Barriers to Nationwide Adoption of the Smart Grid Technology in Ghana

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***Abstract*—**The purpose of this paper is to determine the barriers affecting the nationwide adoption of the Smart Grid Technology in Ghana. It is anticipated that achieving this aim will eventually contribute to efforts in mitigating barriers to a wide scale deployment of smart technology and help the decision makers to prioritize the product feature implementations. This paper provides a quantitative approach to determine the barriers affecting the nationwide adoption of the Smart Grid Technology in Ghana. Data was collected via a survey among professionals in three energy companies in Ghana. The findings revealed that Smart grid technologies in the coming years hold the promise of significant benefits to end users, utilities, and to the functioning of the economy. However, this promise will be realized only if all artificial barriers are eliminated to the full participation of smart grid technology.

***Index Terms*—smart grade, implementation, barriers**

I. Introduction

Supply of adequate, reliable and economically priced power supply is vital for the socio-economic development of every nation. It has been observed that the growth rate of a nation has a direct relationship with the growth in the per capita electricity consumption (2009).The importance of energy cannot be denied. Energy is the underlying currency that governs everything that humans do with each other and with the natural environment which supports them as defined in Keep Conceptual Guide (1996). Access to reliable, environmentally safe and affordable energy is vital to the economic prosperity and quality of life of people around the world (Exxon Mobil, 2004).

The rapidly growing world energy use has already raised concerns over supply difficulties, exhaustion of energy resources and heavy environmental impacts such as ozone layer depletion, global warming, climate change, etc. (Grid wise History, 2007). According to McMahon (2007) current predictions show that this growing trend will continue and Energy use by Ghana will grow at an average annual rate of 3.2% and will be exceeded by 2020 Ghana's electrical grid is outdated and overburdened. Infrastructure investments over the past decades have not kept pace with the growing demand for electricity. In addition, the old grid has numerous problems including reliability and power quality, transmission and distribution bottlenecks, as well as environmental concerns that require the integration of renewable energy and distributed generation (Friedman, 2009). According to Adu (2009), energy is inefficiently used in Ghana resulting in the wastage of thirty to forty percent of total energy consumed. Adu (2009) further states that present energy use efficiency could be doubled without a loss in productivity or standard. The rationing of electricity supply in Ghana is a manifestation of the problems in the power supply system mainly because most of the equipment in use is old, obsolete and overburdened. The frequent power cuts and continual rationing of electricity is the strongest indication that problems with the transmission of electricity will persist as long as the system remains obsolete. Adu (2009) therefore stated that "the power system is as strong as its weakest link; hence because of major weak links within the power system because of lack of investment over the last 40 years, all sorts of problems occur unexpectedly within the system.

As part of the efforts at mitigating the impact of the power crisis in Ghana, the Ministry of Energy, in August 2007 launched the National Compact Fluorescent Exchange Programmed, which was intended to reduce the national electricity demand by 200-220 MW. A total of about 6 million Compact Fluorescent Lights (CFLs) were imported into the country and distributed to Government institutions and households free of charge. It resulted in Capacity Savings, 1,200MWh per day or 480GWh per year in saving. Other energy programs are (EDMP) Power Factor Correction, Load Management in Industry saved over 30MVA. Also , Energy Efficiency in Public Buildings with the government of Netherlands in 2002-2004 saves US$148,000/annum in electricity cost to Government. It is important to carry out energy efficiency programmers in the energy supply system in order to defer the construction of power plants in the interim or get more mileage out of existing generating assets.

Smart Grid technologies have the potential to reduce up to 30 percent of electricity consumption and dramatically reduce the need for the construction of new power plants or the operation of environmentally harmful sources of generation (Dellotte, 2009). According to Dellotte (2009)

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major manufacturers and utilities should explore partnerships with, and consider acquisitions of smart energy companies. Companies should not be distracted by falling oil prices because supply remains volatile and demand uncertain. Moreover, while the oil prices have dropped over 50 percent from its peak in 2008, energy costs remain well above their long-term trends. Smart Grid technologies have the potential to reduce up to 30 percent of electricity consumption and dramatically reduce the need for the construction of new power plants or the operation of environmentally harmful sources of generation (Dellotte, 2009). According to Dellotte (2009) major manufacturers and utilities should explore partnerships with, and consider acquisitions of smart energy companies. Companies should not be distracted by falling oil prices because supply remains volatile and demand uncertain. Moreover, while the oil prices have dropped over 50 percent from its peak in 2008, energy costs remain well above their long-term trends.

