban communities in large quantities. Particularly with respect to charcoal, the local producers preferred high profit margins gained from meeting urban demand than local rural demand. In the process, incomes are generated but the prices are dictated by the middle men and women; the irony of the situation is that the 'improved' form of energy is exported to the cities at the expense of rural energy, while the rural environment is degraded for the urban consumption. However, with appropriate and modern charcoal production methods, production efficiency will be high, less wood will be needed for the same amount of charcoal currently produced, and there will be less pressure on the environment.

In terms of improving existing earning activities through returns by increasing productivity, 50 percent of respondents would have preferred to have electricity for their economic activities. Table 5-20 showed anticipated economic activities with improved source of energy ranging from large scale farming to improved agricultural processing to operating convenient shops and cold stores, and a number of electricity based activities. Regarding reducing drudgery and releasing time for other activities, agricultural activities, agricultural processing, economic activities such as fish mongering, and woodfuel gathering among others were identified as time consuming. Fish mongers in the Atebubu-Amantin District had to improvise other ways of preserving their unsold fish by frying or drying them. That implied another activity and in the process also changed the form of their product. In addition, the capacity of the mongers to take in and store the fish was highly limited because of preservation challenges which consequently required frequent trekking to the fishing port, a distance of about 100km. The resultant effect was that the rural economy lost economic interactions due to its traders' inability to bring in more goods and services. For study communities in the Upper East Region, cereal processing was a daily battle of time. Respondents travelled not less than five kilometres on foot to grind their cereals every market day which occurred every three days. When the need was urgent, human mechanical power was applied. Shea butter processing took about two weeks when carried out the traditional way. Similarly, women in the study communities in Builsa and Kassena-Nankana East Districts travelled an average of nine miles each firewood gathering day, which was not part of their farming activities as in the case of the study communities in the Atebubu-Amantin District. As a coping strategy to saving time during the planting season, the women undertook this exercise twice or three times a week and supplemented their fuel with crop residue: *"the fuel gathering takes so much of* *our time and we return with backaches, but you know it is the planting season so we cannot leave our farms and search for firewood every day"*, said a respondent in Balansa in the Builsa District. Respondents indicated that if they spent less time on this activity, they could undertake many other more economically viable activities or even enjoy leisure time. The introduction of MFP in Fakwesi community showed significantly how women are saving time and money in cassava processing - the same activity that initially took two weeks done mechanically using human power took one week with the introduction of the MFP with the same output of better even quality. The women saved 50 percent of their time for other activities.

In conclusion, solar, woodfuel, water, cow dung, rice husk and groundnut shells were the potentials that existed for decentralised energy development in the communities studied. These should however (i) add value to the social development of the communities and create new livelihood opportunities which will not be possible without access to energy; (ii) improve returns on existing livelihood activities increasing productivity, lowering cost and improving the quality of goods and services; and (iii) reduce drudgery and release time to enable new earning activities. In addition, there is the need for innovative business models to make them accessible and affordable.

8.4 The preconditions necessary for implementation and sustainability of DE systems

The concepts of Bottom of the Pyramid and Disruptive Technologies advanced by Prahalad (2005) and Christensen (1997), help to address the question on which preconditions are necessary for the implementation and sustainability of decentralised energy systems. This question was split into external and internal preconditions.

8.4.1 External factors

External preconditions consisted of those emanating from the macro governmental level and from international development support agencies. Prahalad (2005) argued that in the delivery of services to the poor, benefactors are often prisoners of their own socialisation - their inherent assumptions - which he terms as their dominant logic. In a similar vein, Christensen (1997) presented value networks as the context within which an 'organisation'[55] operates, identifying and responding to customers' needs and solving problems, among others. The stakeholder analysis (Refer Chapter 4.3) highlighted the fact that energy decision-making rested more with the highest policy making body of the energy sector, that is, the Ministry of Energy and the Regulatory Agencies, than with the Renewable Energy Directorate which is the subsidiary directorate designated with the responsibility of the decentralised and renewable energy development. A proposition for a Rural Electrification Agency had been declined. Meanwhile, the value network and the dominant logic of the Ministry and the Regulatory Agencies focused more on the promotion of conventional energy. Christensen (1997) continues to support his argument of developing different value networks by further advancing that managing innovation mirrors the resource allocation process, that is, innovative proposal that get the funding

[55] The original word used by Christensen (1997) is "firm". This is modified to suit the context of the study.

and manpower they require may succeed and those given lower priority whether formally or de facto will have little chance of success. From this perspective, the development of decentralised energy and renewable energy have until recently been suppressed. However, with the recent promotion of the sector through the passing of the Renewable Energy Bill and the country's participation in the UN initiative on Sustainable Energy for All, this dominant logic is gradually allowing other value networks to be created if the country is to meet its target of having ten percent of renewable energy component in the country's energy mix.

Christensen further advocates that the capabilities of most organisations are far more specialised and context-specific than most managers are inclined to believe. Therefore, new markets enabled by disruptive technologies require different capacities and capabilities. Decentralised energy systems identified and promoted during the field study were the GEDAP solar systems and the multifunctional platforms. It was evident that unlike previous instances where projects were managed from the central government offices, the GEDAP project had its own project offices within the various rural banks who were involved. The administration had been moved from a central government control to a demand-oriented locally administered programme. None of the beneficiaries interviewed ever made reference to the central government. The implementing stakeholders they knew were the Apex Bank Rural Banks and sometimes the suppliers of the products. Without the creation of this capacity, it is plausible that the project would have been subject to the fate of previous programmes. In the Atebubu-Amantin District, one of the key interviewees of the Agricultural Development Bank remarked – "*the government face attached to the bank increases its vulnerability. People think that this is government's money so it is for everybody; it does not matter if I default payment*". Closely linked to this is North's (1991) theory on institutional economics and the implications for institutions and organisations. According to North (1991), in every system of exchange, economic actors have an incentive to invest their time, resources, and energy in knowledge and skills that will improve their material status. The position of the microfinance institutions (MFI) identified in the Districts of study was in consonance with this assertion. The institutions were unwilling to go into any kind of exchange that would result in a material loss to them. Thus even though the MFIs were located in the rural Districts, they were not motivated to grant agricultural loans because they had lost immensely in the past due to non-payment of these loans. Thus North (1989) posits that institutions are formed to reduce uncertainty in human exchange. Therefore, personal loans came with high interest and straight line application of interest to reduce the risk; again, they were more interested in loans for productive uses for which they had a certain amount of surety that they would be repaid within relatively convenient timelines. Consequently, the MFIs had very little interest in "energy loans" except for loan models such as the GEDAP. The concept of path dependence is also manifested here, where history of high risk loans have shaped economic models of MFIs in financing.

External factors (preconditions) identified are also commensurate with formal constraints identified by North (1990). Incremental change comes from the perceptions of the entrepreneurs in political and economic organisations that they could do better by altering the existing institutional framework at some margin – in this case, the creation of the Renewable Energy Directorate, the passing of the Renewable Energy Bill, and even an attempt to institute a rural electrification agency. Where formal constraints are internal, altering the institutional framework at some margin can be said to be relatively easier whereas preconditions set by international development agencies cannot to a large extent be influenced. Therefore among the external preconditions, in-country modifications are much more within control than those that are outside the jurisdiction of the government. North (idem.) also observed that an essential part of the institutional evolution entailed a restraining (shackling) of the arbitrary behaviour of the state over economic activity. Where the investor anticipates no protection, it is unattractive to invest no matter the opportunity presented. The supply side of DE has suffered this fate over the period. Even though it is well acknowledged in the developing world and for that matter Ghana that the private sector has a greater stake in the alternative energy sector, it is not attractive to the private sector because of the inadequacies of the formal institutional framework expected from the state. From the study, representatives of investor organisations such as the Association of Ghana Solar Industries (AGSI) often found itself in a state of disagreement with regulations passed concerning their operations such as regulation on taxes. Eventually, the profit oriented investors found it profitable to operate in the urban areas where cost could easily be passed unto consumers than in the rural areas that needed them most. Such situations have become supply barriers. Again, while the government appeared to be concerned about creating an enabling environment for the private sector involvement in the provision of energy, the arbitrary power of the state made this contradictory. There were too often ad-hoc government decisions concerning the extension of power to rural areas that threw renewable and decentralised energy investments and plans out of gear especially so when the investment in decentralised energy had often not been government funded. While this creates disinterest in alternative energy use by the target beneficiaries, they are also disillusioned as RE and DE then seemed as second-hand energy options.

Subsequently, it can be inferred that the following needs to be considered as necessary external preconditions for implementation and sustainability of DE systems: (i) the value network of the management institution – the management institution needs to be created specifically for the initiative, and the management institutions should be capacitated specifically for initiative and not thrown together with the needs of the bigger energy sector; (ii) the model of implementation for financial and business investors must create a win-win situation for the investors and the target beneficiaries; (iii) investors will also be attracted when the regulatory framework provides a protection against loses and when government interference is restrained; (iv) it is important the process of implementation factors the fact the international preconditions may not be possible to alter. Planning and implementation therefore will need to include some contingencies which can cushion unfavourable preconditions. A wider variety of external support options may be helpful.

8.4.2 Preconditions affecting household decision-making

At the household level, Christensen asserted that the basis of product choice often evolves from functionality to reliability, then to convenience and ultimately to price. From the empirical studies (Chapter 7.2.2), affordability often referred to as cost, was the most considered key consideration. Functionality (and feature) and reliability were often combined in the value consideration and came as the next issue after affordability. Thus the general question respondents asked was: "*how will it be better than what I am using now?".* Hence, while Christensen's conceptualisation may apply generally to disruptive technologies and small markets, in the particular case of rural markets, the dynamics are different.

Inferring from North (1990), energy decision-making like many an economic decision was found to be following procedural rationality other than instrumental. The parameters respondents gave as key considerations before making an energy decision, though converged at points of affordability, availability and accessibility, also had individual divergences. Individuals did not have perfect information to make decisions but different compelling reasons, which were examined under key considerations, to make energy decisions. In some cases, certain informal constraints and perceptions prevented the energy decision. This was particular so with cooking energy. Electrical energy appeared to have no match and had superior priority.

Again, North (idem.) indicates that institutions and standard constraints of economic theory determine the opportunities in a society. The economic laws persisting in the study communities and their Districts such as those defined by the microfinance institutions, and the economic state of the rural societies which were mainly agrarian societies with low incomes also shaped the choices and preferences of these societies. Financial organisations had incrementally evolved institutions that deter easy access to financial support. Farming households in Azaasi would not apply for loans because they were certain that they will not be granted, and because they were afraid that if the season failed and their farms were not able to meet production target, the law will have its grips on them. An economic institution had eventually evolved to become an informal constraint accepted among the local farmers. Consequently, their production remained at the barest subsistence level; they did not have enough disposal income to consider bringing grid lines to their homes from the main distribution lines in the communities let alone alternative and decentralised energy systems. Similarly, in the Brong Ahafo Region, the financial organisation will not give out individual loans unless the applications were backed by the collateral of salaries being paid through the bank. This was a very unlikely situation for farming communities visited.

The effect of the rural social systems on household decision-making was also assessed. The theory was used to help to identify the extent to which the rural social system affected household decision-making on decentralised energy. This was based on two rationales: rural communities are closely knit, and decentralised energy systems are unconventional. The theory was employed to help assess the extent to which the communality of rural systems served as a precondition for households' acceptance or rejection of these unconventional energy systems and the rural value systems that affected their decision-making. Empirical evidence showed that though rural values are embedded, generally, there were no communal values that interfered with household decision-making on energy. While values such as the use or non-use of cow dung were traditional and were the result of the "meanings" the cultural system attributed to it (Parsons, 1991), the reasons given for their non-consideration for energy development – that is, *"used as fertilisers"*, "*source of chicken feed"*, and *"used as building construction material"* - were relatively logical, and respondents did not have cheaper alternatives. In addition, household decisions were based on critical individual household assessment so that the final decision was a household decision and not one which has been forced on the household or which the household had been coerced into. To this effect, two individuals who were using solar home systems in Kumfia and Fakwesi both for personal household and commercial purposes, even though their communities were not ready to adopt solar home systems (SHS), and the communal system did not interfere with that. This is noteworthy particularly in the case of Kumfia where the ownership of the system was an 'ordinary' member of the community and not the traditional authority (in Fakwesi, the owner of the solar home system was a sub-chief ("Krontihene"))[56]; the same scenario replicated itself in the study communities in the Builsa and Kassena-Nankana East Districts where some individuals owned solar home systems even though the traditional authority did not. Thus, Parsons and Shils (2008:190) assert that even though the actions which constitute the social system are also the same actions which make up the personality system of the individual actors, the two systems are however analytically discrete entities despite this identity of their basic components. There was the extreme case of Kandema, where roofing houses with metallic sheets was prohibited by customs, beliefs, and supernatural attributions which therefore inhibited the adoption of solar home systems, so that as Parsons (1991) advanced, where we are is an important component of how we behave. There is the possibility that in the near future, these beliefs will be swallowed up by surrounding development and modernisation even as the two communities bordering it to the east and the west were already adopting the systems. As emphasised by North, values are not given and constant, but dynamic, following procedural rationality instead of instrumental rationality. What we see happening is that, unless the decision is against the welfare of the rural community itself, no interference is expected. That is the essence of the rural traditional institutions. It can also be inferred that that as actors interrelate with other actors, they interrelate within the expectations of the other party. Therefore, to some extent, these expectations influence their actions which though will not be visibly forced on the participating actors, has intrinsic influence on the party. Hence, knowledge of and decisions to adopt a new product could be influenced by the testimonies of market women in the Upper East Region. Again, even though generally, households indicated that their final decisions were independently made, about half of 40 in-depth interview respondents indicated that they needed to see an average of 1.8 persons of a certain respected category using the new system to convince them.

Moreover, modern energy use is a desired state by most rural households. The social systems rather helped to promote energy systems. The market and other such

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[56] The traditional authority is the custodian of cultural values, norms, and behaviour.

social gatherings were good sources of information. It may be said conclusively that values are more likely to cause a tilt in individual household decision-making.

In summary, the following preconditions affect household decision-making which may be necessary for an investor or a DE promotion initiative to acknowledge:

- Decision making follows procedural rationality and may not be predicted. Informal constraints such as socio-cultural meanings may affect expected decision making.
- Prevailing economic laws and environment could serve as opportunities or constraints to decision makers
- Word of mouth is an effective tool in promoting ideas and in the dissemination of information
- Household decision makers require practical demonstration to show the of workability of proposals

8.4.3 Preconditions from the energy system environment

In the rural energy system environment, certain informal institutions exist. North (1990:37) identifies informal constraints to be important sources of continuity in long-run societal change. However, informal constraints in economic exchange identified in woodfuel production had hindering effects on energy development, the rural environment, and the economic development of the rural economy. Perhaps, the contention in this case was that the human interaction within which these informal institutions persisted was between two different societies. Their common platform was economic exchange but the factors and motives which affected their exchange were disparate. The basis of exchange was meeting energy needs at the urban areas, but a more unbalanced business agenda overrode this basis of exchange. Lack of knowledge of the market on the one side (the rural woodfuel producers), and monopoly of the market on the other side (the urban traders), drew limitations on the extent to which exchange is unbiased. The injection to a certain degree of some formal constraints may be necessary to bring some level of equilibrium, to control a major externality, that is, the effect on the environment, and to be able to effectively draw a woodfuel consumption plan that will first meet rural energy needs, and then urban woodfuel needs. As North (1990) says, formal rules can complement and increase the effectiveness of informal constraints.

Formal constraints involving the role of organisations especially District Assemblies (DA) as agents of change especially where economic growth is desired for whole local economies were also identified. In all three study Districts, the DA was very rarely involved in energy development. Meanwhile, the energy issues of their political jurisdiction were affected by that of other Districts. For example, electricity supply in the Atebubu-Amantin District was controlled by a transformer in Techiman District, a neighbouring District which was not within the jurisdiction of the Atebubu-Amantin DA. In this case, if the Atebubu-Amantin DA had a local energy plan, the effect of the performance or rather, non-performance of the transformer on the District would be minimised.

The above discussion suggests that the following preconditions from the energy system environment need to be considered for the implementation and sustainability of decentralised energy systems:

- Knowledge of the energy market and its institutions is necessary to prevent biases and disequilibrium in a situation where an exogenous demand is a critical determinant of the sustainability of the rural market,
- A formal local institution responsible for the administration and supervision of the dynamics within the system environment, and
- Territoriality is important, since energy decisions of neighbouring Districts could influence the energy system of the District in question. Moreover, as posited by the endogenous development theory, administrative districts lying next to each could work together to complement each other's energy situation.

8.5 Conclusions – the main conceptual and theoretical convergences and divergences and why

Energy access development models

From the concepts of accessibility, availability and affordability as defined by energy development agencies, the study did not identify any departures. Even though the concepts were modelled for country-wide applications, the definitions were narrowed and applied to rural areas studied. Therefore the parameters were reduced to suit the rural context. At the theoretical review stage, the Author summarised that accessibility, availability, and affordability (the 3A's) are phenomenal in identifying alternatives to reduce energy poverty. At this stage, demand in the form of preference will be added to the three. This is deduced from the experience in the communities in the Upper East Region where biogas was not preferred, even though it could satisfy the 3A's. A relation between demand as a preference and affordability evolves, which must be established to make the 3As effective. Demand which was expressed as need plus affordability was assumed as substantive and expressed as a preference. From the study, without affordability, preference will be invalid as a measure of demand. From Prahalad's (2005) application of the 3As, the 3As also serve as important factors that should influence supply. Value and functionality which was also emphasised by Prahalad (2005) was also emphasised from the results of the study. By implication, the development of models for implementation should incorporate the 3As and the value parameter as well as the context specificity of the options under consideration. Modernity was also identified an important parameter for rural users.

