Low Cost Early Adoption Procedures for Implementing Smart Prepaid Metering Systems in African Developing Countries

An Effective Way of Dealing With Energy Crises

Eliel Keelson[1], K.O.Boateng[2]
Computer Engineering Department
Kwame Nkrumah Univ. of Science and Tech.
Kumasi, Ghana
[1]elielkeelson@gmail.com,[2]boat.soe@knust.edu.gh

Isaac Ghansah
Computer Science Department
California State University
Sacramento, U.S.A
ghansahi@ecs.csus.edu

***Abstract* – From the recent upsurge in electric energy demands, most developing countries in Africa are often plunged into extended seasons of energy crises. A great deal of these crises results in crippling these economies as well as increasing poverty. To address the crises would mean to pump in more capital resources into the energy sector. Bearing in mind that the cost of generation, transmission and distribution is borne exclusively by the consumer, it is important to note that this capital would only come from consumers. This understanding has often resulted in most utilities enormously increasing energy tariffs. Despite the continuous increase in tariffs, the issue of energy crises still persists. Evidently, this strategy is not sufficient enough. To suggest other effective measures for dealing with this problem, we first identify key challenges affecting most utilities in Africa, which make them unable to realize the needed capital to end the crises. We then suggest effective mobilization of revenue and reduction in operational cost of utilities, as additional strategies for dealing with the problem of energy crisis. We indicate that these strategies are attainable through the implementation of smart prepaid metering systems. Finally, we conclude by proposing low cost procedures for the early adoption of these systems in African developing countries.**

Keywords— Africa, Energy Crises, Utilities, Smart Metering Systems, Prepaid Metering Systems

I. INTRODUCTION

Over the past few decades, the continent of Africa has seen an increase in the number of electrification projects. This is highly due to the rapid growth in population and economic development [1]. However, most regions would still not enjoy the benefits of these electrification projects due to the predominance of energy crises facing most parts of Africa [2]. Most of these energy crises are as a result of either energy resource constraints or capacity constraints and in some cases both. To bring an end or lessen the effect of these crises would mean increasing the generation capacity and/or increasing the quantity of the energy resources needed to generate electricity [3]. It is important to note that these two measures are very cost intensive and require a lot of financial resources. For example the technical working group set up by the government of Ghana has estimated that the nation would need USD 4 billion to solve its energy crises [4].

It is worth noting that the total cost of generation, transmission and distribution of electricity is borne entirely by the consumer [5]. In other words to end these energy crises in Africa, there would be the need to mobilize revenue that is generated from payments made by consumers. Looking at the magnitude of capital required for this task, most utilities in Africa have only resorted to increasing electricity tariffs. For example in Ghana, shortly after recognizing the need for USD 4 billion, energy tariffs were increased by 78% [6]. Despite this high increment in tariffs, the estimated capital has not been realized till date and the energy crisis still remain unsolved. This is a clear indication that increasing electricity tariffs alone as a measure of raising this capital is not adequate.

Considering the inauspicious circumstances created by energy crises and the lack of an adequate strategy of dealing with the issue, it is imperative to find alternative measures of mitigating this issue. These measures should be capable of raising the needed capital without necessarily increasing tariffs. Also they should deal with challenges which make utilities unable to effectively deal with the problem of energy crises. In this paper, we propose the implementation of a smart prepaid metering system as an effective way of dealing with this problem. This measure would raise the needed capital with time by effectively mobilizing revenue, reducing the cost of operation of utilities as well as precisely matching demand with supply [7][8].

In section II of this paper we briefly highlight the adverse effects of electric energy crises to African economies. In section III we identify key challenges affecting utilities, which make them ineffective in dealing with the problem of energy crises. From section IV through to VII, we bring to light features of the smart and prepaid metering system which are essential in addressing the identified challenges and we propose its implementation. In sections VIII to XI we suggest an inexpensive procedure for the early adoption of smart prepaid metering systems in African developing countries. The conclusion is provided in section XII.

II. ELECTRIC ENERGY CRISES

Electric energy crisis can be described as a severe power shortage which makes it impossible for a utility to meet its consumers demand for electricity. These crises often last for extended periods of time; a month to several years [11]. During such periods most utilities in Africa tend to address the situation by rationing power.