It is important that Governments around the world should look at the cost effectiveness of tradeoffs between sustainable energy subsidies compared with commitments to upgrading the existing grid. In line with this, the Ghana energy sector engaged the services of Better Power Lines Global Ltd (BPLG), Pittsburgh, is a smart grid technology company dedicated to leading the transformation of energy efficiency, optimisation and reliability of the energy sector. The partnership between BPL Africa and Ghana's national utility company is to enhance the implementation of smart grid technologies and broadband over power line (BPL) communications technology on the 11kV power distribution (Worldwide Telecom, 2009). In July 2008, BPLG and BPL Africa deployed a pilot project for energy sector demonstrating a modern grid. The energy sector declared the pilot project a great success, exceeding their goals for return on investment, improved energy efficiency and service reliability. Consequently Volta River Authority (VRA), Electricity Company of Ghana (ECG) and Ghana Grid Company (GRIDCo) has decided to deploy the smart grid and BPL solutions across their power distribution as identified. Ghana energy sector chose BPL Global's Power SG smart grid solutions as they believed that building an intelligent and modern grid is the best investment for the future. The move to a smarter grid promises to change the industry's entire business model and its relationship with all stakeholders, involving and affecting utilities, regulators, energy service providers, technology and automation vendors and all consumers of electric power. After the pilot project that promised to revolutionize Ghana's energy sector not much has been done.

The inability of the various utility companies to carry a wide scale deployment of the smart grid thus suggests the presence of barriers which are hindering the adoption of the smart grid technology. It is against this backdrop that this research project is being undertaken to provide answers regarding the barriers to the deployment of smart grid technology on a wide scale in Ghana.

The research question which this research seeks to answer is thus: What are the barriers affecting the nationwide adoption of the Smart Grid Technology in Ghana. Barriers to improving energy efficient technology deployment may be divided into three broad categories: economic, organisational, and behavioural barriers. In addition, some barriers may be classified as institutional and technological barriers (Sorell *et al*. 2000; Thollander 2008).

II. RESEARCH METHODOLOGY

The research questions and what a study seeks to achieve plays an important role in the selection of an appropriate research strategy (Fellow and Lui, 2008). In the case of this research, the research seeks to provide answers to what barriers are preventing the nation-wide adoption of smart grid technology in Ghana and as mentioned by Fellows and Lui (2003) the quantitative strategy is suitable for answering such questions. Also given that this research does not seek to explain a phenomenon but rather seeks to establish objectively a consensus regarding the barriers to smart grid technology, the quantitative research strategy is most appropriate. Drawing on these, the quantitative research strategy is thus adopted for this research.

In quantitative research, the review of literature yields prior formulations which are then tested objectively by data collection and analysis. The tools for collecting and analyzing data constitute the specific methods employed in research. In the case of this research, the review of literature has yielded insights into the potential barriers to smart grid which indeed constitute a prior formulation as to what the actual barriers in the Ghanaian context may be. As in quantitative research, this prior formulation must then be tested using specific research methods (tools) for data collection and analysis and in the case of this research, a questionnaire was chosen as the instrument for collecting data. The questionnaire followed the structured approach with predetermined set of questions design to capture data from respondents (Money *et al*, 2007). The questions were mainly closed questions. Closed questions mean that the possible range of responses is pre-determined by the tester (McQeen and Knussen, 2006). Likert's points scale is used as the response scale, which allows the respondent to indicate the degree of agreement/disagreement with an issue. Landaeta (2008) used closed ended question on the basis that it would promote faster responses which was critical to increase the response rate. Saunders *et al.* (2003) suggested that responses to close ended questions are generally easier to compare as the answers have been predetermined. The questionnaire is broken down into three main sections as dictated by the literature review together with yes or no questions. The questionnaire contains the barriers that inhibit the adoption of the selected clean and energy efficient technologies. The respondents, who are experts from the power sector, were asked to rank barriers, relating to the smart gird technology piloted by BPL Global Ltd. (BPLG). The barriers are classified as technical, economic and institutional barriers. The technical barrier relate to unavailability of efficient technology locally, lack of infrastructure and technical support, unreliability of the technology and inadequate Research and development

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support for using such technologies. The economic barriers include high capital cost, lack of financing and non-feasibility for small scale use. The institutional barriers include biased policies against efficient technologies multiplicity of authorities for technical clearances and inefficient electricity pricing.

The sample size for the research survey was chosen to include a wide expert inclusion so as to increase the likelihood of a high response rate. Given the technicality of the research area, the research focused on participants who are working with the ECG, VRA and GRIDCO, as such participant are well placed to respond to the issue being investigated. A total of eleven (11) questionnaires were sent to the potential pool of respondents. The questionnaire was electronic and was hosted on the website of question pro. Potential participants were identified through an online search of the companies' website (i.e. ECG, VRA and GRIDCO). The contact emails of the respondents (who are personnel responsible for energy efficient technology) were gathered from their company web sites using the contact us option for media and public press release communication. The weblink to the website where the electronic questionnaire was hosted was then sent to the participants including a covering letter.