The theoretical concepts of "dominant logic" and "value network" as submitted and explained by Prahalad (2005) and Christensen (1997) were confirmed with evidence from the field. A convergence with their explanations was demonstrated particularly in the relationship between the central government and the local government (the DAs) in addressing energy issues at the District and rural community levels. Christensen also asserted that the basis of product choice, that is, disruptive technologies, often evolves from functionality to reliability, then to convenience and ultimately to price. A divergence was recognised in the case of the rural market for disruptive technologies. In the dynamics of the rural market, the basis of product choice evolves from affordability (price) to functionality and reliability (combined in value consideration).

Institutional economics

From the theory of institutional economics, North (1990) identified informal constraints to be important sources of continuity in long-run societal change. A divergence is however registered when informal constraints identified in the rural energy system environment had hindering effects on both energy development and rural ecology, and has been the case over a long period of time. It is inferred that when informal constraints occur between two ideologically different societies, it could result in exploitation rather than in (a positive) long-run societal change.

In the initial conceptual framework, institutions considered were government policies and international preconditions. The study identified the District Assembly as an important agent of change apart from being a government instrument of policy implementation. Thus, a distinct recognition in the conceptual framework is necessary. Similarly, the availability of financial support is a corresponding necessity to ensure affordability from the demand side (and the supply side). Therefore, financial institutions should constitute an important component of the conceptual framework. North concludes that if institutions change, then values are bound to change as against the neo-classical assumption of instrumental rationality. Changing rural perceptions may also be influenced by changing rural institutions embedded in traditional institutions such as the traditional authority. It is for instance well acknowledged in recent times that when the chiefs and the elders of traditional communities are educated, their approaches to the development of their communities are different due to their exposure - they are up to date with changing development trends, and they can for example, lobby in the political sphere, among others. The same traditional rules and norms may be applied but differently. In some cases, they have been successful in ruling out practices that are deterrent to both the social and economic development of their communities. In some of the study communities, traditional leaders had issued and enforced laws against indiscriminate tree-cutting and charcoal production, distinguishing clearly between economic and non-economic trees. Such actions, for instance, would mean finding alternatives sources of energy. In the rural social system, the informal systems are so deeply embedded that this incremental change is rather slow. Perhaps that is what North meant by incremental, with no timelines set. However, in recent times, this has picked up some amount of speed with education and exposure. With regards to energy supply, many rural folks have relatives in urban communities who are exposed to the benefits of modern energy. They either return narrating their experiences or the village folk have the opportunity of utilising this multi-locational housing arrangement to experience the benefits of modern energy themselves. Moreover, through the SHEP programme, village communities have seen other village communities benefiting from the national grid connection. Along with this exposure is the desire of the rural folks for appliance and technological upgrade.

Rural social system

The rural social system and its theory were found to be of relevance in the study. Parsons and Shils (2008) asserted that, even though the actions which constitute the social systems are the same actions which make up the personality system, the two systems are analytically discrete entities. A convergence with empirical research was found where individual households took final decisions on the energy situations without interference from the communal system except where these decisions had adverse implications on the rest of the community. The communality of the rural social system was also evident, where societal meanings played an important role in what resources could be used for what purposes, for instance, in the case of using cow dung for the production of biogas. Again, societal values have evolved to embracing modernity so that the social system supported the adoption of modernity rather than preventing it.

Economic growth and development

It is deduced from the economic growth theory that decentralised energy can act as technological progress both as labour or capital-saving and labour or capital augmenting, and also as a consumer good. As an agent of endogenous development and economic growth, decentralised energy as a catalyst will be effective when applied to specific and respective economic development potentials of targeted developing areas, that is, when the productive use application is emphasised in addition to its use a consumer good. The endogenous development framework suggests that the development of any given economy should look at starting from within. The decentralised energy phenomenon confirms this: through empirical study, it emerges as effective when potentials for developing decentralised energy systems are context specific and based on the resource potentials of the spatial context. However, as asserted by Ocloo (2011), endogenous does not necessarily mean 'indigenous'. A key characteristic of endogenous development is linkage with other communities, the intensity of which can promote economic growth. Therefore, where local potentials are inadequate to produce decentralised systems, importation of resources should not be precluded. This can serve as a new avenue for productivity and an employment opportunity for those engaged.

Modification of the study conceptual framework

Based on the synthesis and theoretical reflections, the initial conceptual framework that guided the study will be modified in the diagram shown in Figure 8-1. The new inputs are:

- At the energy demand decision-making stage, the effect of the rural social system is made more specific. Decision-making is based on procedural rationality, meanings within the socio-cultural context where the decision is to be made, the personalised meanings of the individual decision maker (household), and the prevailing local economic laws.

- Even though there are other competing needs and other household priorities, energy demand decision can be favoured when the local financial support system is favourable.
- The existence of an energy policy development framework of the District Assembly (DA) is an important factor. It defines the DA's level of interest in energy development, causes the DA to take local initiatives, attracts private investments, increases the interest of local financial institutions in the decentralised energy business, and causes the DA to lobby for assistance where necessary.

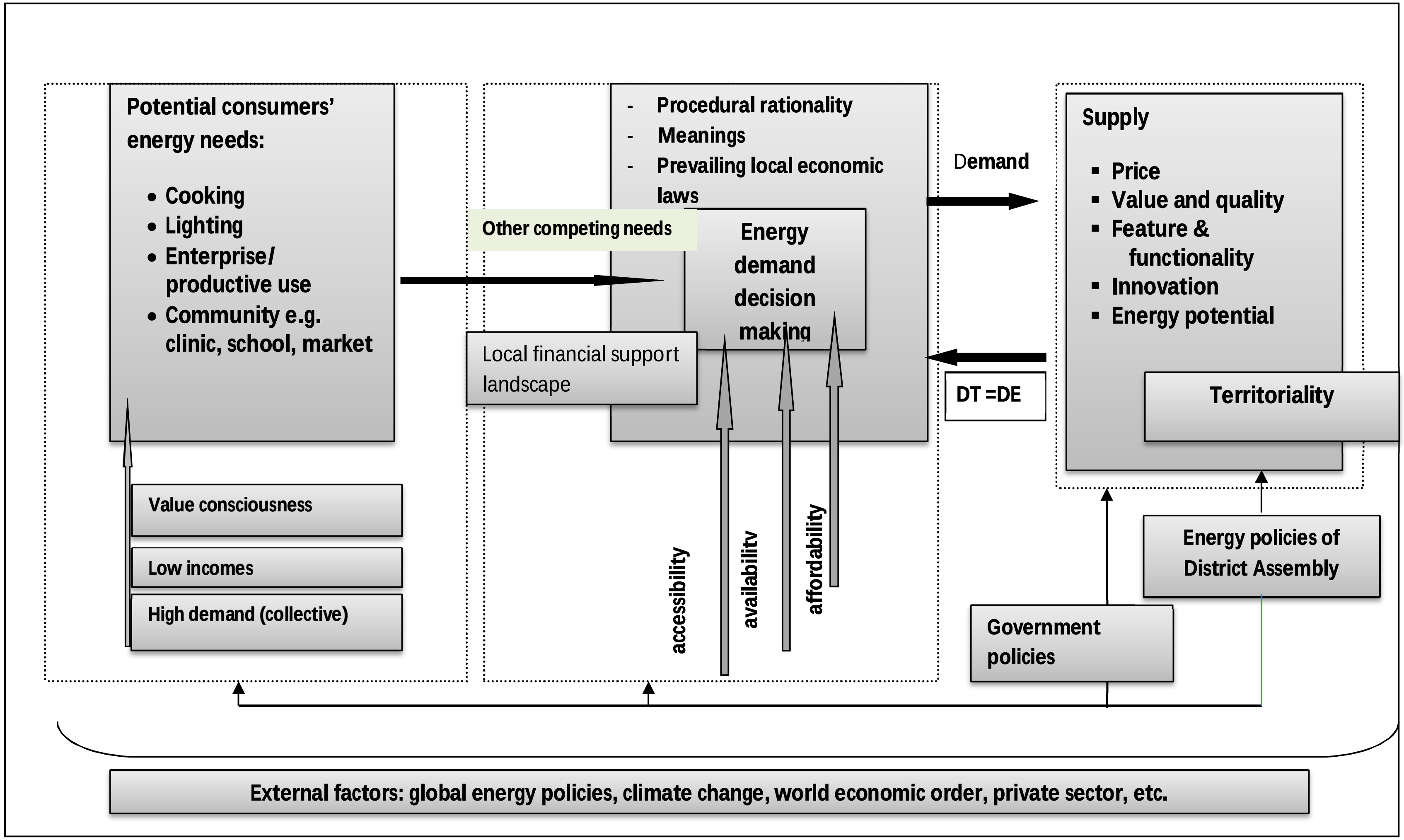

Figure 8-1: A modification of conceptual framework
Author's construct

Legend to the conceptual framework (Figure 8-1)

Symbol	Meaning
Thick grey shaded arrow	A characteristic
Thick black shaded arrow	An input or result
Thin connecting lines and arrows	Linkage
Dotted boarder lines	Boarders of specific frames

9 CONCLUSION AND RECOMMENDATIONS

9.1 Summary of key findings

The study identified a number of issues which are important to consider to enhance access to energy within the communities studied. The following summarises the existing situation:

- *Household energy needs and how they are being met*
  - The energy needs of cooking, lighting, appliance, and economic activity were unmet or inadequately serviced.
  - The proportion of economic activities identified which depended on energy was insignificant: the agricultural sector was the dominant sector and depended more on human power and energy in the non-technicalised state such as sunshine and wind. In the study communities in Builsa and Kassena-Nankana East Districts (Upper East Region), agriculture was rain-fed and purely subsistence. However, in the Atebubu-Amantin District (Brong Ahafo Region), it was in addition a business activity. Even though it was also rain-fed in both situations, the weather conditions in the Atebubu-Amantin District were more favourable. Again in the study communities in Builsa and Kassena-Nankana East Districts, the respondents identified few enterprise development options apart from farming, and could not anticipate how energy could impact the agricultural enterprise. However, the communities in the Atebubu-Amantin District were highly enthusiastic and identified enterprise options they wished to be engaged in, including agriculture that could be promoted with access to reliable and modern energy.

- *Available options for decentralised energy development*
  - The most prevalent energy resources identified for developing decentralised options were solar and wood. Other resources such as cow dung (biogas) and rice husks (briquettes) in the Upper East Region, and water in the Brong Ahafo Region were either inadequate, did not meet technical requirements, or had socio-cultural restrictions.

- *Preconditions necessary for implementation and sustainability of decentralised energy systems*
  - There was extreme inability to pay among communities studied particularly those in the Upper East Region.
  - Energy had a middle place priority among other household needs.
  - The financial landscape for credit mobilisation was generally unfavourable. The communities had little option for financial support, and were also hesitant to apply for financial assistance from the financial institutions.
  - Productive uses of energy (PUE) were not prioritised for decentralised energy supply.
  - The District Assemblies did not have strong mandate over their energy situations. They were not largely involved in negotiations and lobbying.
  - The role of the central government overshadowed the role of the local government in energy provision, evident from the implementation of the

National Electrification Scheme (NES), the Self-Help Electrification Programme (SHEP), and the Ghana Energy Development and Access Project (GEDAP).

- The District Assemblies were either not adequately technically capacitated in the promotion of decentralised energy or had little interest in it.
- There was not a single department specifically responsible for energy but a number of district departments which were robbed in an ad hoc manner. Addressing energy at the rural level was affected by a number of district departments.
- Technical backstopping was not sufficiently prioritised in the implementation plans of decentralised energy projects.
- The private sector felt side-lined in the formulation of policy decisions that affected them.

9.2 Conclusion

This research was based on the assumption that local energy resources have spatial locational advantages and therefore are easy to access, cheaper to produce and may provide the opportunity for 'technological leapfrogging' to address the energy poverty problem. Decentralised options have been identified as the option for energy supply for remote communities such as the ones studied where investment is costly and yet returns are scattered and unattractive to utility service providers because of the scattered and remote nature of communities. Three key phenomena were recognised as fundamental to improving energy access; these were accessibility, availability, and affordability. Improving energy access involves dynamics that cut across resource availability within the target communities, regulatory frameworks both at the local and national levels, finance, supply chain, and community expectations. It may be concluded that promoting decentralised options may not necessarily require the identification of new resources based on the premise that the alternative energy resource base has not changed since research on that began. Innovation should however come in the form of new business models and approaches to solving the energy access issue. Again, the hybrid approach to energy supply is recommended. On the basis of the Renewable Energy Bill, off-grid electrification is expected to complement on-grid electrification. Based on the fact that power supply is inefficient and insufficient, a system where the rural communities are more dependent on off-grid electrification is recommended. In the case of impact of energy on livelihood development, two sets of conclusions may be drawn. Even though energy access alone is not a guarantee to improved livelihoods, it is a major and fundamental step to diversifying the rural economy and improving upon the productive abilities of the existing enterprises particularly, agriculture. On the other hand, for communities such as those studied in the Upper East Region, without identifying specific enterprises for development, energy access may do little to improve the economic growth of the communities, and similar ineffectiveness of grid extension on productivity which was reported by the Energy Commission (2012) could result.

9.3 Recommendations

9.3.1 The energy future scenario for the communities studied

It is envisaged that in ten to twenty years[57], the energy situation in the communities is improved to reflect the following:

Pattern of energy supply

- Electrical energy is provided using the hybrid model, from both on-grid and off-grid sources. Solar energy will be developed optimally for off-grid stand-alone home systems and mini-grid electrification. All communities studied will be lighted and will no longer be in darkness. Movement at night and at dawn will be clearer and safer. Fakwesi and Kumfia both in the Atebubu-Amantin District, have more vibrant weekly markets. Traders can arrive at the centres the night before the actual market days. Communities which are closer to the national grid will be connected on-grid while the remote communities are connected off-grid.
- Cooking energy is provided through woodlots purposely created to serve the biomass energy needs of the communities. In addition, the study communities in the Upper East Region are involved in the production of rice husk briquettes to serve households and also as a form of employment for the communities. It is also envisaged that households use improved and movable firewood cookstoves which burn efficiently, and more than 50 percent of households especially in the communities in the Atebubu-Amantin District and sandcrete houses in the communities in the Builsa and Kassena-Nankana East Districts use LPG for cooking and commercial activities such as food vending.
- Household water supply is provided through solar water pumping in the study communities in Atebubu-Amantin District.

Increase in productive use of energy

The economic development base for rural development may depend primarily on small-farmer agricultural progress and it includes among others, efforts to raise farm and non-farm rural incomes, job creation, rural industrialisation, and other non-farm opportunities (Todaro and Smith, 2011). It is envisioned that:

- Closely linked the hybrid approach to electrical energy provision suggested above, an economic enclave around a set of on-grid and off-grid communities is created. An industrial-commercial hub is created within the on-grid communities which serves the enclave. The off-grid connected communities have smaller commercial facilities such as kiosks and convenient shops which serve the immediate needs of the communities
- Agriculture and agricultural processing is enhanced - in the communities in Upper East Region, it is envisaged that farming households employ more of animal traction resulting in increased agricultural productivity. Irrigation agriculture through solar water pumping from the extensive drainage system is the farming practice and therefore dry season farming is possible. Farming

[57] Ten years for off-grid and on-grid electrification, and twenty years for long term result project such as woodlot development

progresses beyond the current purely subsistence farming, to farming as a planned economic activity. Consequently, farmers earn more than they do currently and are able to plan the future. There is increased application of animal traction in the communities in the Upper East as an 'appropriate mechanical energy' to boost for soil fertility and consequently increase productivity, given that the cultivable lands in these areas have thin top soil (as against the use of tractors which rather destroys such soil).

- Value is added to agricultural produce. In the communities in the Atebubu-Amantin District, activities such as cassava processing using the MFP continues and are up-scaled. The MFP and other similar inventions have multiple processing units such as sharpeners, dehuskers, water pumping component and a battery charging unit. Investors are attracted to set up vegetable preservation industries for vegetables such as tomatoes, pepper, and okra. Solar driers are engaged for drying maize, one of the main produce of the communities, which is then properly stored to prevent falling food prices which accompany bumper harvest. In addition, farmer cooperatives are vibrant in setting up farm-gate prices.
  In the Builsa and Kassena-Nankana East Districts, diesel (fossil and bio) engine grinding mills are located in the communities and household food processing is made easier. There will be grid connected grinding mills in the economic claves proposed. Communities do not have to travel to the District capitals to process food for their households. The shea butter and "dawadawa" (soumbola balls) industries of the women are vibrant because the mills provide the grinding facility, the firewood cookstoves burn more efficiently, and the overall processing time is reduced by about one-third.
- Commerce and service are vibrant - the fishing industry and marketing are boosted in the communities in the Atebubu-Amantin District through the operation of cold stores. In addition, other cold food products are supplied.

Earning from the supply of energy

- In the study communities in the Atebubu-Amantin District, charcoal production is vibrant, controlled, and carried out more efficiently. The wood is harvested from lots designated for charcoal. Portable metal kilns are used instead of the traditional earth kiln to improve efficiency, and also to be able to easily move the kilns along as the producers move from one site to the other.
- In the communities in the Upper East Region, production of rice husk briquettes is taken up also as an economic activity.

Energy development, organisation and management

On the administrative front, the District Assembly is keenly involved in the energy development of the District and plays a more facilitating role in government initiatives, collaborates more effectively with the private sectors, and takes a leading role in finding energy investors for the District as a whole.

To be able to reach the vision discussed and determine appropriate recommendations, the issues summarised in section 9.1 above have been identified under three broad themes – regulatory framework, finance, and maintenance and sustainability – and are grouped as short-term and long-term. Recommendations are made to that effect. Short-term recommendations are expected to be achieved within one to five years and will serve as leverage for the long-term recommendations.