Power crises have been one of the major contributing factors that have crippled most African economies. The absence of reliable power supply affects the productivity of many industries, which in a long run affects the gross domestic product (GDP) of their country [12]. African enterprises experience an average of 56 days of power outages annually which results in 6-20% losses in sales and thus affecting the GDP [13]. Fig. 1 shows the various GDP's of all the countries in the world. From the figure it is evident that Africa, as compared to all other continents, has the lowest GDP.

Power shortages are either as a result of a deficit in generation capacity and/or a constraint in the primary energy resource needed for generating electricity [11]. Therefore to end/lessen power crises in Africa would mean to increase the generation capacities and/or increase the energy resources needed to generate electricity. Both of which are cost intensive processes. For example; as submitted earlier in the introduction, Ghana has stated that it would require approximately 4 billion USD to end its current energy crises [4]. Also for the year 2013, the World Bank's aid to Africa's energy sector for 48 projects was totaled at 3 billion USD [13].

It is worth noting that a majority of the capital that runs the generation, transmission and distribution of electricity is derived from revenue mobilized from consumers [5]. This implies that the above mentioned cost intensive measures needed to salvage the crises would be majorly funded by consumers. Utilities having realized the need to raise such capital have resorted to increasing energy tariffs [6]. In Sub-Saharan Africa, the average electricity tariff is 0.13 USD per kilowatt-hour (kWh) whiles in most developed countries it ranges between 0.04 – 0.08 USD/kWh [13]. Despite these high tariffs and increments, the issue of energy crisis still persists in Africa.

So considering the current high state of energy tariffs in Africa, it would not be prudent to deal with the issue of energy crises by only increasing tariffs. There is the need for other strategic measures to raise this capital. In the next few sections, we suggest additional strategic measures for raising this capital by first identifying key challenges affecting utilities.

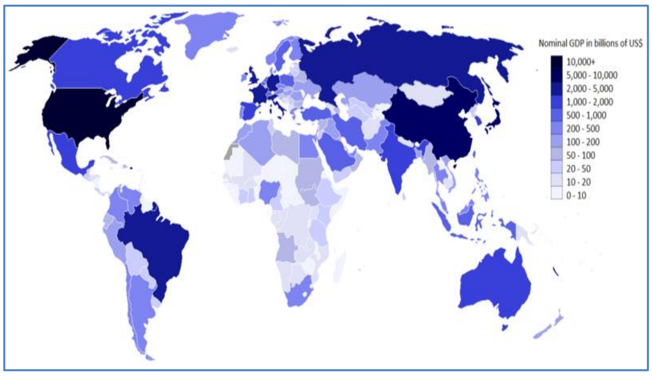

Fig.1.*World Map showing Nominal GDP [12]*

III. CHALLENGES AFFECTING UTILITIES

It would be out of place to attempt to suggest measures to ease the situation without taking a critical look at the prevailing situation of most utilities in Africa. After a careful study of the challenges affecting utilities; the reasons for the constant surge in tariffs and yet the never ending crises, the following are key:

- High operational cost
- Energy theft
- Payment defaulters

These important challenges would be touched on in detail in the following subsections.

A. *High Operational Cost*

Generation and distributing companies have to pump in a lot of financial resources to keep them running. These operational costs are on a constant rise [14]. For instance, Fig. 2 shows the cost of operation and maintenance, cost of human resource and administrative cost for Electricity Company of Ghana (ECG), the main distributing company for southern Ghana.