III. DISCUSSION

Eleven (11) questionnaires were administered to professionals working in Ghana energy sector through question pro. A total of 34 people view the questionnaires. The respondents that answered questionnaire were 14 and one was uncompleted. The research analysis is therefore based on 13 valid responses constituting a 92.85% response rate.

The findings of this research agrees with other research discussed in literature with regards to economic barrier (Carlsmith *et al*.,1990).The research results reveal that lack of capital is considered to be one of the barriers. The financing barrier, sometimes called the liquidity constraint, refers to significant restrictions on capital availability for potential borrowers (Golove; Eto, 1996). Financing is of interest because it offers the potential to stimulate large-scale implementation of energy efficient technology. Also according to Mallet *et al.* (2009) national governments as well as international governmental bodies may therefore play a role in financing initial uptake of these technologies. Mallet et al. (2009) went on further to say that Government intervention in technology transfer must recognise the central role that private investors play in the transfer process. Failure to engage with private companies has been a key issue in hampering the long term success of government led initiatives since the result shows the majority respondent (75%) think that there is a positive incentive for utility seeking optimisation in smart grid deployment.

The financial barriers were closely followed by high levels of political and financial risk, inconsistent and punitive tax regimes, government energy-price subsidies, closed domestic markets, high cost of electricity generation, low emissions fines, and lack of market and management training.

Capital cost subsidy and tax incentives are the usual incentives provided to investors. Such measures could prove to be effective if applied together regulatory measures to limit local pollutants and setting benchmarks for energy efficiency. Further, mandating purchase of a certain percentage of electricity from such plants together with appropriate tariffs would provide adequate incentive for investment in such technologies.

The inefficient pricing of electricity is also identified as one of the major barriers to adoption of technology which point towards higher cost of power produced. This has been necessitated by subsidies and pricing of electricity to final consumer by most of the state utilities. Since such utilities are not able to recover the cost of supply, there is a continuous pressure to seek cheaper source of power.

Cost recovery is always a central issue as an electric utility contemplates making any large capital expenditure.

Incorporating efficiency standards such as dynamic pricing into these renewable standards would initiative state-regulated utilities to position smart equipment and technologies and essentially endorse nationwide smart grid implementation (McDonald, 2009).Regulatory reforms that decouple profits from sales and allow utilities to recover costs (and make a profit).

Government could provide a direct incentive to utilities that invest in Smart Grid technology by providing a tax credit or by reducing the depreciation period for smart grid technologies to 5 years. Smart grid technology also carries significant upfront costs that may end up saving companies and consumers in the long run. Advocates of smart grid technology say government should consider more incentives for smart grid investment, including accelerated depreciation.

The World Bank and regional development banks should work on an energy investment framework that aims to address cost, risk, institutional and information barriers to scaling up public and private investment in smart grid technology (Global Smart Energy, 2008).

Lack of market information and disagreements with joint-venture partners were considered to be the third largest barrier.

Consumer education and engagement is a top priority for reaching a common understanding. Without consumer education, the full benefits of a smarter grid cannot be realized. Consumers must understand that smart grid will benefit their society, economy, environment and wallets. McDonald (2009) stated that because most smart grid pilots will begin as opt-in programs, consumer education can serve to encourage consumers to opt in. The effective supply of relevant information of the right quality and the education and training of the consumer are important contributions to overcoming the barrier posed by the ignorant.

The literature and players involved in energy efficiency indicate a consensus that institutional barriers remain a major concern. According to McDonald (2009) for example,

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several institutional barriers have been identified in the deployment. The role of institutional barriers to energy efficient technology varies greatly between sectors.

The current research revealed that the main barriers hindering the development of the present grids and the design of future electricity networks are found in weak enforcement of regulatory standards. Regulation and standardization covering grid issues are either not harmonized or lacking in national laws and codes.

Technology risk from changing standards represents the largest risk to utilities, the development and institutionalizing of national standards that are available to all players will greatly accelerate development. Standards would cover such technical areas as communication among smart grid devices and security.

Regulations and policies enacted at state and regional levels will have a profound impact on steering smart grid success, and these policies must be conceived with an underlying, holistic understanding of the needs of the nation's energy consumers and providers.

The electricity network stakeholders and all the energy production technology sectors should work together in conceiving a future Ghana energy sector that takes into account the needs of all its users. As soon as common regulations governing the electricity systems, e.g. grid access and operation rules, are put in place (Xcel Energy Smart Grid, 2007).