9.3.2 Long term recommendations

i. Regulatory framework

Policy is fundamental to the development and promotion of decentralised energy (DE) and improved energy access. The regulations drawn by the central government provide the framework that guides implementation by the local government. A sound regulatory framework set the enabling environment for private sector investment and affects the other themes. In the long term, the following regulatory adjustments are proposed.

a. Decentralising the energy system (medium term to long term)

From the stakeholder analysis, it can be concluded that the District Assemblies (DAs) do not have strong mandates over their energy situations as the local authority overseeing the development affairs of their districts. The study showed that the energy system is managed by the central government. Policies on energy are not formed district-wise but are handed down from the central government to the local governments. The local governments manage implementation. The result has been the imposition of the dominant logic of central management on local governments so that for example, with the NES, the local governments were only to choose the communities while the central government organised everything including engaging contractors. Consequently, the three districts studied did not have well laid out energy plans. This is a contradiction in the local government (decentralisation) system which the country practices. It is recommended that the central government cedes power to the DAs in this regard. The prevailing local system of government could serve as leverage for decentralising the energy system. It is further proposed that the DAs team up with neighbouring DAs to be able to raise the capital needed to execute energy projects both as internally generated capital and from external sources. Already, the Atebubu-Amantin District and two neighbouring Districts relied on one sub-station for power supply to their districts. This culminated in frequent power rationing because the load on the transformer was much higher than the capacity of the transformer. However the operation of the transformer was under the management of the national utility agency - the Northern Electrification Distribution Company (NEDCo). With a decentralised system of energy management, the two or three local district administrations could team up resources to undertake and manage energy projects. Decentralising the system will promote effective lobbying for the necessary energy investment, innovativeness and keen participation at the local government level. From the empirical study, the district officials did not appear to be much interested in energy issues over which they had no authority. Moreover, the resulting energy projects will be districts-enclave specific and not simply wholesale energy projects which have been handed down and which may not work. The districts' ownership of the projects will also be promoted as communities within the districts will identify themselves with and will be responsible for projects they have contributed to. The Districts will tend to be self-reliant and able to take its own decisions and develop. The

Districts will also tend to be responsible for managing its own energy system environment.

b. Institutional development and capacity building

The District Assemblies should undertake capacity development of its staff. A district department responsible for energy development should be created by the District Administration with well trained personnel who are able to handle the energy development from lobbying, to collaborative efforts with potential investors, and to ensuring apt and well executed implementation.

i. Energy development and finance

In the long run, energy development and supply should be wholistic, addressing all facets of energy access identified, that is, household comprising access to energy for both lighting and cooking; community energy access which ensures energy for community services; and energy for productive uses. In terms of finance, both the central government and the local governments should create the opportunities to improve financial access to energy options for the poor rural communities in a win-win-win situation for the private investors, the rural beneficiaries, and the government's social and developmental goals.

ii. Maintenance and sustainability

A system of maintaining decentralised energy projects in order to sustain them must be incorporated into energy development programmes and project by both the central government and the local governments.

9.3.3 Short-term recommendations

i. Regulatory framework

a. *Decentralising the energy system*

<u>*Policy framework*</u>

Rural energy provision has over the years concentrated on grid extension according to the National Electrification Scheme (NES), with adhoc considerations for off-grid electrification. The Renewable Energy Bill has recently been passed. The content of the Bill stipulates a ten percent renewable energy component in the country's energy mix. This policy framework provides a basis for the Districts studied to step up and engage the private sector and development organisations to provide alternative energy. This will be particularly expedient for the Builsa and Kassena-Nankana East Districts which falls within the lowest solar diffusion zone in the country. The DAs will need to capitalise on the Bill in their respective medium term development plans, and set clearly their policies on the complementary roles of on-grid and off-grid electrification, as well as policies on the kind of suppliers. During the field study, one key informant in renewal energy supply industry indicated an intention of building a community solar off-grid electrification system, and a community petroleum gas distribution depot on the build-operate-transfer (BOT) business model but needed a confirmation on the kind of agreement with the local authority. Thus it will be expedient for the districts to clearly indicate whether suppliers will be independent power producers (IPP), or (as in the case of majority of suppliers identified in the study districts) importers of energy appliances and equipment. Kemausuor et al. (undated) following from a study has proposed the cost and various tariff rates for the various off-grid electrification technology options. It is recommended that the Ministry of Energy and specifically the Renewable Energy Directorate, the Energy Commission as well as the Public Utility and Regulatory Committee cross-examine these rates and institutionalise them as the national rates for off-grid electrification. It will provide a tariff framework within which private off-grid investors at the district level and in the rural communities will operate, and also prevent investors from exploiting the rural consumers.

In the past, the idea of Rural Electrification Agency was suggested to the Ministry of Energy to manage rural energy. The idea was not applauded due to the bureaucracies involved in setting up the agency (Refer Chapter 4.4.2). Currently, a Renewable Energy Directorate has been instituted. It is recommended that the Ministry of Energy merges the idea of Rural Electrification Agency and the Renewable Energy Directorate to address energy development at the rural level. Even though the development of the renewable energy sector does not only target the rural areas, most of the current activities of the Directorate are targeted at the rural areas. A corresponding department or agency is suggested therefore to be created by the Renewable Directorate at the DA level which will be represented on the energy committee suggested above. The DA could either separate alternative energy from the roles of the District Sub-committee on Works to this agency or create a sub-sub-committee within the Works Sub-committee that is solely responsible for the development of renewable energy as well as other decentralised energy options.

Furthermore, at both the local and central government levels, the Ministry of Energy and the Energy Commission, and the corresponding energy committee at the District Assembly must involve all stakeholders in the formulation of policies, especially the private sector which has been the forerunner in the promotion of alternative energy. The private sector indicated being side-lined in the formulation of policies that affected them. The DA could engage the private sector in strategic partnerships in energy investment. The private sector is also encouraged to collaborate and press for the lifting of shared regulatory restrictions.

Energy development priorities

Throughout the study from reviewed literature to empirical data gathered from the field, improvement in energy access was viewed more often than not as access to electricity. This may be attributed to the myriad of applications of electricity to household energy needs. However some of major health concerns related to poor access to energy as well as the daunting environmental deterioration are to a larger extent linked to the poor access to cooking fuels. The Ministry of Energy should review government policy on cooking fuels to ensure that it is clear and rightly targeted. At the district level, re-afforestation and the development of woodlots require more pragmatism and action; that policy decision should evolve from being just a forestry concern to being on a larger scale, a critical energy access improvement concern of the District. The energy committee should incorporate this into the District's energy policy framework and ensure implementation by the forestry department.

Dissociate energy production from distribution

The central government and for that matter the Ministry of Energy should dissociate energy production from distribution. The key issue here is to enable suppliers to operate economically and to achieve efficiency gains. Energy is a public good and all persons have the right to it as a basic need. However, it cannot continue to be supplied on social grounds; supply needs to be efficient and be sustained. The Central Government through policy should separate the commercial from the social aspects of energy supply by preventing interference in the commercial and economic component. Producers should not be pushed to sell below cost of production as is the case when the commercialisation is mixed with the social goals of redistribution of government, to prevent them from operating below expectation or folding up in a few years. Alternative measures to ensure redistribution such as tariff and other forms of subsidies can be put in place to ensure redistribution. This policy will be important for independent power producers (IPP) who intend community-wide off-grid power supply for the rural areas, and eventually, for the centralised power supply system through the grid.

Energy supply and economic productivity

To boost the economic productivity of the remote and rural communities such the ones studied, the Ministry of Energy and its Renewable Energy Directorate should consider a government policy that makes the rural areas more dependent on off-grid electrification when it is possible. It is suggested that as part of government policy and business plan of the District Assemblies, the District Assemblies create economic enclaves around sets of communities such that the economic or industrial hub of an enclave is specifically located within the community which is close to the national grid. The economic activities of this enclave and economic interactions will be within this hub. The extension of on-grid electrification will target just the industrial centre, while the rest of the community as well as the other communities within the enclave depend on off-grid electrification to satisfy other domestic and community energy needs. This could be a starting point so that as the enclave gets more and more vibrant and the communities are in a better economic position to be able to pay, on-grid electrification can be extended to the other parts of the enclave, or the off-grid can be upgraded and expanded to absorb lower economic activities (if the demand per community is enough to sustain them).

It is also important for both the local governments, that is, the District Assemblies, and the central government to recognise the importance of agricultural development to rural economic productivity. This is true for all communities studied. In Upper East Region, the communities must move beyond subsistence living. Less direct productive investment such as irrigations systems raises the productivity per unit of land. By implication, if an energy input can enable irrigation, then the energy input cannot be ignored. In the Atebubu-Amantin District, wastage and falling prices can be prevented with agricultural processing. It is therefore recommended that both the DA and central government consider the energy development component as necessary component in agricultural development plans.

b. Institutional development and capacity building

Capacity development and role casting

The involvement of the DAs in the management of local energy is elemental to improving energy access. The DA needs to engineer pragmatism and competence in district management of energy. Empirical evidence showed a lax attitude of district officials towards energy development. Through collaboration with capacity training experts such as the European Union (EU), the DA could receive external assistance on capacity training and developing new approaches towards promoting energy access. In order to assess the effectiveness of the training, a pilot phase can be implemented under the oversight of the sponsor. In the process of managing the pilot phase, capacity can be sharpened and improved before a scale up.

In addition, the responsibility for promoting decentralised and renewable energy at the district level is not assigned. Various departments and agencies are dragged into the energy management system as and when it becomes necessary. For example, forestry, water and sanitation, and environment district departments are all related to energy and contribute in an ad hoc manner when required. This unstructured nature of managing the decentralised and renewable energy system leaves a regulatory gap and promotes abuse by foreign investors. It is recommended that the District Assemblies form an energy committee with representation from each of these departments with clear roles and responsibilities, and also require that the departments incorporate energy access objectives into their respective departmental policy frameworks. The committee will be in charge of district-private sector cooperation and any cooperation or partnership of such manner. The committee will also collaborate with the District offices of the utility agencies. It will also facilitate the selection of communities and the determination of project locations. More importantly, the development frameworks of the DAs, i.e. the Medium Term Development Plans, should contain a chapter on energy. This chapter should outline the respective District's specific energy focus and specific policy strategies and implementable action plans which will serve as a guide to investors. It will be the responsibility of the energy committee to ensure adherence to this energy development framework of the District. It is further recommended that the Ministry of Local Government and Rural Development leads the replication of the same committee at the central government level where an inter-ministerial energy committee composed of the Ministries of Energy, Environment and Science, Local Government and Rural Development, Lands, Forestry and Mines, and Food and Agriculture is formed. This committee will be necessary to prevent a disjointed approach to energy development handed down from the mother-Ministries, and to provide an oversight authority to whom the committee at the District level could report to.

Interactions within the energy system environment

The woodfuel industry is highly unregulated. The basis of exchange appears as meeting energy needs of the urban areas, but a more business agenda overrides this basis of exchange. Lack of the knowledge of the market on the one side (the rural producers) and monopoly of the market on the other side (the middlemen and women who buy on wholesale) results in inequitable scales of exchange. It is recommended that the District Assemblies which are the governing authorities inject some formal constraints necessary to bring some level of equilibrium, to control the effect of woodfuel production on the environment, and to be able to effectively formulate a woodfuel consumption plan that will meet first rural energy needs, and then urban woodfuel needs. Drawing from Douglass North (1991), formal rules can complement and increase the effectiveness of informal constraints. The suggested regulation at the origin must however be met with regulation at product destination in the urban centres – a general regulation that sets price ceilings - to prevent traders from passing on their (equitable) cost to urban consumers, to maintain the balance required. Hence, even though market prices are determined by the market forces and are not influenced by the government, it may be necessary in this case for some level of regulation just as it is with the fossil fuels (even though the fossils are deregulated, prices oscillate within a certain range). It should therefore be a central government policy directive for all Metropolitan, Municipal and District Assemblies (MMDAs) to set price ceilings of woodfuel products particularly charcoal, to ensure this restriction is adhered to by the market. This should be controlled by finance and administration sub-committee of the MMDAs. In addition to that, the rural producers are encouraged to organise themselves into cooperatives to give them leverage and a stronger bargaining power.

ii. Energy development and finance

a. Subsidisation and cross-subsidisation

Affordability remains one of the key issues that should be arrested in order to improve access to energy for poor rural communities. Even when physical accessibility is possible, affordability is a determinant of energy access. In addition, the financial landscape of the communities do not support low income credit schemes. Financial institutions have become weary of defaulted payments and have therefore limited non-commercial loans as well as commercial loans for small-scale rural farmers. This situation has gradually become an informal constraint of no-credit for low income earners. In that regard, a household in Azaasi, a community in the Kassena-Nankana East District remarked that they would not risk applying for a loan from the banks even if the loan was available because if the rains failed and they were unable to repay, they would go to jail. Again, it is generally known that rural households will prefer being connected to the conventional grid than off-grid electricity. Evidence from the empirical research showed that in a few communities where the grid was available, households were unable to connect due to financial constraints. In others, that is, Azaasi and Akudugu-Daboo, where the grid lines had been extended into the community, households would not extend the service to their houses due to the cost involved. The question remains that if the households could not find alternative financial means to connect to the grid, why would they consider a decentralised system? The issue of alternative financing becomes important. Conventionally, subsidy is a fiscal instrument used by governments to promote affordability among low income groups. Subsidy promotes effective demand. It is recommended that the energy committee in collaboration with the District Assembly's Information Service (and investors) do both extensive and intensive education so that the rural communities become aware of the subsidy packages which are available to them such that subsidies affect the targeted population and are not eventually enjoyed by the rich, which happens in most cases.

Also, cross-subsidising energy involves policy arrangement that engages the urban households to bear part of the cost intended for the rural households. As a government policy, the subsidy component can be built into the price of other forms of energy highly consumed by urban users or consumed by both, so that both urban and rural consumers who are able to pay may support those unable to pay. Therefore, the National Petroleum Authority should include a subsidy component in the prices of other petroleum products and commercial LPG (which may be determined by the volume of the cylinder), excluding domestic LPG which is being promoted; the electricity companies should also have a subsidy component in the electricity tariffs for tariff bands above the 50Kwh lifeline tariff band. The principle should be based on numbers and proportions so that given the broad denominator, the effect of paying the subsidies on the consumers will not be onerous; proportions will ensure that rural consumers who are able to pay will not be over-burdened.

b. Output-based schemes

Ghana has tried both the fee-for-service and output-based schemes in energy financing for the low income rural population. Although it is early to assess the GEDAP, the output-based implementation scheme which was adopted has been comparatively more successful and has accelerated service delivery over a wide coverage as against fee-for-service schemes previously tried in the country. It is recommended that both the District Assemblies and the Central Government continue to employ this scheme for other energy projects but must be context specific, adapting it to the requirements of the project. The scheme is also recommended to private investors and financial institutions as an implementation strategy in implementing district energy projects. It also recommended that the scheme is applied in the promotion of improved cookstoves. In the rural communities, the idea of improved charcoal stoves did not seem attractive because of the initial cost involved in the purchase of cookstoves and recurrent cost of charcoal. Further research by both government and private research institutions on alternative efficient cookstoves is lauded. The initiative by the Centre for Scientific Research (CSIR) (see Chapter 4.4.3) on improved firewood needs further and extensive dissemination to remote communities. The CSIR should also take up the responsibility of organising training programmes that trains local people to build these stoves which could kick-start set a system of replication through the communities.

c. Farmer cooperatives

To present a stronger credit front, it is recommended that the farming households form farmer cooperatives. Based on the cooperative principle, the farmers can support each other to apply for credit for individual energy investments.

d. Productive uses of energy (PUE) (short – long term)

Related to this, PUEs must be an important component of energy programmes and projects. With regards to rural on-grid electrification, the productivity that was anticipated to characterise electrification has not been achieved (Energy Commission, 2012). In the supply of energy using the DE, it is easy to concentrate on social aspect of community development but DE options must also bring economic productivity. Without such growth, the local economies do not emerge out of poverty. It should be part of the District Assemblies' energy development and poverty reduction policies to identify productive activities that could be spurred with energy. Potential investors in collaboration with the suggested energy committee of the DA, or the energy committee (if the project is purely internally funded) may identify specific households who are interested in improving their energy situation and attach productive use of energy as a necessary component of the package. The same is recommended for community level energy projects. From the concept of endogenous development, it is inferred that the economic functions of DE options can only be realised when it targets specifically the economic opportunities of the community. Therefore to ensure ownership and keen participation, communities should be involved in economic activity identification. For instance farming households in the study communities in Builsa and Kassena-Nankana East Districts (see Chapter 9.1 above) should be allowed to identify feasible off-farm activities themselves.