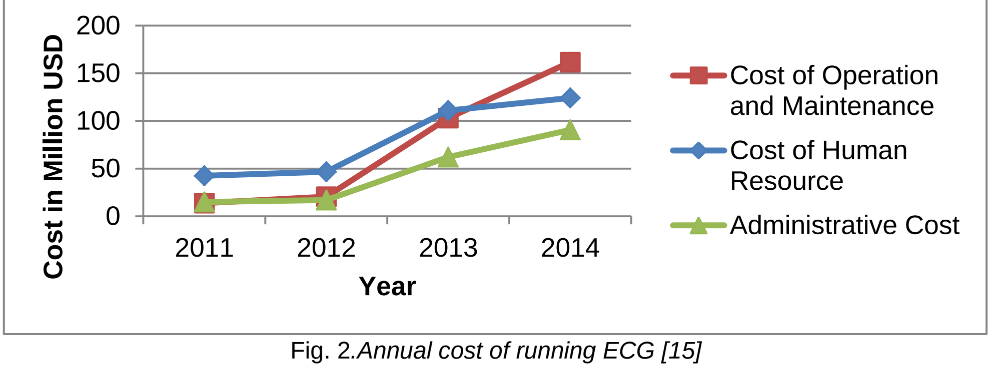

Fig. 2.*Annual cost of running ECG [15]*

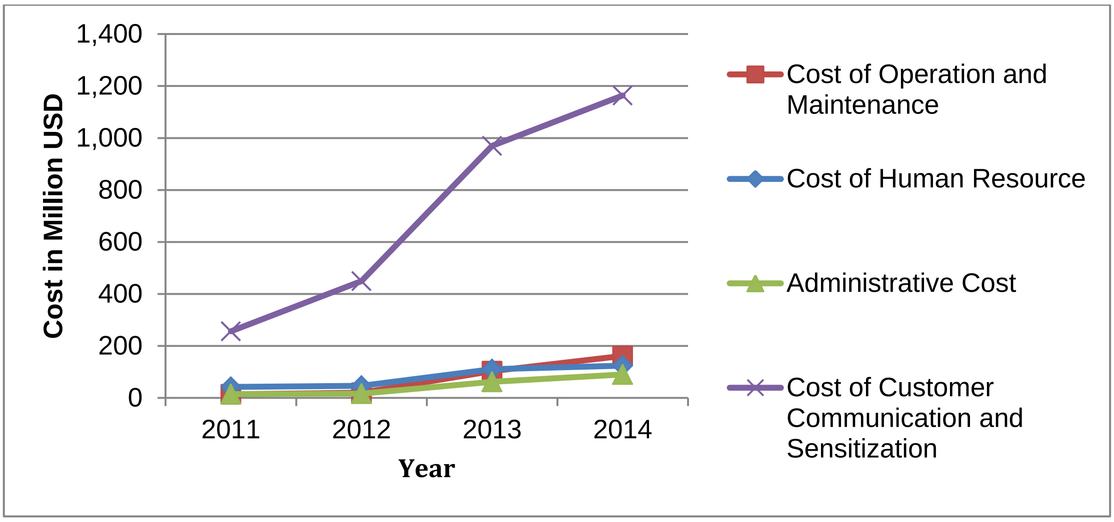

Fig. 3.*Annual Cost of Customer Communication and Sensitization [15]*

Despite the high and ever-soaring nature of the above mentioned annual costs which range between 15 million USD and 162 million USD, they are far less than the cost incurred in customer communication and sensitization. The annual cost of customer communication and sensitization incurred by the ECG between 2011 and 2014 ranges between 257 million USD and 1.16 billion USD as depicted in Fig. 3.

This cost is targeted on educating and alerting the public via radio and television adverts as well as moving vehicles installed with public address systems. Issues often addressed include: prompt payment of electricity bills, disconnection exercises, tariff updates, power outage notifications, energy theft and energy conservation tips. Reliance on these expensive communication channels are very typical of standalone postpaid metering systems. ECG currently has 70% of its customers on this system and that explains the high cost of customer communication and sensitization [16]. This is very typical of utilities in African developing countries; e.g. Kenya Power has 86% of its customers on standalone metering systems [17].

B. *Energy Theft*

Another major problem affecting the energy sector is the issue of energy theft. Energy theft is a felonious act where electric power is stolen or used illegally. This is often done by either altering the metering system or bypassing it altogether [18]. If this act goes undetected the utility would incur losses in revenue. The ECG currently records 30% of power lost through power theft [19]. Also in Zimbabwe, energy theft costs the nation a whopping 10 million USD every month [8]. Likewise South Africa is also affected by the same problem, losing an average of 450 million USD every year [20]. These losses in revenue are possible because most of these metering systems are standalone in nature and lack the technology to detect such schemes. These losses in revenue go a long way to affect the successful running of these utilities. This contributes to the reason why energy tariffs in Africa are higher than in most parts of the world and yet the most plagued by energy crises [13].

C. *Payment Defaulters*

In addition to the above mentioned problems is the issue of payment defaulters. This is also another bane for most utilities in Africa, causing high deficits in revenue. This problem persists because most parts of Africa still use credit based meters which are postpaid in nature. With this system customers are billed after a consumption period; usually a month. The postpaid nature of this system makes it possible for people to default in payments. Payment defaulters cause ECG 12.4% of its annual revenue [21]. Also Kenya Power in 2013 announced that defaulters owed the utility close to 1 billion USD [22]. These are huge losses in revenue and if paid would help utilities bridge the gap in energy demand thus bring an end to energy crises in Africa.