The Ghana energy market and related services should be supported by a stable and clear regulatory framework, with well-established and harmonized rules across Ghana. Regulatory frameworks should have aligned incentives which secure a grid with increasingly open access, a clear investment remuneration system and keep transmission and distribution costs as low as possible. The survey showed that second ranked institutional barriers hindering the smart grid project is lack of comprehensive legal framework, multiplicity of government authorities, multiplicity of authority for technical clearances and institutional barriers.

Governments and law makers will have to prepare new legislation to take into account apparently contradictory goals and bureaucracy. Legislation will be affected by innovative technologies, the evolution of grid organizations, the requirement for greater flexibility and increased cross-border trading and by the need to ensure economic development, greater competitiveness, job creation and high quality security of supply in the Ghana

The current research seems to suggest that the lowest ranked barriers are bilateral trade restrictions, biased policies against efficient technologies, ambivalence about foreign investment. Bilateral and multilateral information sharing initiatives have an important role to play in overcoming these barriers. The success of such initiatives does, however, rely on national governments to properly engage with various stakeholders, for example through the submission of technology needs assessments which are a central. Governments in both recipient and supplier countries have a key role to play in facilitating smart grid technology transfer. Government involvement requires initiatives at both the national and international level (Mallet *et al.*, 2009).

The most significant opinion revealed by the current research were that the top two technical barriers that inhibit the adoption of smart technology are lack of infrastructure and technical support in the country and inadequate research and development support for using such technologies. National governments have an important role to play in ensuring that the appropriate infrastructure is in place to foster technological development. Also 75% of the respondent perceived that more training is needed for the existing workforce to be able to carry out wide scale deployment.

Other barriers such no environmental compulsion for option of these technologies, lack of technical and financial information and unavailability of efficient technology locally were well ranked by the respondent.

Differences in technical standards, non-feasibility for small scale use and risk associated with new technology, Low level of awareness about the technology were ranked lowest by the respondent.

Since the technology is yet to make its commercial appearance in the Ghana power sector, Lack of local technical capability to adopt, operate and maintain technology was identified as a barrier.

The majority (71 %) of respondents indicated lack of adequate preparation as one of the key barriers which has affected the project deployment which is also noted by Thollander (2008).

Measures identified to overcome this include significant enhancement of local technical support, collaboration among project developers to locally develop and adopt such technologies and to create a pool of trained manpower and to establish research centers to promote the same.

Effective policy support together with awareness and technical support would provide impetus of adoption of clean energy efficient technologies in the power sector.

The result reveals that majority of the respondents (50 %) believe that difference in technical standards is affecting smart grid deployment. According to Mallet *et al.* (2009) technology transfer is not just a process of capital equipment supply from one firm to another. Comprehensive technology transfer also includes the transfer of skills and know-how for installing, operating and maintaining technology hardware, and knowledge for understanding this technology so that further independent innovation is possible by recipient firms.

Common technical rules and tools need to be adopted by the different players regarding data exchange, modeling grids, ancillary services and their users. They must also share a vision of electrical system performance (Jiménez, 2006).

IV. CONCLUSION

Smart grid technologies in the coming years hold the promise of significant benefits to end-users, utilities, and to the functioning of the Ghanaian economy. However, this promise will be realized only if all barriers are eliminated to the full implementation of smart grid technology are eliminated. New technologies for improving the efficiency of energy use are often not adopted as quickly or as extensively as might be expected based on cost-effectiveness considerations alone. Despite profitable business opportunities and a large potential market, actual investments in energy efficient technology have not reached economically optimal levels according to many experts.

The research findings show that limited access to capital, lack of infrastructure and technical support in the country and inadequate research and development support for using such technologies constitutes by far the largest barrier to wide scale smart grid adoption. These three largest stated barriers may be difficult to overcome by government alone energy policies. Instead, company oriented policy instruments like promoting third party financing and striving for long-term energy strategies are more likely to encourage energy efficiency investments. Action is needed at national levels to remove potential barriers to technology transfer. Such action includes implementing fair trade policies, removal of technical, legal and administrative barriers, creating stable macro-economic conditions and transparent, enforceable regulatory frameworks. This study has, by exploring different barriers to energy efficient technology, contributed to important knowledge of the complex factors inhibiting and stressing the implementation of cost-effective energy efficiency investments.

The study however has limitation which merits further investigation, since the sample location is only three regions out of 10, poses some limitation to which the results of this study could be generalized although most energy sector organizations in Ghana are based in the sample location which is the Greater Accra Region. Due to this limitation, the survey may not have identified all barriers. However, this notwithstanding the study made a significant attempt at identifying the major barriers.

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