Generally, from the study, energy had a middle place priority among other household needs. The creation of awareness on DE must go beyond simply advertising the DE to hammering the value it brings particularly with regards to productivity. In the case of the rural communities studied and similar other rural communities where agriculture is the stronghold of the economies, the value addition of energy to the various stages of agriculture and agricultural productivity must be strongly emphasis. This activity must be vigorous and vibrant enough to make an economic principle simple and driven home to the rational rural households. The DA should undertake this education through its Business Advisory Centres (BAC)[58], first within the district administration itself; then in conjunction with the Unit Committees of the various localities, the traditional authorities of the communities and the leaders of community-based organisation can be trained, who in turn can engage the communities intensely in this education. The local financial institutions which will provide credit must also be involved.

e. Supply side financing

Supply side financing is also important for local innovators and investors. A finance policy on guarantee credit administered either by financial institutions backed by government policy or by the central government itself on behalf of the Ministry of Energy could stimulate private energy investors' interest especially in uneconomic zones such as the remote rural areas. Again, the Community Development Carbon Fund (CDCF) could be an option. The CDCF, a public-private initiative administered by the World Bank aims to contribute to a more equitable regional distribution of carbon finance resources, as a pro-poor countries and poor communities' component of the carbon finance. As part of its poverty reduction scheme, the CDCF purchase emissions reductions from small-scale projects in the same way the Clean Development Mechanism (CDM) projects earn credits. Promoting rural access to energy in remote and poor communities falls under such projects considered by the fund. This funding opportunity has not been well utilised in the country. Both local investors and the District Assemblies could tap into this financial resource. In addition, the Central Government through the Ministry of Energy and the District Assemblies could reward private sector investment in decentralised energy systems in the rural areas using specific rural energy investment tax rebates.

f. Financial institutions (point of leverage)

An assessment of the financial landscape showed one which is hesitant to offer credit for individual household energy initiatives. The financial institutions had little interest

[58] The BAC is the district department of the National Board for Small Scale Industries

in energy and in most of the cases did not have specific policy on energy, while external investors - both private investors and development agencies - involved the financial institutions quite late in their project schedules. It is also evident that the rural economic landscape needs the support of the financial institutions to enable households to access credit. Moreover, it will be comparatively easier for local financial institutions to demand repayment from households since they interact on daily basis. The District Assemblies and investors are encouraged to involve the local finance institutions in their energy plans. Again financial institutions are encouraged to adopt the Grameen group-based credit approach. The group loan system is the strength of the scheme, where group pressure ensures individual borrowers honour their repayment obligations. This loan system can be operated in connection with the farmer cooperatives to reduce to risk involved in granting individual farmer loans. Furthermore, it is recommended that financial institutions grant longer term loans, for example for three years, instead of short term loans that lasts only a year or a farming season. This may help ease the repayment burden on farmers.

iii. Maintenance and sustainability - maintenance contract

Maintenance contract involves a written and paid contract by the government to implementing agencies to ensure the maintenance of energy projects. More often than not, the implementation of the projects is prioritised over their sustainability. Decentralised options often constitute new or improved technology which is beyond the local technical knowledge of the rural communities. Product and project maintenance subsequently rely on external expertise, which often delays. This is often so because the private sector which is normally engaged as project implementation agents or distributors is profit and business-oriented and will not expend extra on maintenance or after-sale-service without a maintenance contract. In the medium term however, the training of local expertise will be important to improve efficiency in accessing technical support. This capacity building initiative must be part of project management which should be scheduled in the early phase of project implementation by all categories of investors and implementation agencies. Selection of competent and reliable trainees can be undertaken in consultation with Assemblymen, opinion leaders and the traditional authorities. Trainees must be under a socio-cultural bond and in a position to retrain others such that the communities and districts eventually have a reliable base of technical expertise. The bond is necessary because the communities studied indicated that the few technical experts in the communities had left their communities to work in the towns since their expertise was more needed in the towns than in the villages.

9.3.4 Suggested DE systems

The study attempted to identify decentralised energy resources and possible decentralised energy options. In the identification of options, it will be necessary that suppliers combine what works with affordability without compromising quality. As suggested by Prahalad (2005) and Christensen (1997), for such markets, it is recommended that investors identify the services the people demand, in the form they want them, and at the price they are willing and able to pay. In the past, solar photovoltaics had been expensive and the cost deterrent for consumption. Over the years, the cost has fallen drastically and solar home systems are available and even affordable to some households in the rural communities. Along the rural income continuum, a range of solar systems could be made available to meet the needs along the continuum. A similar logic can be applied with community off-grid projects, where individual households' consumption is customised to households' level of affordability using the points system of energy consumption.

In the study communities in Upper East Region, the most available energy resource identified was solar which is not optimally being exploited. The possibility of the production of biogas and briquettes could not be fully ascertained due to socio-cultural inhibitions and inadequate resource availability. On the other hand, the study communities in the Brong Ahafo Region fell within the moderately high solar diffusion zone; yet two households were identified in two communities who were providing commercial solar energy services using solar home systems. It is recommended for both private investment and District Assembly-led investments that the provision of energy for the communities employs the hybrid model where more than one energy resource is available and feasible. For example, the communities in the Brong Ahafo Region had previously been earmarked for grid electrification. The Atebubu-Amantin District however experienced frequent power outages due to the load on the power station that served the District and two other neighbouring districts. By implication, any further on-grid electrification in the District is likely to worsen the power supply situation. A hybrid system will offer the communities the opportunity of having alternative sources of energy, and a greater balance and efficiency in the energy supply system. Ultimately, it will reduce the load on the grid electricity system.

In the case of cooking energy, it is widely acknowledged that biomass will remain with developing countries for a long while in the future. In the short term, it is suggested that the improved three-stone fireplace which has improved efficiency in combustion and has been experimented by the Council for Industrial and Scientific Research – Institute of Industrial Research (CSIR-IIR), should be extensively promoted. It is also recommended that the CSIR modifies this model to make the earthen stove movable. This will prevent it from being utilised in less ventilated kitchens and also prevent it from being washed away in the rain in the event that it is built outside.

In addition, it is recommended that the government and for that matter the National Petroleum Agency, by policy extends the current LPG promotion programme which adopts the bottle recirculating model intended for the urban poor, to the rural areas. The cross-subsidisation instrument being used should be maintained. However, there is the need for the Agency to firmly operationalise the legislative instrument (LI1592) that restricts using LPG as transport fuel.

9.3.5 Other important considerations - Physical access to communities

Although it is not a direct energy sector issue, the study found out that access to communities played a very critical role in the supply and distribution of energy. National utility services providers, private off-grid investors, and financial institutions which could be engaged in collaborative energy plan were unwilling to engage remote rural communities which were not easily accessible mainly due to the overhead cost involved. By implication, the Ministry of Energy should involve the roads and transport sector in energy planning that target remote rural communities.

9.3.6 Further research

Rice briquettes

The communities in the Upper East Region studied are rice producing communities. An analysis of possible energy resources in Chapter six sought to find the feasibility of rice husk briquettes production. However, the data available was insufficient. I propose a further feasibility study to ascertain the quantum of rice husk produced per community or that could be imported from one community to the other for the production of briquettes to supplement cooking energy.

Shea butter

Shea butter production was identified as a popular economic activity among the women in the communities studied in Builsa and Kassena-Nankana East Districts and in the Upper East Region as a whole. The residue resulting from the production process is often dried and used as traditional fuel, among other uses. The possibility of using the residue as fuel is due to its oil content. It will be worth further research to check the energy efficiency component of shea butter residue as a possible decentralised energy resource.

Energy development priorities

Torchlights with light-emitting diode (LED) bulbs ('Chinese torchlight' as it is popularly called) had taken over the paraffin market in all the ten rural communities studied. This is a new phenomenon which has changed the energy use structure of rural Ghana. By implication, there is a market niche for LED lighting. These in the interim seem cheaper to households because they utilise dry cells which can be purchased in piecemeal. It is also an obvious indication that rural communities need something brighter and safer than the kerosene lamps. Furthermore, for the rural households, the lighting effect the LED produced is comparable to solar lanterns. The maintenance of these systems is also within the ability of the rural user unlike the prevailing situation with solar lanterns where expertise for maintenance must be imported with unpredictable waiting time. Users were however clear that the lifetime of the torchlights could not be predicted – '*when one is lucky, it can last for as long as three months; otherwise it could even last for just two weeks*', a statement made by a respondent in Kori-Alam-Yeri, and affirmed by majority of respondents. It will be expedient if the Energy Commission together with the Ghana Standards Board could take interest in this market niche and also regulate the quality of the products sold on the market. Further research on the comparative costs of these as against solar lanterns is recommended.

The recommendations suggested can only bring positive results when there are national, district and community levels wills are to implement them. In addition, consistent awareness creation and conscientisation will be necessary to influence the values and perceptions of the rural communities for which these recommendations are suggested.

9.3.7 Recommendations for theory

From the theoretical reflections conducted in Chapter eight, the following recommendations are suggested for theory:

Promoting decentralised energy at the household level
It will be helpful for investors to consider the following in promoting decentralised energy systems at the rural level:

- Household decision-making follows a procedural rationality and may not be predicted. Informal constraints such as socio-cultural meanings may affect expected decision-making.
- Prevailing economic laws and environment could serve as opportunities or constraints to decision makers.
- Word of mouth is an effective tool in promoting ideas and in the dissemination of information.
- Household decision makers require practical demonstration to show the workability of proposals.

The effect of the energy system environment

- Knowledge of the energy market and its institutions is necessary to prevent biases and disequilibrium in a situation where an exogenous demand is a critical determinant of the sustainability of the rural market.
- A formal local institution responsible for the administration and supervision of the dynamics within the system environment to prevent exploitation is important.
- Territoriality is also an important consideration since energy decisions of neighbouring districts could influence the energy system of the District in question. Moreover, as posited by the endogenous development theory, administrative districts lying next to each could work together to complement each other's energy situation.

External factors

- Value network of the management institution – Where the initiative is an external injection into the community (and when it is also an internal District initiative) a management institution needs to be created specifically for the initiative. The management institution should also be capacitated specifically for initiative and not thrown together with the needs of the bigger energy sector.
- Again, the model of implementation for financial and business investors must create a win-win situation for the investors and the target beneficiaries.
- Investors will also be attracted when the regulatory framework provides a protection against loses and when there is restrained interference by the government.
- It is important that the process of implementation factors the fact the international preconditions may not be possible to alter. Planning and implementation therefore will need to include some contingencies which can cushion unfavourable preconditions. A wider variety of external support options may be helpful.

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APPENDICES

Appendix I: Definition of key terms

This section provides definitions of key terms as they are used and implied in the study.

Attitude: the state of mind or feeling of an individual, group or society regarding issues such as material gains, hard work, saving for the future and sharing wealth.

Bio-energy: the product of the conversion of biomass (residue, crops) to heat, power and transport energy. Bio-energy includes biomass and biofuels.

Conventional energy: this consists of the oil, gas, coal, nuclear material, and electric power.

Decentralised energy: defined as an alternative approach to production of electricity and the undertaking and management of the electrification project that may be grid connected or not. It is also defined as electricity production at or near the point of use, irrespective of size, technology or fuel used. It allows for more optimal use of renewable energy, combines heat and power, reduces fossil fuel use and increases eco-efficiency. Decentralised energy is also referred to as distributed generation, on-site generation, dispersed generation, embedded generation, decentralised generation, distributed energy or district energy. Electricity is generated electricity from many small energy sources.

District: in Ghana, it is a second-level administrative sub-division below the level of a *Region*. It is created as part of the process of administrative decentralisation and devolution of political power to local communities. The creation is influenced by chieftaincy and culture such that people under the same traditional authority and of the same ethnicity are in most cases not divided by the boundaries of Districts created.

Energy access *(working definition from various definitions)*: the fundamental energy requirement for any group of persons forming a household and that must include sufficient energy for lighting, cooking and some form of livelihood.

Energy efficiency: an energy source or appliance is energy efficient if it delivers more services for the same energy input, or the same services for less energy input.

Energy poverty: the lack of adequate modern energy for the basic needs of cooking, warmth and lighting, and essential energy services such as for schools and health centres, and income generation.

Energy gap: the difference between a country's energy needs (1,500W per person or 13,140kWh/capita-year on average in Africa) and current consumption.

Energy Power Measurement Units:

- Watt - capacity to supply energy at a rate of 1 joule per second
- MW - Megawatt: 10^6 Watt
- GW - Gigawatt: 10^9 Watt
- TW - Terawatt: 10^{12} Watt

Energy security: the availability of energy at all times in various forms in sufficient quantities and at affordable prices without unacceptable or irreversible impact on the environment.

Final energy consumption: energy that is supplied to the consumer for all final energy uses such as heating, cooling, and lighting.

Gross National Income: the total domestic and foreign output claimed by residents of a country. It comprises gross domestic product (GDP) plus factor incomes accruing to residents from abroad, less the income earned in the domestic economy accruing to person abroad.

Household: the definition of "household" is a difficult task within rural communities of developing regions where communalism strongly persists. It is even more difficult in rural polygamous communities. The definition of household for this study will be in relation to the phenomenon under study – energy. The definition will combine acceptable definitions within the development planning context, the locational context, and discretionary perspective. Basically, a household may be defined as a group of people eating from the same cooking pot and staying under the same roof. In polygamous communities, it is defined as the man, his wives and children and any other family member under his care. In extreme cases where there are many wives with children (and other wards) totalling seven [59] or more persons occupying different quarters in the compound as in the case of some traditional rulers in the Upper East Region, these women and their children may be considered a separate household as their energy needs are completely different from that of the other units of the compound. However, in the computation of other household expenditure such as livelihood activities particularly farming, the households will be considered will be again as one entity. This is because irrespective of their energy habits they all work and feed from one farmland. In the rural communities in the Northern parts of Ghana, where sons marry and bring their wives to their parents' home, these will be considered off-shoots and are therefore considered as separate households.

Human capital: productive investments in people such as skills, values, and health resulting from expenditures on education, on-the-job training programmes, and medical care.

Income per capita: total gross national income of a country divided by total population.

Kilowatt hour (kWh): a unit of energy equal to 1,000 watt-hours, or 3.6 mega joules.

Lumen: a measure of the total "amount" of visible light emitted by a source

Modern energy sources: these encompass electricity, oil, liquid fuels (such as kerosene), gaseous fuels (such as liquefied petroleum gas (LPG), natural gas), biofuels, and clean fuels for cooking and efficient cooking methods including improved biomass cookstoves, but also refer to biomass which is converted to electricity by use of modern technologies. They exclude traditional biomass and coal. Modern energy sources are more convenient,

[59] The 2000 Population Census of Ghana estimates the average household size of the Upper East and Brong Ahafo Regions as 7.2 and 5.3 respectively.

of better quality and can be comparatively cheaper than traditional fuels since they deliver more energy per unit volume and are easier to store and distribute.

Oil production: the production of oil can be divided into 3 stages.

Upstream production: refers to the segment of the oil and gas value chain that deals with searching for, recovery and production of crude oil and natural gas. The upstream oil sector is also known as the exploration and production (E&P) sector.

Mid-stream production: includes petroleum activities between the well-head and refinery, transportation and storage of petroleum.

Downstream production: the segment of the oil and gas value chain that deals with the refining, distribution and marketing of petroleum products. The downstream sector includes oil refineries, petrochemical plants, petroleum product distribution, retail outlets and natural gas distribution companies.

Particulate matter: finely divided solids or liquids that may be dispersed through the air from combustion processes, industrial activities or natural sources.

Poverty: generally, people living under 2USD a day are considered living under the poverty line. Those living under 1.25USD a day are considered living under extreme poverty.

Primary energy consumption: refers to the direct use of energy at the source, or supplying users with crude energy which has not been subjected to any conversion or transformation process.

Purchasing power parity (PPP): measures the amount of a given currency needed to buy the same basket of goods and services, traded and non-traded, as one unit of the reference currency. The US Dollar is mostly used as the base currency.

Renewable energy: energy derived from natural processes (*e.g.* sunlight and wind) that are replenished at a faster rate than they are consumed. Solar, wind, geothermal, hydro, and some forms of biomass are common sources of renewable energy.

Region: it is an administrative enclave headed by a regional secretary. There are ten administrative regions in Ghana.

Rural: the definition of 'rural' is contextual and dependent on a number of variables. In Ghana, a rural community is defined as any community with of a population of less than 5000. Despite the different specificities in definition according to different geographical contexts across the globe, rural areas are comparable to each other particularly within the milieu of developing countries, because they basically exhibit certain similar characteristic in their type of society and levels of services available to them, when compared with their urban counterparts.

Small hydropower: insular grids with less capacity between 1 and 10MW providing electricity to rural villages and may feed into public grid system. What is identified as small hydro power however differs between countries. It may be further classified into smaller systems:

- Pico hydro power – production capacity <5 - 10KW

- Micro hydro power – production capacity 10 - 100KW
- Mini hydro power – production capacity 100KW – 1MW
- Small hydro power – production capacity 1 – 10 MW

Solid fuels: these are wood, coal or charcoal.

Terawatt: equal to one trillion watts

Traditional energy sources: energy source which are ready for combustion and direct usage. They include charcoal, wood, straw, agricultural residues and dung.

Values: the principles, standards, or qualities that a society or groups within it considers worthwhile or desirable.