IV. Propsed Measures To Mitigate Crises

After having identified the above key challenges affecting utilities in Africa, we would now suggest measures that would help mitigate energy crises. From the earlier sections it has been submitted that to address this issue of energy crises would mean to increase generation capacity and/or provide ample energy resources for utilities to meet peak demand; both of which are cost intensive activities. So the strategic measures needed to mitigate energy crises in Africa should border on effectively raising the capital required for carrying out these activities.

These strategies should be aimed at increasing tariffs and levies, as the norm has often been, but to extenuate the keyed out challenges affecting the successful running of utilities. These challenges if properly dealt with would slenderize the high losses in revenue; thus making available more capital needed to mitigate energy crises. Therefore these strategic measures should effectively mobilize revenue, reduce operational cost of utilities and precisely match demand with supply.

Journal of Multidisciplinary Engineering Science and Technology (JMEST)
ISSN: 3159-0040
Vol. 2 Issue 2, February - 2015

The traditional measures of handling the challenges affecting utilities have often been consumer education, policy formulation, implementation and enforcement. These traditional measures have often not succeeded because they are long winding and highly dependent on human efforts. However, in this paper we propose the implementation of a combination of the prepaid metering system and the smart metering system as a simple method of dealing with these challenges. This combined system would effectively mobilize revenue, reduce operational cost and accurately match demand with supply. In the next two sections we would elaborate on how these systems can be used to achieve these goals.

V. Prepaid Metering Systems

Prepaid metering systems work on the principle of "pay before you use". In this system the consumer purchases some amount of credit or units from a vending point. The vendor provides the consumer with a token on which the credit has been loaded. The consumer upon reaching his premises uses the token to load the purchased credit on his electric meter. As long as his credit is not used up or expired, he would continue to have to access to electricity [7]. This process is summarized in Fig. 4 below.

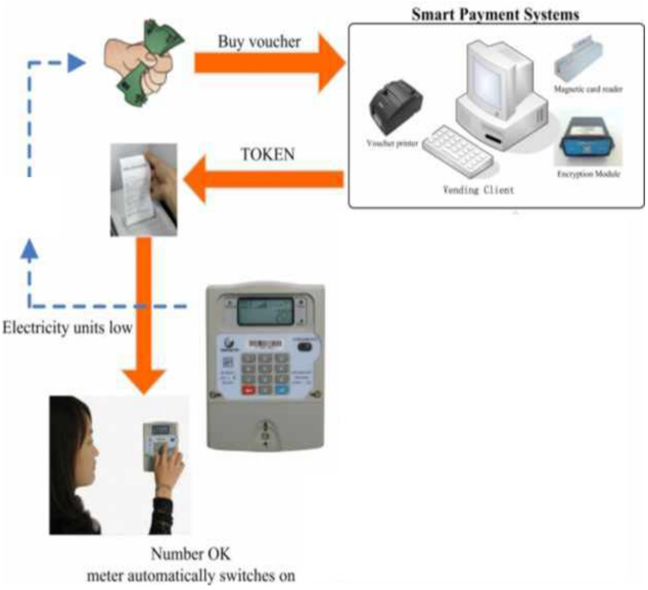

Fig. 4: *Prepaid Metering System*

This system eliminates the need for periodic meter reading, printing and distribution of bills, disconnection and reconnection hence it reduces the operational costs of utilities. This means that distribution companies will make big saves on operational cost as well as the cost of consumer communication and sensitization. This system also extinguishes payments of bills since the cost of electricity is paid for before it is consumed. This implies that the problem of payment defaulters is completely dealt with in this system.

However, most prepaid metering systems deployed in Africa are standalone in nature; lacking communication ability [8]. The absence of this communication ability makes it incapable of detecting energy theft in real-time as well as provide real-time data to utilities to help match generation with consumption. Also the absence of this capability makes it impossible to leverage on wireless mobile and online payment platforms which require no tokens. Using such payment platforms would mean energy units can be purchased at any time of the day and from anywhere without necessarily visiting a vending point. This communication ability is however present in smart metering systems [10].

VI. Smart Metering Systems

Smart metering systems are advance metering systems that are capable of recording and transmitting user electric consumption data to utilities in real-time or near real-time. With this data utilities can plan to match up demand with supply more precisely [9]. Utilities would no longer have to wait till the end of a consumption period; which is typically a month for most standalone metering systems, before studying the current nature of energy demand. This therefore eliminates the issue of generating more than is needed, thus avoiding energy waste. This in a long run would reduce the cost of operation for utilities.

Also the provision of such real-time data makes it possible to detect energy theft using consumption patterns as well as anti-tamper mechanisms [10]. This would therefore help utilities identify such culprits easily and earlier than using standalone systems. This would also mean that losses in revenue caused by energy theft would be extinguished.

With this system's two-way communication ability, utilities could leverage on modern mobile and online payment technologies to help consumers conveniently purchase energy units. This would reduce the overdependence on vending points. Vendors would no longer have to be available at all times and in all areas. These technologies are highly automated hence human resource cost and human errors are completely done away with or minimized.

This communication ability also provides utilities with the possibility of communicating and sensitizing their consumers via their meters. Messages concerning tariff updates, service disruption and energy conservation tips can be transmitted and displayed on their meters [9]. This would cause a major reduction in the cost of carrying out these processes. Also utilities can make available each consumer's consumption history on a web platform accessible via the internet which would in turn help consumers make informed decisions about their consumption lifestyle. Fig. 5 shows a basic demonstration of how the smart metering system works.

Fig. 5: *Smart Metering System*

VII. Proposed Metering System

Having identified the features of the prepaid metering system and the smart metering system which are important in addressing the issue of energy crisis, we propose the implementation of a smart prepaid metering system. This implementation would help African developing countries effectively address the issue of energy crises. This system has the combined features of the smart and prepaid metering systems and therefore offers the advantages of both systems. Some of which are:

- Remote meter reading (no more meter reading and distribution of bills – reduction in operational cost)
- Remote and real-time detection of energy theft
- Provision of real-time consumption data to help match consumption with generation
- Prepayment of energy eliminates issue of payment defaulters
- Customer sensitization via meter display
- Adoption of wireless payment platforms – convenience

Migrating from the old standalone postpaid metering system to the new smart prepaid metering system would require some initial capital investments. If this capital is very high, this migration would be infeasible for most African developing countries. Most countries in the Europe and North America that have taken this initiative have had to invest huge capital resources. For example, in July 2010, the Department of Energy and Climate Change (DECC) of the United Kingdom Impact Assessment forecasted the accelerated rollout of smart meters would cost a whopping £10 billion [23]. This high cost of deployment may be the reason why most African countries have not yet migrated from the old system.

However, we are of the view that this migration would be feasible for African developing countries if the major cost elements of this migration are optimized to meet their budget. In the next few sections we identify the major cost elements of this migration and suggest a low cost alternative for carrying out some of the identified processes.

VIII. Major Cost Elements

To suggest a low cost alternative would require identifying the major cost processes/elements in the migration which ought to be optimized. In migrating from the old system to the new system the following processes outlined in table 1 have been identified as key and costly.

TABLE 1: IDENTIFIED KEY AND COSTLY PROCESSES REQUIRED FOR MIGRATION.

	Process	**Sub Processes/ Cost Element**
1	Complete replacement of existing meters	Transportation of human resource and equipment
		Human resource needed for replacement
		Provision and installation of new smart prepaid meter
2	Network setup for two-way communication	Obtain spectrum license
		Network planning
		Network infrastructure (hardware, software, systems, structures, land/permits for structures)
		Manage dedicated network infrastructure
		Implementation of data exchange protocols and security
		Network maintenance and expansion
3	Information Technology (IT) systems, hardware and software to facilitate reception, retrieval, storage and processing of meter data.	Provision of Meter Data Management Servers (MDMS), software and backup servers
		Provision of Customer Information Servers (CIS), software and backup servers
		Provision/integration of payment platforms and customer services
		Control, fault analysis, billing, reporting and statistics and general management of systems and data.

To give an idea of how much these processes would cost, let us look at what the estimated cost was for the deployment of 15,257,931 Advanced Metering Infrastructure (AMI) smart meters in the United States of America. This deployment was carried out under the Smart Grid Investment Grant (SGIG) Program [24]. Table 2 shows the various cost elements and the incurred cost.