Appendix II: Protocol of field activities

The key activities were undertaken in the following sequence:

- First batch of Key Informant Interview (KII) with international energy experts in Tunisia – African Development Bank, Tunis - which led to a revision of the KII guide,
- Presentation and revision of instruments through peer reviews and review by academic Mentors,
- Contacting of key informants and further snow-balling to key persons in the field,
- First batch of key informant interviews in Ghana - Accra, Kumasi, Tamale - including participation in national consultative meetings and energy policy discussions; reconnaissance visit to the Builsa District Assembly
- Two-day training of research assistants – Kumasi, Ghana
- Pre-testing of instruments in the Sekyere Afram Plains District in the Ashanti Region and further revision of instruments
- District survey (1) in the Upper East Region – household survey and all other interviews intended at the District level in Kassena-Nankana East District in the Upper East Region
- Break, reflection on field proceedings and re-strategizing
- District survey (2) in the Upper East Region – household survey and all other interviews intended at the District level in Builsa Districts in the Upper East Region
- Key Informant Interview of energy research institution and NGOs in Tamale, Northern Region
- Break, reflection on field proceedings and re-strategizing
- District survey (3) in the Brong Ahafo Region – household survey and all other interviews intended at the District level in the Atebubu-Amantin District
- Second batch of key informant interviews in Accra, Kumasi

Appendix III: Establishing logic between research questions, indicators and variable

RQ1&2: ***What are the energy needs of the rural household - how are these being met (Gap)? How can these being met?***				
Specific Research question	**Indicator**	**Variable**	**Tool**	**Source of data**
1.1 In which structure and magnitude is energy demanded?	Energy demand structure and magnitude	- Energy consumption patterns for households, rural livelihood activities, and community services - prices; substitutes; seasonal access to energy resources; variations in energy use patterns - sources of energy supply	- Household survey - Community key informant interviews - Economic activity survey - Energy producers and retailers survey	- Households - Opinion leaders - Economic activities - Energy producers and retailers
RQ 3: *What are the available options for Decentralised Energy?*				
What are the available options for Decentralised Energy?	Energy resources and options for developing Decentralised Energy	- Existing and potential energy resources within the community or other communities in the district that are accessible - How the existing energy resources are used	- Community key informant interview - Observation - household interviews (exclusive with women) - Key informant interviews - Document review	- the Assemblyman, Unit Committee members, the traditional authority, i.e. 'tandams' (Upper East Region), and 'Akrontihenenom' in the Brong Ahafo Region and other representatives of the traditional authority, Opinion leaders - Communities - Women in households - Agriculture, Veterinary, and Forestry Departments of the District Assemblies - Districts Medium Term Development Plans
	Energy system environment	Organisational structures operating in the system: ▪ charcoal burners, ▪ firewood gatherers, sellers, etc. ▪ middle (wo)men activities' ▪ fossil fuel retailers	- Energy producers and retailers survey	- Energy producers and retailers

RQ 4: ***What are the pre-conditions necessary for the implementation and sustainability of Decentralised Energy Systems?***				
4.1 What influences household decision making on adopting a form of energy?	- Ability to pay - Willingness to pay	- Rural incomes - Affordability of access - Affordability of consumption - Economic characteristics: types of economic activities, number of working adults/employment, household expenditure pattern, household expenditure priorities - Knowledge of alternative energy - Previous use of alternative energy - Proximity to national mains	- Household survey - interview with District official for information on proximity	- Households - Office of District Engineer
	- Socio-cultural factors - societal interactions - Social utility	- Rural formal and informal institutions: perceptions, ideas, understanding, values, value placed on the energy sources) - the level of information flow and diffusion - Combined usage	- In-depth interviews of individuals and selected household - Key informant interviews	- Households - Opinion leaders
	Production utility	- Economic characteristics: types of economic activities, average income per economic activity type - Productive application of potential energy - indications of production uses of potential energy,	- Economic activity survey - Observation	- Economic activities - Communities
RQ 4: ***What are the pre-conditions necessary for the implementation and sustainability of Decentralised Energy Systems?***				
4.1 What influences household decision making on adopting a form of energy?	Socio-cultural acceptability	- Aversion or otherwise, to new technology - socio-cultural values with identified energy resources *e.g. Aluminium roofing, cow dung* (*conflicting or otherwise*)	- In-depth interviews of Opinion leaders and selected households - literature review of the study context	- Opinion leaders - Households - Literature
	Conflict of usage	The possible effect of the development of potential energy resources on other components of the rural system - environment, livelihoods, agriculture, building industry (*e.g. UER as dung use for housing construction*), time (f*or farming for collecting dung*)	- Household survey, - Expert interview at District Assembly - Observation	- Households - Agriculture Department - Community
	Household decision making process	- Actors in household decision making - Levels of involvement of the actors - Types of consultations among actors - Key considerations in decision making related to energy - Effect of the community on household decision making	- In-depth interview with selected households, - In-depth interview of key persons in the community - Observation	- Households - Traditional Authority, Unit Committee - Community

4.2 What are the pre-conditions emanating from the energy system environment	Conflicting or complementing usage	Current use or alternative use of identified energy resources	- in-depth interview with selected households - Observation	- Households - Community
	- Organization of the existing energy system - Energy resources and institutions - Price determination	- The actors/ stakeholders in the energy system and their roles - demand of energy forms, cost, competition, sales channels, life cycle – i.e. the current phase of the product life in the market, government/project/ NGO –i.e. these may influence the pricing by pre-determining prices - Sources of energy	- Individual interviews	- Producers and retailers of local energy forms
RQ4: ***What are the pre-conditions necessary for the implementation and sustainability of Decentralised Energy Systems?***				
4.3 What are the external pre-conditions over which the rural unit has very little or no control	Government commitment to alternative energy	- International financial support for energy sector - Rural energy development policy statements - Investment in alternative energy sector apart from the grid - Incentives for rural energy investors	- Expert interviews - Document review - Key Informant Interviews	- Energy experts – African Development Bank - Energy policy statements - Energy Sector Strategy and Development Plan, reports of Energy Consultative For a - Reports and Policy documents - Ministry of Energy, Energy Commission, National bodies or representative of alternative energy producers and distributors
	Institutionalisation of the alternative energy in the energy development framework	- Rural energy development policy statements - Inclusion of alternative energy in energy development frame - The existence of institutions for alternative energy development - Decentralised departments/ units of alternative energy development and management at the District level	- Document review - Key Informant Interviews	
	District energy development	- The existence of an Energy Development Framework at the District level - inclusion of otherwise of alternative energy development in the energy framework in the District Medium Term Development Plan - The existence of independent energy investors in the District - Local government incentives for rural energy investors	- Document review - Key informant interviews	- District Medium Term Development Plans - Office of District Planning Coordination Units (DPCU)
	Supply chain	- Scope of suppliers of alternative energy - Distribution – possible chain of retailers and wholesalers, barriers - Source of components of DEs - Consumers (demand which should compel the supply)	- Key Informant Interview –	- Suppliers (importers) - Distributors: wholesalers and retailers - NGOs and Research Institutions

RQ 5: ***What mechanisms should be instituted towards a sustainable energy supply which will in tend ensure sustainability of economic development?*** **(Sustainability)**				
5.1 What management systems and capacities are available for effective functioning of Decentralised Energy systems	Technical backstopping	- Local technical base for implementation and repairs	- Key informant interview - Individual interviews	- Opinion leaders - Electricians, Fitters - Energy producers and distributors - DPCU
	Financial support system	- Sources of income, - types of economic activities, - indications of production uses of potential energy, - the investor capacities in the District*, - the microfinance support landscape in the District*, - indications of economic cooperatives (**District because there may be no investors in the particular community*)	- Household survey - Economic activity survey - Key Informant Interview	- Household - Economic activity - Microfinance institutions – Agric Development Bank, Yapra Rural Bank, Sinapi Aba Trust, Builsa Community Bank, Naara Rural Bank, Sirigu Rural Bank
	Management capacities	- District administration support systems and capacities	- Key informant interview	- DPCU

Source: Author's Construct, 2013

Appendix IV: Field Instruments

HOUSEHOLD SURVEY

INTERVIEW DETAILS

Date…………………………………….
Name of Interviewer…………………………………………..
Village ………………………………….
Start Time………………………………

Name of Interviewee ……………………….
District/Region…………………………………….
End Time…………………………………….

INSTRUCTIONS FOR THE INTERVIEWER

A. Interviewers will have read the guidelines for interviewers and attended the briefing session prior to the field interviews
Introduce yourself and explain that this is part of an academic exercise. The aim of the study is to examine how the energy-economic development nexus translate to Decentralised Energy improving economic development at the rural level in Ghana within the complexities of the rural system.
B. Interview the member of household who is involved in making household decisions. If necessary, information on other household issues should be supplemented by another member of the household. The second part of the interview where it is energy related must necessarily involve the women.
C. Please communicate the following to the interviewees:
That this is purely an academic exercise, and this exercise is supposed to provide the knowledge lacking in planning for effective decision-making. All the information given us will be treated **<u>confidential</u>**. It will not be communicated to anyone outside the research team.
We would like him/her to answer the questions for the households, and not just for him/herself.

BASIC HOUSEHOLD INFORMATION

1. What is your position in this household? □Husband □Wife □Daughter □Son □Other……….
2. Age of respondent…………………………………………..
3. Educational background…………………………………..
4. Number of members of the household ……………………………………..
    i. Number of children under 18 years ……………………….
    ii. Number of children above 18 years ……………………….
    iii. Number of children living in the house and in school (primary to tertiary)………………

Housing Information

5. Type of flooring in dwelling (Interviewer: Observe):
□Earth/Mud □Wood □Stone/Brick □Cement/concrete □Other ……………………
6. Type of roofing in dwelling (Interviewer: Observe):

□Thatch □Wood □Corrugated Iron □Asbestos □Other ……………………

7. Do you own or rent this house?
   □Own □Rent □Free accommodation (relative's house) □Other ……………………….
8. If renting, what is your monthly rent? …………………………………….
9. How many rooms do you have in the house? ………………………….

Energy Profile – energy needs of your household and how these are being met

10. Indicate the purposes for which you use energy, the primary form of energy used and their substitutes

Purpose	1st Energy	2nd Energy	3rd Energy	Preferred energy	Preferred available in community (Y/N)
Cooking					
Lighting					
Heating					
Ironing					
Learning					
Radio					
Economic activity (specify agric, com/serv, Indus) ……………………….					
Others (specify) …………………					

11. If you had a choice and all fuels or energy sources were available in your community, which fuels or energy would your household use most for the listed energy services? What are your reasons?

Energy End Use	**Which fuel would the household like to use most if it had a choice?** *Electricity[1] firewood[2] kerosene[3] candles[4] dung/crop residues[5] charcoal[6] solar[7] LPG[8] dry cell[9] car battery[10] other (specify)[11]…..*	**Reasons for using this energy source**	**If the fuel of your choice is not used regularly, what are the reason(s) for this?** *Too expensive to use[1] Fuel/electricity not available in the area[2] Have no electricity connection[3] Don't have appliances[4] Other (specify)[5]…….*
Cooking			
Lighting			
Heating			
Ironing			
Learning			

Radio			
Economic activity (specify agric, com/serv, Indus)………………			

12. How much did you pay for energy in the past week?

Energy	**Unit of measurement**	**Cost/week (GHC)**
Charcoal		
Firewood		
Car battery		
Battery charging		
Grid electricity		
Diesel/Petrol		
Dry cells		
Ordinary Torch		
Chinese Torch		
LPG		
Generator		
Solar – lanterns, panels, etc		
Others (specify)		

13. Is there or are cases where you have had to depend on a neighbouring village or town for some form of energy? □Yes □No
14. What kind of energy? ……………………………………………………………………………………………
15. Is there or are cases where you have had to depend on a neighbour for some form of energy?
□Yes □No
16. What kind of energy? ……………………………………………………………………………………………
17. Where do you get the energy?

Energy form	**Inside or outside community**	**Source 1 Distance/time**	**Source 2 Distance/time**	**How often – once a week, 2x a week, etc.**

18. If energy is supplied from the community, where do you get it from?
□Gathered from the field □Buy from producer □Buy from retailer
19. If fuel is gathered from the field, who does the gathering? …………………………
20. Do you have enough fuel the whole year?

Energy/ fuel for	Available whole year Yes/No	Period/month/season not available
Cooking		
Heating		

Ironing		
Learning		
Radio		
Generator		
Motorcycle		
Economic activity (specific agric, com/serv, industry) …………………………………………………		

21. At what period or season do you consume energy most, and why?

Season or quarter	**Reasons**

22. Please help complete the table below to help now the periods of energy demand

Energy use area	Morning	Afternoon	Evening 1 (6-10pm)	Evening 2 (after 10pm)
Lighting				
Cooking				
Water heating				
Ironing				
Learning				
Listening to Radios				
Watching Television				
Others				

Estimation of energy needs/requirement:

Please indicate satisfaction or otherwise for the following:

23. Energy for cooking/heating □Not satisfied □Satisfied □Very satisfied
24. Energy for lighting □Not satisfied □Satisfied □Very satisfied
25. Energy for economic activities □Not satisfied □Satisfied □Very satisfied

Other energy resources available

26. Apart from the energy types you have mentioned to be using, what are the resources of energy which you have seen people using but which you are not using (both natural and technological wise)?

The pre-conditions necessary for the implementation of Decentralised Energy Systems

a. Household expenditure and economic characteristics
27. Number of working adults…………….; Number of non-working adults ………….
28. What economic activities are you engaged in?

Adult	Main economic activity	S- self owner HW – hired worker FB – family business	Secondary economic activity	S- self owner HW – hired worker FB – family business

29. Household expenditure pattern (weekly)

Expenditure item	**Cost GHC**	**Expenditure**	**Cost GHC**
Energy			
Food			
Education			
Remittance			
Funerals			
Entertainment			
Rural business			
Transportation			
Others			
…			
…			

b. Affordability of access – travel cost, opportunity cost e.g. children's education, late to farm, etc.
30. Do you travel to access energy? Yes No
31. If Yes, and you take transport, how much money do you spend in and out? ……GHC
32. If Yes, and you walk, how much time do you spend? ……………..
33. If you walk to access energy or if you gather from the bush, are there other activities you could rather have done with the time you spend to access energy? Yes No
34. If Yes, what are these activities?
35. What time of the day do you get your energy?
    Fuel for cooking □morning □afternoon evening
    Fuel for lighting □morning □afternoon □evening
    Fuel for economic activities □morning □afternoon □evening

c. Affordability of consumption
   a. Are you able to buy as much energy as you need?
   b. If No, why?

HOUSEHOLD INCOME QUESTINNAIRE

37 INCOME

A. Agriculture producer

37.1 Do you earn daily, weekly, monthly or seasonally?
□ daily □market day □weekly □ monthly □seasonally

37.2 If seasonally, which time of the year do you harvest and sell?

37.3 How much are you able to produce per season?

Type of Farm produce (crops, birds, animals)	Production (Bags/Bowls/Olonka/no. of animals)

37.4 How much of the harvest is for the market and how much for home consumption?

Type of Farm produce *(crops, birds, animals)*	Market *(Bags/Bowls/Olonka/ no. of birds/animals)*	Home consumption *(Bags/Bowls/Olonka/no. of birds/animals)*	Untouched/stored *(Bags/Bowls/Olonka/no. of birds/animals)*

37.5 What is the market price for a bag, bowl, etc. at a 'good' market and at a 'bad' market? Please provide the following information

Type of Farm produce *(crops, birds, animals)*	**Good market**	**'Bad' market**
	Market price (GHC)	*Market price (GHC)*

37.6 What happens to the rest of the produce?

....
....
....

37.7 (*If cattle rearing/animal husbandry*) How often do you sell the birds or animals?

□ daily □market day □weekly □ monthly □seasonally

37.7.1 Why do sell them?

□ as source of income □ for a particular reason (specify)....................................

B. Non-agric: teacher, nurse, driver, commerce, small shops, small scale industry, mills, etc.

<u>*Salaried worker*</u> – teacher, nurse, other civil/public servants

37.8 What is your occupation? ....

37.9 How much do you earn monthly? .... GHC

<u>*Non-Salaried worker*</u> *– commerce, service, small shops, small scale industry, mills, etc.*
(Interviewer: PLEASE use your discretion as much as possible to get the information)

37.10 What do you sell/produce/mill, etc.? ....

37.11 How much are you able to sell daily/weekly? Fill in the table below

Type of work	Unit of measurement	Quantity	Unit price

	(Sales/trips/no. of bowls, etc.)		*(GHC)*

C. Other forms of income

37.12 Do you receive remittances or do you give remittances to others? ....

37.13 If you receive, about how much can you expect in a month? ....GHC

37.14 If you give, how much do you spend on remittances in a month, season or year? ....GHC

D. Savings

37.15 Are you able to save? ☐Yes ☐No

37.16 If Yes, how much are you able to save? .... GHC

37.17 How do you save? ☐Bank ☐Susu ☐Microfinance ☐At home

37.18 If No, how are you able to respond to emergencies?
....
....
....

37.19 Have you borrowed before? ☐Yes ☐No

37.20 If Yes, from where?
☐Bank ☐Microfinance institution ☐Susu ☐Relatives ☐Friends ☐Money lenders
(If the Bank Susu type, classify it under MFI)

37.21 At what interest rate do you have to pay back? ....%

37.22 What is the maximum time for repayment? ....days/weeks/months

Indications of productive uses of potential energy

38 If you had a better form of energy, what economic activities are you likely to undertake?
....
....

39 Apart from energy what are the other reasons why you are not undertaking the economic activity?
....
....

HOUSEHOLD IN-DEPTH INTERVIEWS

Date.......................................

Name of Interviewer...................................... Name of Interviewee............................

Village.......................... District/ Region ..../...............................

Start Time........................... End Time..................................

Estimation of energy needs /productive use

1. A time-activity line for the use of energy for: a. domestic purposes (with the time component)
   a. Domestic purposes (with time component and type of energy)

Energy use	Type of fuel	Morning (time)	Afternoon (time)	Evening (time)	Night (time)
Cooking					
Lighting					
Water heating					
Ironing					
Learning					
Listening to radio					
Watching TV					
Others					

   b. productive purposes – e.g. agric from bush clearing till harvest and sale at the market; also for the other economic activities

Agric activities	Type of fuel	Commercial/Service activities	Type of fuel	Industrial activities	Type of fuel

Estimation of energy needs

1. How do children learn after school? Can the children use the energy form available to learn any time they want or do they only have access when the whole household is using it?

....

....

Household decision making process

2. Do you know about Decentralised Energy systems? (Explain and give examples).................................
   a. How did you know about it? Who told you?...
   b. What do you know about it? ....

c. Do you know anyone using them?..
d. Are you interested in them?...
e. If Yes, and you have not pursued it, why? ....
f. If Yes, and you have pursued it, how is the performance? Are you satisfied with it?............................
3. Are they any advantages or disadvantages in the use of firewood, charcoal, cow dung, etc?................
4. (Interviewer: Provide information on the upfront cost for DE you will like them to consider e.g lpg) What will you consider before adopting a new form of energy? (internal)
5. What will in influence you to or not to adopt a new form of energy?