TABLE 2: PROCESSES AND THEIR INCURRED COST

	Process/Cost Elements	**Incurred Cost (USD)**
1	Complete replacement of existing meters	2,545,320,027
2	Network setup for two-way communication	627,632,211
3	IT systems, hardware and software to facilitate reception, retrieval, storage and processing of meter data.	634,170,814
4	Other AMI related costs	288,067,668
	TOTAL COST	**4,095,190,721**

To have a better understanding of the proportions of the various cost elements Fig. 6 shows a pie chart of the above mentioned cost elements.

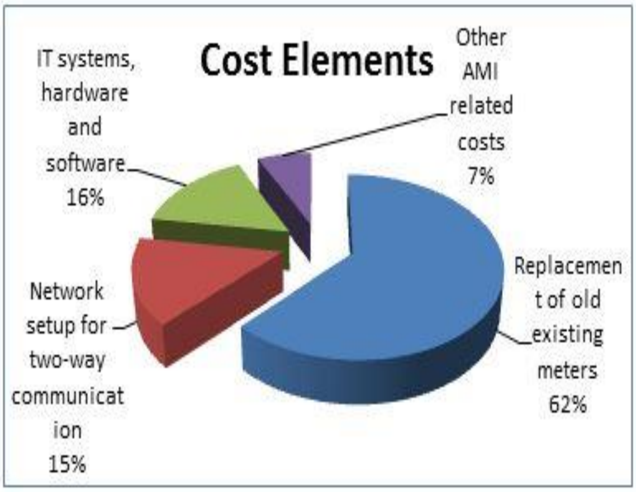

Fig.6. *Pie Chart illustrating proportions of cost elements in SGIG Program*

Each of the above mentioned cost elements are very important hence cannot be done away with completely; rather they can be optimized to meet the budget of most African developing countries. Each cost element, if brought to the barest minimal would make the migration to this new system feasible. To attempt to bring this cost to the barest minimal, we would in the next few sections prose low cost strategies for tackling the above mentioned processes. These strategies would border on two guiding principles: Outsourcing and Retrofitting, as explained in table 3.

TABLE 3: GUIDING PRINCIPLES FOR CUTTING COST

	PRINCIPLE	**BENEFITS**
1	Outsourcing	Lowers cost of operation and labour
		Little/zero investments in technology, infrastructure and people
		Helps utilities to focus on core function
		Swiftness - shorter lifetime of deployment (fewer man hours)
2	Retrofitting (maximum reuse of existing most reliable/available infrastructure/equipment)	Economical
		Time saving (swifter)
		Reliable (existing device has been tested over time)

IX. PROPOSED LOW COST ROLLOUT OF METERS

To tackle the most significant cost element, which involves the replacement of the existing postpaid standalone meters with smart prepaid meters, we are of the view that the principle of retrofitting can be applied to cut cost. In both the old and new meter there exists an overlap of functionality, which is measurement of consumption of electricity. This overlap is depicted in Fig. 7.

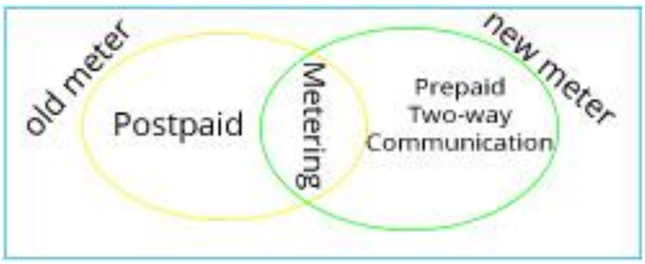

Fig. 7. Overlapping functionality between the old meter and new meter

A complete replacement would mean spending time and capital on a functionality that already exists. Since the old meter is capable of measuring consumption, it would likely be cheaper to retrofit it with just the new functionality of prepayment and two-way communication. This would mean the existing meter would still be used for measuring consumption and the retrofit would provide the additional prepaid and smart metering functionality.

In [25] a retrofit was proposed to augment an existing standalone postpaid meter with smart prepaid metering functionalities. The retrofit has the following capabilities

- Two-way communication via General Packet Radio Service (GPRS)
- Secure transmission of user consumption data
- Remote (dis)connection
- Power quality measurement
- Outage notifications and tariff updates
- Tamper proof mechanism and energy theft detection via consumption data analysis

The attachment of this retrofit to the existing meter does not require tampering or reengineering of the existing meter. This implies that the installation of this retrofit is relatively simple. Considering the fact that manual meter reading would not be required in this new system, utilities can retrain their human resource responsible for meter reading and distribution of bills to install these retrofits. This would mean that utilities would not have to recruit additional people or experts to install these retrofits, thus cutting cost.