Social utility/returns

6. Socio-cultural factors
a. How does information on a new thing/idea normally circulate in the community?
b. What are some of the social and informational groups in the community?
c. Do you belong to any of them?
d. Are they useful in information circulation? If Yes, how?

7. Social restrictions and other uses

Potential energy resources	Social restriction (Y/N)	Other uses
Cow dung		
Crop residue		
Agric waste		
Water		

8. Will you like the above potential energy source to be used for energy instead of the current use? Why?
9. The effect of the community in decision-making: to what extent does the community affect decisions made at the household level? (provide a vivid life example that they can relate to)
   a. How are important decisions taken at the household level?
   b. Who decides whether or not to adopt a new energy system?
   c. How will you be convinced that it is workable? Which category of people, when using the DE, will be convincing proof for you - neighbours, family members, your social group members, opinion leaders, traditional authority, and/or personnel of the DA?
   d. If a neighbour adopts it, will you be convinced about it? How many neighbours will be enough to convince you – 1,2,3,4,5,5+?
10. Are there extra expenses that sometimes come to you unannounced? provide a vivid life example that they can relate to e.g. an unexpected funeral)
   a. What are some of these? How do you respond to them? How often does it occur?
   b. Who determines the level of importance – yourself, your family, or the community? If any of these instance occurred, and at the same time you had to make a decision to adopt a new energy system, which one will you prioritise and why?
11. If your first 5 expenditure priorities including energy (assuming energy is included) needed your attention at the same time, which one will you attend to first? Grade in the scale 1-5, 1 being the highest. List out the expenditure priorities in addition to energy. (Play with pieces of cards or papers)

Ability to pay

12. If there was an alternative form of energy that will improve your domestic life and your livelihood, will you be interested in it if
a. You have to pay for this energy source? Yes..... No....

b. the cost of this energy source is 2X the cost of the present energy you are using Yes….. No….
c. the cost if 4X the cost of the present energy source Yes….. No….
d. the cost will be spread over a long period of time and you will pay over the seasons Yes….. No….
e. If none of the above, under what conditions are you able to pay? ……

Willingness to adopt

13. If there is no possibility to getting the grid in the next 15 years, would you be willing to have an alternative better form of energy? Yes….. No….
a. If there is no possibility to getting the grid in the next 10 years, would you be willing to have an alternative better form of energy
b. If there is no possibility to getting the grid in the next 5 years, would you be willing to have an alternative better form of energy
c. If you knew you will have grid electricity in the next 5 years will you opt for DE now?
d. If you knew you will have grid electricity in the next 3 years, will you opt for DE now? If No or Yes, explain
e. If you had to prioritise the following needs and expenses in decreasing priority from 1-5, under a short notice of 1 month, which will be first and why?

Expense	**Scale**	**Reason**
Funeral		
Education		
Marriage		
Water		
Energy		

14. If an agency came in tomorrow to present to you an alternative energy, how much time will you need to make a decision on it?
a. Why will you need this amount of time to make a decision?
b. What are the important considerations you will take before considering it?

15. Prioritise your energy needs if you could have a better form of energy to address all of them (Scale 1-6, 1 being the highest)

Energy need	**Scale**	**Reason**
Cooking		
Heating		
Lighting		
Ironing		
Learning		
Radio/TV/ Phone charging		
Economic activity		

16. If you had grid connection in one year after taking this new form of energy, will you abandon the new Energy? Yes….. No…..

Willingness to pay

17. Will you be willing to pay for any better form of energy if the initial cost is
a. 3X the cost of energy now? Yes….. No…..
b. 4X the cost of energy now? Yes….. No…..

c. 5X the cost of energy now? Yes….. No…..

18. Would you like it if it spread across a long period of time? Yes….. No…..

ECONOMIC ACTIVITY (both agric and non-agric)

Production utility and Sustainability - indications of productive uses of potential energy

1. (Interviewer) Note the business activity undertaken.............................

2. What forms of energy do you use for your business activity?

3. How much do you spend on this energy component? Per day/month/etc

4. What are the other expenditures items for the activity – labour, raw materials, etc? (Determine the % of the cost of energy in the total cost of production.) per period/season/cycle (Interviewer: Prompt respondents to give all inputs)

5. Do you always have access to this energy form? Yes.... No....

   a. If No, how often?
   b. When it is not available, what alternative do you use? (Interviewer: note from [2] above to answer all the energy forms mentioned)

6. When you have energy, how much are you able to produce?

7. If an alternative form of energy will increase your productivity, will you invest a little more in it?

   a. If No, why not?

8. Is the form of energy able to perform the job rightly?

9. What critical changes in business will you make with an improvement in energy supply?

10. What specific expectations in business performance will you look forward to?

11. In your own opinion, to what extent will a better source of energy improve your productivity?

GUIDED INTERVIEW – OPINION LEADERS

1. **General community information**
   a. Which of these social amenities are present in the community – schools, health post, post office, irrigation, etc.? ***[Gather the statistics from an Assemblyman or the District Assembly or this can be compiled along the way]***

   b. What type of energy do these use to operate?

   c. Proximity to national mains (Cross-check with VRA map)

   d. What are the typical economic activities of this community?

   e. Have there been previous attempts of providing some forms of energy? How was it received? Was it sustainable? If No, why? Who/which organisation was responsible?

   f. Do you think there has problems with energy supply in the community?
   g. Have you as a community ever fought for better forms of energy? What was the outcome?

2. **Options for Decentralised Energy systems – Energy system environment - Estimation of Energy supply/potential energy resources**

RQ: What energy resources are available? - Energy system environment: (i) Energy resources within the community or other communities in the district that are accessible, both existing and potential; How the existing energy resources are used (ii) Organisational structures in the ESE

a. What potential energy resources are in your community which are not being tapped? E.g. Jatropha farms, or any local fuel resource that we aware of; Charcoal burners, firewood gatherers

b. Present the various possible DE systems and their components – cow dung, crop residue, Jatropha, solar – in addition to the energy resources they have mentioned
   a. Are there any social restrictions to the use of these raw materials?
   b. Will their usage for the purpose of energy generation be in conflict with other usages?
   c. If Yes, will you be willing to sacrifice these usages?

c. Observe!!!

d. Energy resources in the community – this information should also be sort from secondary data – wind levels, solar radiations – background information that the rural energy system is dependent on bio-fuels. Information on the natural endowment of these from the Forestry Department or any organisation responsible. However these may information regarding areas in their direct jurisdiction or on information is reserved areas and not necessary of the entire community.

Who are the players in the current energy supply system?

- Charcoal burners……………………
- Charcoal sellers……………………
- Firewood gatherers……………….
- Paraffin retailers……………………

3. **Household decision making process**
    a. What category of decisions can be made at the household level and which can be made at the community level? ***[present them with a good practical examples they can relate with]***
    b. Rural formal and informal institutions – perceptions, ideas, understanding, values, value (value placed on the energy source)

4. **Understanding the systems functioning of the community *[present them with a good practical examples they can relate with e.g. how a cattle disease broke out and how the information was circulated]***
    a. How is information circulated in the community?
    b. What lines of authority operate in the community?

5. **Sustainability -** What mechanisms should be instituted towards a sustainable energy supply which will in tend ensure sustainability of economic development? – management capacities

    Technical backstopping – are there local technical base to be engaged in implementation and repairs?

VERTINARY DEPARTMENT
GUIDED INTERVIEW

Options for Decentralised Energy systems – Energy system environment - Estimation of Energy supply/potential energy resources

> *RQ*: What energy resources are available? - Energy system environment: (i) Energy resources within the community or other communities in the district that are accessible, both existing and potential; How the existing energy resources are used (ii) Organisational structures in the ESE

Information need: Cattle population and animal waste for the estimation of resource availability for biogas

FORESTRY DEPARTMENT

Question: What is the estimated population of woodlots in the community?

Background information

Comparatively speaking, estimating the availability of animal waste is manageable though the requisite data (village level cattle population) are usually available ... at the district level with the Veterinary Department. The level of errors in the estimation procedure, however, may be equally large due to a host of factors, the chief among them being grazing/feeding practices and fodder availability. Crop residue availability can be estimated through the estimates of different crops and the standard (or, preferably, measured) straw to grain ratios. The availability of other local energy resources (such as small hydel and wind energy potential) must also be assessed. (Sinha, Venkata, Joshi 1994).

GUIDED INTERVIEW
DISTRICT ASSEMBLY

RQ: Sustainability - What mechanisms should be instituted towards a sustainable energy supply which will in tend ensure sustainability of economic development?

What management systems and capacities are available for effective functioning of Decentralised Energy systems? - Financial support: seasonal) Sources of income, types of economic activities, indications of productive uses of potential energy, the investor capacities in the District*, the microfinance support landscape in the District*, indications of economic cooperatives (*District because there may be no investors in the particular community)

1. **General community information**
   a. Which of these social amenities are present in the community – schools, health post, post office, irrigation, etc.? ***[Gather the statistics from an Assemblyman or the District Assembly or this can be compiled along the way]***
   b. What type of energy do these use to operate?
   c. Proximity to national mains (Cross-check with VRA map)
   d. What are the typical economic activities of this community?
   e. Have there been previous attempts of providing some forms of energy? How was it received? Was it sustainable? If No, why? Who/which organisation was responsible? ***(identify communities where there have been previous attempts at alternative energy for household interviews)***
2. **Types of economic activities and indications of productive uses of potential energy**
   a. Can you describe the energy supply in the District? Is it adequate, accessible, reliable..?
   b. (Indications of potential productive uses from MTDP preparation)
   c. What opportunities for productive uses are available?
   d. How can energy improve these opportunities?
   e. To what extent are these opportunities energy dependent?
3. **Investor capacities**
   a. Are there energy based investors or alternative energy deploying agencies in the District?
   b. What kind of investor capacities are there in the District? [a snow-balling follow up] Are these interested in energy? (*Are there retailers and distributors in the District?*)
4. **Technical backstopping**

a. Is there a local technical base which is possible to be trained into the variety of DE installation and repairs?
b. Are there any fitters or electricians interested in supporting energy installations?

5. Microfinance institutions

a. Which microfinance institutions or economic cooperatives are available in the District?
b. Are there any ones that support energy projects? [snow-balling to these for further interviewing]

6. External Preconditions – Rural Energy Plan

a. What efforts have made to attract sustainable energy provision in your community?
b. Is there any National Policy that compels District Assemblies to promote DE in the districts?
c. If there is a bilateral or donor agreement to provide alternative energy sources, which office of the DA is responsible? How are the communities involved? What kind of structure exists for the operationalisation of such?
d. Are there any incentives for rural energy investors?
e. How does the provision of energy fit in your overall (economic) development plan? – are there clearly drawn linkages between energy improvement and development and your District Development Plan?
f. Identify the opportunity for Community-Based Decentralised Energy Investment or rather District-Based Decentralised Energy Investment?

GUIDED KEY INFORMANT INTERVIEW
MICROFINANCE INSTITUTIONS/ ECONOMIC COOPERATIVES

Sustainability – Investment Capacity

1. Have you invested into the energy sector before? Which type of energy?
2. Will your financial entity be interested in investing into Decentralised (alternative) Energy for the rural communities either as supporting the chain of retailers or the consumers through long term loans?
3. Do you consider energy supply as an important input when appraising projects for financing, e.g. for fitters?

LOCAL TECHNICIANS/ELECTRICIANS/FITTERS

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1. What is your level of education?
2. What kind of technical/ electrical/fitting works have you been involved in?
3. If there was project and you were to be trained to assist, will be interested in learning a little more?

COMMUNITY ENERGY PRODUCERS, RETAILERS

- **The unit price of energy type**

Energy type	**Unit of measurement**	**Unit price (GHC)**
Charcoal		
Firewood		
Paraffin		
Dry cells		

Battery		
Others...		
...		
...		

- External Source of supply of energy

Energy type	**Source of supply**
Paraffin	
Dry cells	
Battery	
Solar lanterns	
Others...	
...	
...	

SAMPLE OF EXPERT INTERVIEW GUIDE
INTERVIEW WITH THE AfDB ENERGY GROUP

Introduction: AfDB Energy Group's experience with rural systems

i. There seem to be emphasis on modern energy systems which you have defined in your Energy Strategy paper as including fossils. Can you explain the rationale for this approach?
ii. Is the Bank not interested in Decentralised Energy (DE) systems? Is the Bank not weary of the effect of fossils? What is the Bank's view on DE systems?
iii. What approaches towards DE have you used in the past? Are there any evaluation reports about outcomes?
iv. Is there a Bank policy for rural energy development? How are your experiences like? Did these rural systems work sustainably?
v. The aim of the study - *to seek to examine how the energy-economic development nexus translates to Decentralised Energy improving economic development at the rural level in Ghana within the complexities of the rural system-* In your experience, has the rural system stood in the way of achieving this?

RQ: What are the energy needs of the rural household - how are these being met (Gap)? How can these be met?

i. When development agencies talk about inadequate energy or poor energy access, the focus seem to be on electricity. Figures quoted to support these assertions are mostly are tones of energy and percentages of households or persons using biomass for cooking. Meanwhile, very scarcely will the rural household employ electricity in cooking and even for heating. How can we effectively synchronise these 2 disparate phenomena to get the energy problem and therefore the solution right? (In your opinion, how can one effectively measure energy access in the rural areas?)
ii. Literature names 'lack of perceived value' as one of the reasons why the poor will not adopt a new energy technology – (what is your opinion on this?) Are they able to reconcile with the perceived value? How can they reconcile with that? To what extent will education be able to achieve this?

iii. What is the guarantee that when the unit cost is reduced, energy access will be improved? Has the Bank any experiences where reduction in cost resulted in improvement of energy access?

RQ: What are the pre-conditions necessary for the implementation and sustainability of Decentralised Energy Systems?

Sub-Q: What influences household decision-making on adopting a form of energy?

i. It is part of the Bank's Strategy to help build and operate efficient, cost effective energy systems – how do you manage that from the demand side, i.e. ensuring that it is cost effective to the consumer
ii. 'Demand side management' and 'Willingness-to-adopt' – is there a meeting point for these 2 standpoints within the framework of improving rural energy access?

Sub-Q: Production utility

i. Ensuring economic growth and productive uses
ii. Production utility – is there any evaluation report that proves this?

RQ: Sustainability

Sub-Q: Investment

i. Is it possible that competition in the provision of alternative energy will induce more investment in the sector and therefore provide the rural dweller with a number of alternatives to choose from? But what will induce this competition? How can we create this competition? Any Bank examples?
ii. Decentralised Energy (Renewables) targets low income groups but the cost of renewables are considerably high. How do we reconcile these 2 positions?
iii. There is a school of thought that supports market-oriented approach to energy delivery that is expected to make the energy market equally accessible to all and attractive to local investors. In very typical rural areas, how will this may applicable? What will cause people from depending on a 'free gift of nature' to a priced commodity? Are there any case studies involving the Bank?
iv. Scalability – how does this work with the market/demand driven approach to energy delivery for the poor?
v. In your various experiences, what is most fundamental for the successful implementation and sustainability of energy project at the rural level? How can appreciation be enhanced?
vi. What are the key things to look out for in an African country's implementation plan? What are the major obstacles?

Sub-Q: Supply

i. What are the typical issues with supply chain and how can these be overcome?
ii. How effectively can rural DE supply systems be integrated with the centralised energy supply systems? Are there examples from other developing countries?
iii. What finance facilities are available?
iv. How do you encourage governments to create the enabling environment? (NOT what is the enabling environment?)

EXPERT INTERVIEW NATIONAL

Ministry of Energy or its Representative/ Energy Commission

RQ: External pre-conditions

1. What is the government's rural energy development focus?

2. Recent statements on the energy access accentuate that the African countries and especially sub-Saharan African countries are unable to reach their MDG targets due to energy poverty particularly prevalent in their rural areas. Where does Ghana stand in this assessment?
3. Which of these is the government's priority: grid-electrification of rural communities or promoting Decentralised Energy dissemination in the rural areas? Why?
4. Are there any forms of incentives for agencies that go rural energy – supply, financing, technical, consultants, etc.?
5. How can we integrate the Decentralised Energy supply into the centralised supply of energy (not the technical integration?)
   [*e.g. so that centralized energy supply do not compete with decentralized energy systems but rather that they complement each other; to prevent the private investors' lack of interest in low-profit rural markets due to public funded competition.* ***Direct the discussion to the possibility of the government investing and supplying Decentralised Energy as a cheaper alternative to extending the national grid to the remote rural parts*****.]**
6. There was a Solar Conference in Accra from 4-6 April 2012 which the Ministry of Energy supported. What is the outlook for rural energy improvement after such conferences? What role does the government and the private sector play respectively in this regard?
7. Currently, the country is subjected to power rationing due to inadequate power supply from grid. Why would the government persist in expanding the national grid when it is currently difficult to maintain those currently hooked to the grid? Are there no other alternatives?
8. How does the consideration of energy access, not rural electrification, influence the country's energy investment?
9. Concerning the current oil discovery- what are the implications for fuel supply? What will be the implications for energy access in the rural areas? Are there any policy guidelines and specific strategies to address rural energy poverty in the light of this discovery? What about the gas? Will there be a consideration for gas powered power generation?

KEY INFORMANT INTERVIEW - DE SUPPLIERS AND DISTRIBUTORS

[If there are no DE suppliers or distributors in the District, they should be checked for at the regional level whose work extends to the Districts]

1. What has been your experience with DE distribution or installation in the past?
2. What pricing policies do you adopt?
3. What specific rural specific pricing policy did you adopt? (to ensure pricing is favourable to you and attractive to the rural households)
4. How do you propagate information about a new technology?
5. Is your supply project target based or demand-oriented? How does it work? How does the result compare with your expectation?
6. What are the life-spans of these systems? To what extent are you involved in the repairs and maintenance of the systems? Any after sales service? How accessible is it? *[Tune the discussion to find out if there is any involvement or integration of the local technical base such as a training programme, any Trainer of Trainers programme for the local technical base*]

7. There is the challenge of energy mix for uninterrupted supply once supply is based more renewable energy. How do we circumvent this problem? What are the options to consider?
8. From your experience, are the rural areas interested in alternative energy other than grid electricity? How is your market share of the rural populace?
9. Please provide Price estimates and productions cost for technologies:- wind, hydro, thermal, gas, biogas, solar, 2nd generation biofuels, hydrogen, etc. for potential uses for heat, transport, engines, electricity, light... (*this will be better organized on the field*)

Alternative Energy sources and innovative energy technologies:-
Production cost and price estimates per kilowatt-hour

Alternative Energy/ Innovative Energy Technologies	**Production Cost**	**Price estimates/kwh**				
		Heat	Tpt	Engines	Elec/light	
Solar						
Wind						
Mini/micro Hydro						
Geo-thermal						
Bio-gas						
2nd generation biomass fuel						
Hydrogen						
....						
.....						

KEY INFORMANT INTERVIEW
EXPERTS – Energy Research Institutions, (Energy) Development Experts

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Introduction/Rural systems

i. One aim of the study - *to seek to examine how the energy-economic development nexus translates to Decentralised Energy improving economic development at the rural level in Ghana within the complexities of the rural system-* In your experience, how do we achieve this improvement of economic development 'in spite of' or within the context of the complexities of the rural system". (taking the rural areas "as is")
ii. What are the major obstacles to rural energy implementation?

Emerging concepts and innovations/Technological developments

i. Are there some emerging concepts and technological innovations you have uncovered in your work or developed? Have these been tried anywhere? How successful were they?
ii. Where implementation was successful, what implementation strategies have been used?
iii. There is the challenge of energy mix for uninterrupted supply once supply is based more renewable energy. How do we circumvent this problem? What are the options to consider?
iv. From your experience, are the rural areas interested in alternative energy other than grid electricity? What could be the possible reasons?

What are the energy needs of the rural household - how are these being met (Gap)? How can these be met?

iv. When development agencies talk about inadequate energy or poor energy access, the focus seem to be on electricity. Figures quoted to support these assertions are mostly are tones of energy and percentages of households or persons using biomass for cooking. Meanwhile, very scarcely will the rural household employ electricity in cooking and even for heating. How can we synchronise these 2 disparate phenomena to get the energy problem and therefore the solution right?
v. Literature names 'lack of perceived value' as one of the reasons why the poor will not adopt a new energy technology – (what is your opinion on this?) Are they able to reconcile with the perceived value? How can they reconcile with that? To what extent will education be able to achieve this?
vi. What is the guarantee that when the unit cost is reduced, energy access will be improved? *(e.g. the issues with the lifeline tariffs of the power sector and the subsidies of the LPG sub-sector)*

What are the pre-conditions necessary for the implementation and sustainability of Decentralised Energy Systems?

Sub-Q: What influences household decision-making on adopting a form of energy?

i. More and more discussions on renewable energy systems particularly decentralised devices are hammering on building and operating cost effective systems. At the same time, recent emphasis on implementation and financing is the market-oriented approach. How can efficient, cost effective energy systems be managed from the demand side? i.e. ensuring that it is cost effective to the consumer
ii. If Decentralised options will have to be managed from the demand side, will there be a 'Willingness-to-adopt' – is there a meeting point for these 2 standpoints within the framework of improving rural energy access?

Sub-Q: Production utility

i. To what extent will Decentralised Energy options ensure economic growth and productive usage?
iii. Will production utility actually be gained from a marginal increase in the cost of energy invested in DE by local entrepreneurs? Do you have any evaluation report that proves this? (Discussion)

RQ: Sustainability

Sub-Q: Investment

vii. Is it possible that competition in the provision of alternative energy will induce more investment in the sector and therefore provide the rural dweller with a number of alternatives to choose from? But what will induce this competition? How can we create this competition? Any examples?
viii. Decentralised Energy (Renewables) targets low income groups but the cost of renewables are considerably high. How do we reconcile these 2 positions?
ix. There is a school of thought that supports market-oriented approach to energy delivery that is expected to make the energy market equally accessible to all and attractive to local investors. In very typical rural areas, how will this may applicable? What will cause people from depending on a 'free gift of nature' to a priced commodity? Are there any examples?
x. Scalability – does this work with the market/demand driven approach to energy delivery for the poor? (Scalability is the ability to move projects from the pilot phase to its full implementation and so the question is, if we are waiting for the poor to demand before we provide as dictated in a market driven approach, can we ever scale up projects? Will there be enough demand to warrant a scaling-up?)
xi. In your various experiences, what is most fundamental for the successful implementation and sustainability of energy project at the rural level? How can appreciation at the rural level be enhanced?

Sub-Q: Supply

i. What are the typical issues with supply chain and how can these be overcome?
ii. There is the challenge of energy mix for uninterrupted supply of energy once the supply is based on more renewable energy. How can we circumvent this challenge in the promotion of renewable? What options are currently available? (...coupling with grid, etc.....)
iii. How effectively can rural DE supply systems be integrated with the centralised energy supply systems?

[*e.g. so that centralized energy supply do not compete with decentralized energy systems but rather that they complement each other; to prevent the private investors' lack of interest in low-profit rural markets due to public funded competition.* ***Direct the discussion to the possibility of the government investing and supplying Decentralised Energy as a cheaper alternative to extending the national grid to the remote rural parts*****.]**

Perspectives and suggestions

i. Concerning the current oil discovery- what will be the implications of this for energy access in the rural areas?
i. What acute recommendations gathering from your experiences, will you make towards improving rural energy access for improved economic development?

KEY INFORMANT INTERVIEW
Ministry of Energy or its Representative - PIAC

1. What is the mandate of the Public Interest Accountability Commission (PIAC)? What mechanisms are you using to ensure accountability?
2. What are the targeted areas of investment of the oil revenue? *What is the whole thinking behind this pattern of distribution and investment?* To what extent are future generations covered?
3. Is there any allocation for energy development in general and particularly for the rural areas? (follow-up: which type of energy development)
4. What is the government plan to prevent misapplication of the revenue as seen in other African countries?
5. For certain finance institutions, it is a financing policy that rural areas within the peripheries of huge energy development projects are should be supplied with energy, say around the Bui, or the Jubilee Fields. Are there development plans for the immediate surrounding rural communities? Does this plan have an energy component?

KEY INFORMANT INTERVIEW
Ministry of Energy or its Representative – Renewable Energy Sector

i. What is the mandate of the Renewable Energy Sector?
ii. Is there a Renewable Energy Plan for the rural Ghana?
iii. What approaches towards DE have you used in the past? Are there any evaluation reports about outcomes?
iv. There is a Renewable Energy Bill in Parliament currently under consideration. What is your opinion on it?
v. What are the new or emerging concepts and technologies in RE and rural energy access? (*Check for examples of implementation and/or feasibility analysis which shows they are feasible*)
vi. How best can rural energy access be confronted?
vii. Please provide Price estimates and productions cost for technologies:-
 Wind, hydro, thermal, gas, biogas, solar, 2nd generation biofuels, hydrogen, etc. for potential uses for heat, transport, engines, electricity, light… (*This will be better organized on the field*)

Alternative Energy sources and innovative energy technologies:-
Production cost and price estimates per kilowatt-hour

Alternative Energy/ Innovative Energy Technologies	**Production Cost**	**Price estimates/kwh**				
		Heat	Tpt	Engines	Elec/light	
Solar						
Wind						
Mini/micro Hydro						
Geo-thermal						
Bio-gas						
2nd generation biomass fuel						
Hydrogen						
….						
…..						
….						

viii. What are the necessary technical implementation requirements?
ix. Estimation of energy needs/requirement:

a. standard energy requirements per person (cooking, heating, lighting)

Energy needs	**standard energy requirements/person**
Cooking	
Heating	
Lighting	

INTERVIEW GUIDE ON ENERGY RESOURCE BASED ON SOME OBSERVED PATTERNS IN THE DISTRICT

Choice of Key Informant – An agricultural extension officer with a wide extension coverage, an indigene of the District; the office provides him with extensive knowledge on trees, planting and practices in the District both from a professional and an indigenous background

- Woodlots in the District and woodlot harvesting
- How sustainable is this kind of practice?
- What type of trees are they harvesting?
- The effect of firewood and charcoal production on economic trees
- Trees for fuelwood
- Trees for charcoal
- Any control measures? Can woodlots be created in the District?
- What measures are being taken to improve supply of cooking energy? What actions are being taken to prevent people from harvesting economic trees (follow-up questions)?
- Any ideas on Jatropha or other bio-fuel plants? Are these possible here?

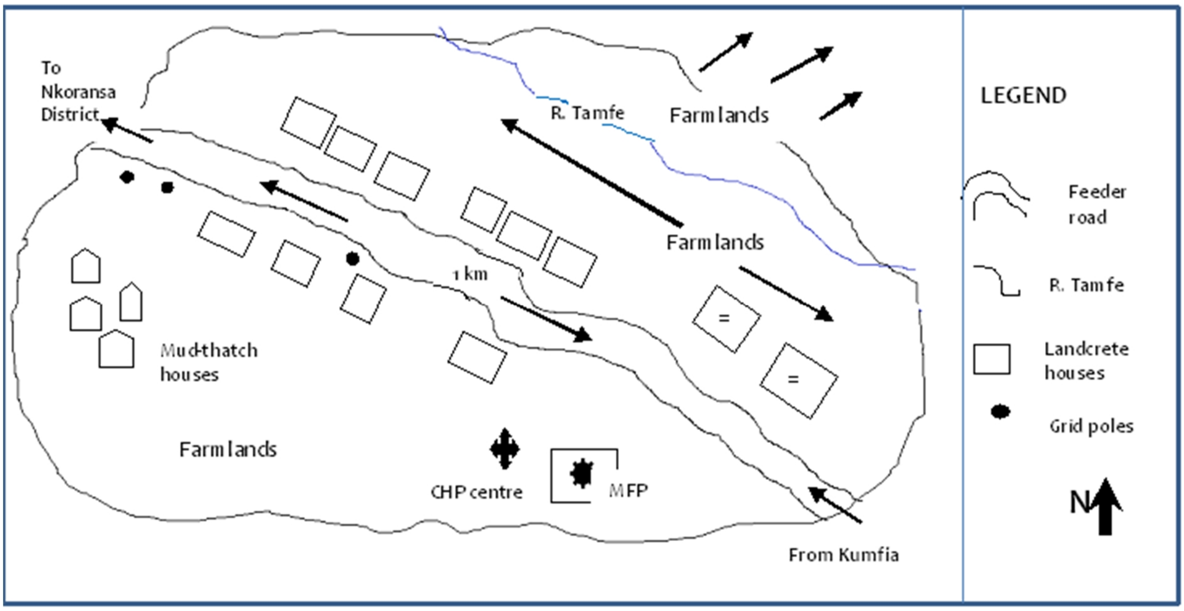
Farming

- Is farming practice manual or mechanized - Subsistence or commercial?
- Is there any energy component in the process from land clearing to harvesting?
- How do they dry and preserve their produce?

Information dissemination

- How do you communicate information across to the farming community? What is the process?
- Do other programmes use your means?

Appendix V: Sample of hand sketch of the community after transect walk - - Community structure of Fakwesi



Source: Author's Construct from field survey May-July 2012

Appendix VI: Dominant logic of multinational corporations as it relates to the BOP

Assumption	**Implication**
The poor are not our target customers, they cannot afford our products or services	Our cost structure is a given; with our cost structure, we cannot serve the BOP
The poor do not have use for product sold in developed countries	We are committed to a form of functionality
Only developed countries appreciate and pay for technological innovations	The BO does not need advanced technology solutions; they will not pay for them. Therefore, the BOP cannot be a source of innovations
The BOP market is not critical for long-term growth and vitality of MNCs	BOP markets are at best an attractive distraction
Intellectual excitement is in developed markets; it is very hard to recruit managers for BOP markets.	We cannot assign our best people to work on market development in BOP markets

Source: Prahalad, 2007

Appendix VII: Challenges in the Power Sub-sector

i. The power sub-sector faces the following challenges:
ii. Inadequate power supply infrastructure requiring huge investments;
iii. Inadequate access to electricity;
iv. High cost of fuel for electricity generation;
v. Inadequate regulatory capacity and enforcement; and
vi. Operational and management difficulties in utility companies
vii. Vulnerability to climate change

(Source: Energy Strategy Document, Ministry of Energy Ghana, 2010)

Appendix VIII: Gazetted Feed-in-tariff for Ghana

Renewable Energy Technology	FIT Effective 1st September 2013 (GHp/kWh)	USD cent/kWh equivalent
Wind	32.1085	0.14934
Solar	40.2100	0.18702
Hydro 10MW or less	26.5574	0.12352
Hydro 10MW >≤ 100MW	22.7436	0.10579
Landfill Gas	31.4696	0.14637
Sewage Gas	31.4696	0.14637
Biomass	31.4696	0.14637

Exchange rate at tariff setting – GHS1.0000 to USD0.46512
(Source: Public Utilities Regulatory Commission, 2013)

Appendix IX: 2013 Approved Electricity Tariff Rates

Residential Customer Class	Existing Tariff (GHp/kWh)	Approved Tariff (GHp/kWh)	Percentage Increase
0 – 50	9.5000	15.6750	65.0
51 – 150	17.5785	31.4479	78.9
151 – 300	17.5785	31.4479	78.9
301 – 600	22.8135	40.8134	78.9
601+	25.3483	45.3481	78.9

(Source: Public Utility and Regulatory Commission, 2013)

Appendix X: Reasons for energy preferences

Reasons for cooking energy preferences	% of respondents, N=199
Easy to use	31.8
Affordable	2.0
Available	8.1
Can be used at all times	0.7
Clean	1.4
Clean, best alternative during rains	0.7
Easy to move around	1.4
Easy to use and clean	0.7
Easy to use and effective	0.7
Easy to use and efficient	2.8
Easy to use and modern	0.7
Easy to use and safe	1.4
Easy to use and time saving	6.8
Easy to use, time saving and clean	0.7
Environmentally friendly	0.7
Familiar	1.4
Healthier and good cooking	0.7
LPG dangerous for kids	1.4
Produces more fire	0.7
Safe	1.4
Time saving	26.4
Time saving and clean	1.4

Time saving and efficient	2.0
Time saving, best alternative during rains	2.5
Time saving, have seen people using it	2.0
Total	**100.0**

Source: Author's field survey, May-July 2012

Reasons for lighting energy preferences	**% of respondents, N=199**
Easy to use	46.8
Brightness and efficiency	21.6
Economical	9.4
Time saving	3.4
Not sure when electricity will come	2.8
Modern, multiple services	2.1
Easy to use and time saving	2.0
Cheaper than solar	1.4
Added value	0.7
Better alternative with no grid soon	0.7
Better and safer than the straw	0.7
Brighter, TV possible	0.7
Brighter, economic improvement	0.7
Brighter, modern	0.7
Brighter, other services as water pumping	0.7
Easy to use and economical	0.7
Easy to use and efficient	0.7
Efficient and economical	0.7
Energy conservation	0.7
Monthly convenient billing system	0.7
Not intermittent like grid	0.7
Renewable	0.7
Ultimate	0.7
Total	**100.0**

Energy for lighting preferences among the Districts	
District	**Grid N=167**
Atebubu-Amantin	42.0
Kassena-Nankana East	30.0
Builsa	28.0
Total	**100.0**

Source: Author's field survey, May-July 2012

Reasons for learning energy preferences	**% of respondents, N=195**
Easy to use	40.9
Better illumination	37.7
Easy to use and cost effective	13.2
Easy to use and time saving	5.8
Better illumination, not sure of grid	0.8
Not intermittent like grid	0.8
Renewable	0.8
Total	**100.0**

Reasons for ironing energy preferences	% of respondents, N=159
Easy to use	46.2
Easy to use and cost effective	11.4
Time saving	9.1
Easy to use and time saving	10.6
Effective and easy to use	5.3
Economical	6.1
Safe	1.5
Safe and clean	1.5
Efficient and time saving, no burning of clothes	1.5
Available	0.8
Easy to use, clothes don't burn	0.8
Easy to use, no burning of clothes	0.8
Easy to use, time saving, no burning of clothes	0.8
Cheaper than solar	0.8
Effective and safe	0.8
Efficient and clean	0.8
Only alt; not sure grid will come	0.8
Renewable	0.8
Total	**100.0**

Appendix XI: Composite timelines of energy-requiring activities

Time (standard hours)	Energy services (% of respondents) N=199					
	Lighting	cooking	ironing	learning	radio	television
1.00	0.0	0.7	0.0	0.0	0.0	0.0
2.00	0.0	0.0	0.0	0.0	0.0	0.0
3.00	0.7	0.0	0.0	0.0	0.0	0.0
4.00	8.7	0.7	0.7	0.0	0.0	0.0
5.00	5.4	10.1	2.0	0.0	7.4	0.0
6.00	2.0	47.7	12.8	0.7	43.0	0.0
7.00	0.0	14.8	24.2	1.3	0.7	0.0
8.00	0.0	10.7	7.4	0.0	0.0	0.0
9.00	0.0	0.7	1.3	0.0	0.7	0.0
10.00	0.0	0.0	0.7	0.0	0.0	0.0
11.00	0.0	4.0	0.0	0.0	0.0	0.0
12.00	0.0	20.8	0.0	0.0	24.2	0.0
13.00	0.0	10.1	0.7	0.0	0.0	0.0
14.00	0.0	12.8	1.3	0.0	0.0	0.0
15.00	0.0	4.0	2.0	0.0	0.7	0.0
16.00	0.0	15.4	1.3	0.0	0.0	0.0
17.00	2.0	38.3	4.0	0.0	2.7	0.0
18.00	79.9	28.9	12.1	8.7	33.6	0.7
19.00	14.1	4.0	4.7	37.6	0.7	4.7

20.00	1.3	0.0	3.4	15.4	1.3	0.0
21.00	0.0	0.7	0.7	0.7	0.0	0.7
22.00	4.0	0.0	0.0	0.7	10.7	0.0
23.00	3.4	0.7	0.0	1.3	1.3	0.0

Source: Author's field survey, May-July 2012

Appendix XII: Reasons for prioritisation of common household needs

For respondents who prioritised education between 1 and 2, some of the reasons given were: '*in order to get good job in future', 'to secure a good future for the children', 'no education then trouble for us', 'knowledge is power', 'to develop a working skill for the future', 'to give the children a firm grounding to take care of me in the future', 'because the child's education is fundamental and important', 'that children will be broad minded', 'it is important to consider the future of children foremost',* and *'so kids can get good grades'*.

For water, *'it was necessary to undertake agricultural activities', 'to survive - we will die without water', 'water is life even more than food', 'it is essential for every chore', 'water is essential and everything depends on it', 'it is a basic necessity'*, and*'...that community will not be water poor'*. For a respondent in a community in Builsa District where water scarcity is a developmental issue, it was not unsurprising to receive this remark: *'...because after school the first thing a child seeks is water'*. However for respondents in the Atebubu-Amantin District (Brong Ahafo Region) where the communities were well-drained, water was poorly ranked and remarks such '*...because whatever be the case we will find some*', and '*the community has water bodies so water is not a priority'* were not uncommon.

Funeral and marriage were the least prioritized household activities. These were social events, and would not be prioritized over household needs of education, water and energy. However, respondents who prioritized these in the first three positions gave the following reasons: for funeral, some of the reasons given were '*to see the dead off', 'to seal human ties', 'a cultural obligation and the dead should not be kept for a certain length of time', 'to clear the burden of sorrow', 'it can occur at any time and people must help each other', 'to bid the dead farewell', and 'to prevent sicknesses and illness in the remaining family which happens when the dead are not sent off'*. However those who relegated funeral to the last two priority levels, one respondent asserted that '*it brings no benefit', 'nobody likes it and brings debt', 'it is not "by force" to attend', 'if you don't attend someone's own no one will attend your own (i.e. if you do not mourn with a bereaved one, no one will mourn with you when you are bereaved)', 'do for others what you want others to do for you*' [an indication of the tightly communal nature of the system and how they affect each other, and how they wish for recognition and acceptance among their own.], and '*the dead is gone and there is nothing one can do about it*'.

For marriage, one respondent had just gotten married (1), '*marriage adds to the family, means companionship and that is everything', and 'to support the celebration', 'an improvement in the family system', 'it is important', 'needs a wife to take care of the children', 'so no one can insult you (a socio-cultural reason)', 'one needs a family before one can have a child to educate the child (2) [this respondent gave education 3 after marriage], it is better and more beneficial than funeral*. For the others, *there is no need to rush*.

Appendix XIII: Key considerations before adopting

Consideration	No. of respondents (households), N=40
Affordability – first cost	12
Mode of payment	6
Sustainability and maintenance - later cost	4
Convenience or ease of use compared to current energy form	10
Efficiency	4
Benefits and disadvantages	4

How useful or important it will be to me	2
How it works – operationability	2
Productive usage	2
What other people say about it	2
Durability	1
Prestige	1
Other pressing needs at the same time	1
Project executing agency to determine the authenticity	1
Improvement in quality of life for the family such as better lighting and access to information	1
Efficiency, cleanliness of energy e.g. LPG	1
Delay in grid connection	1
Inconvenience of the current energy form torch	1
Illumination capacity of the new energy form	1

Source: Author's field survey May –July, 2014

Appendix XIV: Respondents financial response to emergency situations from quantitative survey

Measures	% of respondents, N=132
Withdraw from savings	68
Sell animals and agricultural produce	7
Borrow	25
Total	**100**

Source: Author's (quantitative) field survey, May –July 2012

Appendix XV: Summary of responses for use or non-use of potential energy resources

Responses from the Builsa and Kassena-Nanakana East District (Upper East Region)		
No	**Yes**	**Partially**
These potential energy sources support our livelihood and give us our daily bread. There are alternative sources for lighting and cooking that can be tapped into	The community has energy needs	Yes, water for electricity - with electricity we can do other things apart from vegetable farming BUT No to cow dung because the soil is impoverished without it
because the current usage boost agricultural production and 'food is a basic need'	more energy options means better standard of living	Yes, but not all the potentials
manure is highly prioritized for food production	why not, if it is useful	
because the resources are not enough and the venture will not be sustainable	would like the above to be used to generate energy for cooking and lighting	
Reservations because that will imply for instance going to look for more cow dung for manure and chicken feed. The issue here is that animal husbandry is the open grazing type. In addition, the community does not practice large scale animal farmers.	because the community has energy needs	
Would not like cow dung for energy as it is 'our only way of fertilizing our crops'		
She will not like these to be used for energy instead of their current use. She is pleased with their current use.		
Responses from the Atebubu-Amantin District (Brong Ahafo)		
No	**Yes**	**Partial**
over flooding due to damming displace residents	No reservation on the water body being used and is not afraid of it drying because 'it is a flowing river so it never dries'	but concurrently with its present use, i.e. The River can be dammed for mini-hydro but should also be allowed to be used for its domestic purposes
	so we can access to electricity for economic activities	
	if they can provide an alternative source of energy	
	to enhance economic and domestic activities	
	a mini-dam will be laudable	

Source: Author's field survey, May-July 2012

Appendix XVI: Estimating average sunlight hours per day in Atebubu-Amantin District

Average monthly hours of sunshine over the year

Location	Variable	Month											
		Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Tamale	X	260	245	250	240	250	220	170	140	160	260	280	260
Kumasi	Y	180	195	215	215	200	135	100	75	100	150	190	190

Source: Based on World Weather and Climate Information 2013[60]

Average Sunlight Hours for Sunyani (approximated for Atebubu-Amantin District)

$$= \frac{1}{2}\left\{\left(\frac{\sum x}{30} + \frac{\sum y}{30}\right)\frac{1}{12}\right\}$$

(Source: Author's Deduction)

Appendix XVII: Indicative cost-benefit analysis of suggested decentralised energy options investments

A. Solar energy options:

1. Further dissemination of kit-based solar systems

The Upper East Region at the time of field study was one of the beneficiary Regions of the off-grid solar electrification component of the Ghana Energy Development and Access Project (GEDAP). The project involved the distribution of ready-to-use solar kit-based system, i.e. solar lamps and solar home systems. The costs of the different capacities of the systems are indicated in Appendix 1a below. Although the cost of solar systems are easily obtainable from the global solar market, the estimates below are those which have been implemented in these rural communities and identified to be acceptable to the communities.

Appendix 1a: Cost of solar applications

Type of solar application	Cost (USD)
3W solar lantern	220
Solar home systems	
- 14W	530
- 20W	557
- 30W	583
- 45W	716
- 50W, quick charging, TV	Between 757 - 946
- 100W, quick charging, TV	1470

Source: Supplier quotations and Author's field survey, May – July, 2012

60 http://www.weather-and-climate.com/average-monthly-Rainfall-Temperature-Sunshine,Kumasi,Ghana (Accessed 11/12/13)

http://www.weather-and-climate.com/average-monthly-Rainfall-Temperature-Sunshine,Tamale,Ghana (Accessed 11/12/13)

It is necessary to note however that the GEDAP was implemented with a government subsidy component. Appendix 1a presents the actual cost of the systems as indicated by suppliers. In the communities studied, the market prices of decentralised system suggested were not likely to be affordable to beneficiaries. Subsidies and /or credit schemes are important components that must be built into any solar dissemination investment business model. This is linked to the objectives of this study which are also the basis upon which the energy investment recommendations are made, that is, identifying energy options that will promote both growth and development in financially depressed rural communities.

Benefits:
Similarly, the expected benefits must look beyond the financial benefits to a profit oriented investor to social and economic benefits that first promote growth and human development. Subsequently, as in the case of the GEDAP, suppliers and profit-oriented investors who are involved must be paid their economic profits by the government with support from development partners where necessary.

Expected economic benefits are:

- Human capital development as children are able to learn both in the mornings and in the evenings
- Economic growth – this may be gradual but with increased and flexible productive hours, livelihoods may be improved.

2. Solar standalone systems
The cost estimation is based on the cost of the Wichau Solar village, a solar project in the Wichau rural community in the Upper West Region. The climatic and geographical context is comparable to that in the study communities: the Upper West Region also falls in the Guinea Savannah ecological zone with similar solar radiation and diffuse radiation levels as the Upper East Region. The Wechiau Solar Power Project was conceived to demonstrate universal electrification by solar power complementation. The project was completed in 2007 at the cost of GHS 96,200 (USD100,000, at a USD to GHS exchange rate of 0.9622 as at December, 2007). The cost components involved were the costs of the solar components, installation, land, and local labour. The community provided the land and local labour. The solar power plant had a central 2kWp solar powered battery centre available for charging lead acid wet batteries.

Computed at an average inflation rate of 16.9 percent (2014), a similar project will currently cost GHS 238,999.46 which is still equivalent to USD 100,000.

Appendix 1b: Present value of Solar Village

Year	Inflation on average	Present value in GHS
	Price 2007	96,200
2008	16.5	112,073
2009	19.3	133,703.09
2010	10.75	148,076.17
2011	8.73	161,003.03
2012	11.88	180,130.20
2013	13.5	204,447.78
2014	16.9	238,999.46

Source: Author's deduction based on Adu-Asare (1999); Essandoh-Yeddu (undated); http://www.statsghana.gov.gh/

i. Study communities in the Upper East Region:
Assuming that most of households in the study communities in the Upper East Region fall within the lifeline bracket of electricity tariff rates in Ghana (0-50kWh), it may be desirable to promote this alternative since the lifeline tariff in real terms is subsidised by the government and the users pay nothing to the utility provider.

ii. Study communities in the Brong Ahafo Region:
The communities – Fakwesi and Kumfia are 33km and 23km respectively from Atebubu, the District capital. Sabidi, the third community, already falls within the SHEP threshold of electrification. Appendices 1c and Ib are estimations of the cost involved in extending electricity from Atebubu to Fakwesi and Kumfia.

Appendix 1c: Fakwesi - Extension of power supply at 33km distance in GHS

Cost component	Cost (GHS)
Time	100.00
Material	2,513,314.65
Others	181,524.04
Sub total	2,694,938.69
Contingency - 15% on-cost	404,240.80
Grand total	3,099,179.49

Source: Author's estimation based on field data from the Electricity Company of Ghana, November, 2013

Appendix 1d: Kumfia - Extension of power supply at 23km distance In GHS

Cost component	Cost (GHS)
Time	100.00
Material	1,964,004.92
Others	134,022.64
Sub total	2,098,127.56
Contingency - 15% on-cost	314,719.13
Grand total	2,412,846.69

Source: Author's estimation based on field data from the Electricity Company of Ghana, November, 2013

Compared to the cost of the Wichau Solar Village, the cost of building a solar power centre will be less than connecting Fakwesi community to the national grid.

Benefits

- Based on the Authors recommendation (See Chapter 9.3.3), even though solar power at this level cannot provide the power capacity grid electricity can, it will be good leverage in the creation of economic enclaves, where both on-grid and off-grid community complement each other.
- In the addition to enhanced household energy services such as cooking and lighting, and community services such as education and health, solar energy is also safer to use and environmentally friendly. Again, in the three communities in the Brong Ahafo Region, improvements in livelihoods are anticipated especially regarding the fishing industry, with the Yeji River as the source of supply. In December 2013, it was reported that in spite of the 50.2 percent shortfall in Ghana's domestic fish requirement, post-harvest loss in the sector was estimated at 37 percent (Ghana News Agency, December 2013 *http://www.spyghana.com/ghanas-demand-for-fish-outweighs-*

supply/ Accessed 30/12/2013). The Yeji River is one of the largest fishing sources in Ghana. The communities could be instrumental in addressing a national issue, and in the process, improve their livelihoods.

- Reduce postharvest loses
- The possibility of attracting industrial processing to that corridor of the District

3. Solar water pump

Cost:

Solar water pump can be provided as a community facility or as individual household facilities. The decision will depend on the local context after a feasibility analysis. The cost components estimated below are drawn from two projects conducted in Ghana by Sun Energy Power International in conjunction with World Vision Ghana (2008), and Caritas, iDE, SDC and ennos (2013) in a number of developing countries including Ghana respectively.

i. Community solar water pumping producing 40 litres of water a day to each person (Sun Energy Power International, 2008).

  - Capital investment include power plant, the storage tanks, the concrete tap stand faucets and necessary plumbing pipes and valves, as well as a fence to protect the equipment – GHS 171732.26 (USD 53,333 at a dollar-cedi exchange rate of 3.22 as at December 2014) per community.

  - It is estimated that the cost per person served is GHS 199.64 (USD 62).

ii. Individual farmer household pump – GHS 5367.74 (USD1667) for a 100W system pumping at 40litres per min for 6 hours a day (Caritas, iDE, SDC and ennos (2013)

Benefits:

- Potable drinking water for households and community services such as health services
- Irrigation, possibility of dry season farming and consequent increased productivity and livelihood creation and improvement, and a more consistent in-flow of income
- Physical energy of children saved and possible improvement in evening studies of school children as children they are saved the time and dangers of drawing water from the stream.

B. Multifunctional Platform

Cost:

The cost estimations are based on the Ghana MFP project implemented by KITE and funded by the UNDP.

a. Calculating the future value (as at 2014) of a multifunctional platform with the 2007 base price over the different inflation rates over seven years, the value of the MFP at 2014 will be GHS 68,657.38. The details are shown in Appendix 1e.

$FV=PV(1+i)^n$, where FV = future value, PV = present value, i=effective periodic interest rate or rate of return, n=number of periods

Appendix 1e: Estimated present value of a multifunctional platform

Price of MFP (2007)	Inflation		
USD28,721	Year	%	Future Value (FV) (GHS)
= GHS 27,635.35	2008	16.5	
	2009	19.3	
	2010	10.75	
	2011	8.73	
	2012	11.88	
	2013	13.5	
	2014	16.9	68,657.38

Source: Author's estimation based on KITE, 2007; http://www.statsghana.gov.gh/

b. The average profit made on an MFP per annum when it was implemented was USD1,476 (KITE, 2007). By implication, the payback on a platform was about 19 years. However, he cost of the MFP was subsidised to the communities. Thus, the individual owners and group owners paid 29 percent (USD 8329.09) and 35 percent (USD10052.35) respectively on credit basis for ownership of the platform (KITE, 2008). The rest of the cost was absorbed by the development partner, the UNDP. This brought the payback period to approximately 5.6years and 6.8 years for the rural individual investor and rural group investor respectively.
c. However, one of the major challenges of the UNDP programme was repayment. Therefore, the model of implementation and loan repayment is a key issue that needs to be considered by an investor.
d. The operational cost components are fuel, spare parts, operator wages, lubricants, and miscellaneous overheads. The major operational costs are fuel and maintenance (spare parts) which are approximately 39% and 10% of the total cost of operation.

Benefits:

- Income generating activities both for the operator of the platform and for livelihood activities that are promoted with access to the platform (e.g. cassava processing, shea butter processing, and milling related economic activities)
- Time saved for other activities, both domestic and economic
- Increase in farm sizes for productive activities such cassava processing
- Food processing is made easier, time is saved, drudgery related to covering long distances to process food is avoided
- Children (particularly girls) retained in school because they need not go on long errands to process food for their families
- In isolated rural communities, it also serves as a social capital
- The threshold of operation and benefits could cover other communities in the radius of about ten kilometres (Inkoom, 2009)

C. Rice briquettes

The Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH (GIZ)'s Poverty-oriented basic energy services (GIZ-HERA) programme suggest various options for briquette production ranging from commercial scale which anticipates economies-of-scale with outputs of densified product above 1,000 kg/h (kilogramme per hour), to single household consumption or family business. However, the commercial scale, as in the FAO estimation, also requires the electricity of 20kW or more and capital intensive machinery, whereas production at the family-business level can be done manually (GIZ, 2013; FAO, undated). Given the local context of the study communities where electricity is not available, manually conducted family business is proposed. Appendix 1f is a summary table adapted from GIZ that presents the range of investment requirement. From a similar project, the Food and Agricultural Organisation of the United Nations (FAO) also notes that the cost may also vary after initial implementation when raw materials which were initially free acquire a market price because of the commercialisation of the material (http://www.fao.org/docrep/T0275E/T0275E09.htm. Accessed 30/12/2014).

Appendix 1f: Biomass densification options

Pressure and build-up of temperature	Low	Moderate
Preparation process	Water slurry (solid in water)	Wet/moist (water in solid)
Binder	Natural fibres rearranged	Needs binder: clay, wax, starch, molasses
Shaping process	Hand moulded Pressed into a mould	
Means to build-up pressure	Hand	Light severs, screws
Electricity input needed	None	Optional
Labour intensity	High – can be provided by the community	Moderate
Scale of business (output in kg per hour)	low	
Capital investment	>100 EUR >1000 EUR	
	includes the cost of low pressure levers which ranges from 30-50USD	including the cost of levers - about USD750
Business premises	Drying space	

Source: Based on GIZ, 2013

Benefits:

- A source of livelihood for participating households
- An alternative and more climate friendly fuel
- Productive use of agricultural waste
- Time saving for fuelwood gatherers (women) for other productive activities such as working on the farm, without compromising household nutrition

Investment requirement from communities for suggested energy options

Given the income levels identified in the communities, investment capital requirement from participating households and communities will require an external funding support and/or a cooperative funding approach between households and local financial institutions.