So by installing retrofits instead of completely replacing existing meters, African developing countries can cut down the cost of this process.

X. Proposed Low Cost Network Setup

The two-way communication capability of the smart metering system is its most valuable asset; without it, the smart metering system ceases to be smart. There is therefore the need to establish a communication network between the smart meters and the utilities, through which consumption data and control information are exchanged. A simplified illustration of such a network is shown in Fig. 8 below.

Having identified the relevance of this network, countries that have rolled out smart meters have had to setup a dedicated network for the system. This process has often led them to obtain a radio spectrum license, design the network architecture, purchase hardware, software and systems required for establishing the network system. These are typical routines that Mobile Network Operators (MNOs) go through during the setup stage of a mobile network. They are often time consuming and come at a high cost.

With the economical nature of the principle of retrofitting or system reuse in mind, the paper makes a critical analysis of the existing network technologies in Africa, with the hope of reusing the most dominant and reliable. The analysis revealed that in Africa, most MNOs run on Global System for Mobile Communication (GSM) with support for GPRS [26]. Fig. 9 shows the percentage of the various populations of African countries covered by GSM technology.

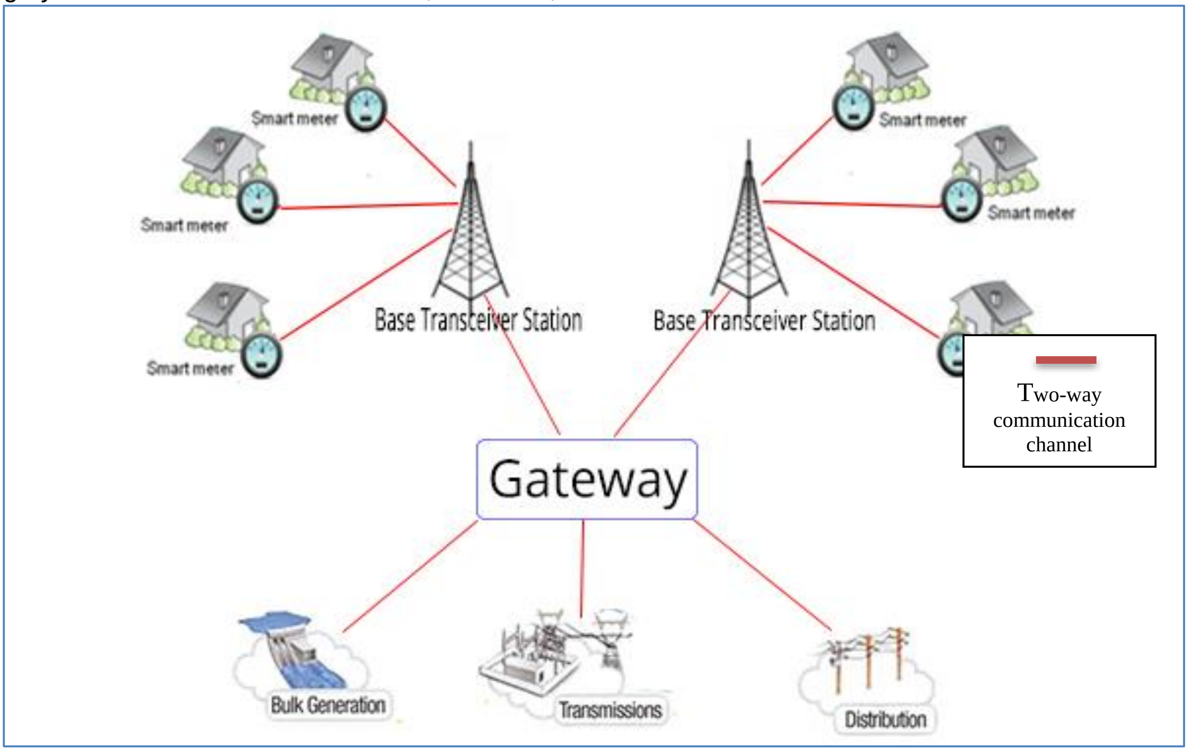

Fig 8: Smart Metering Network Architecture

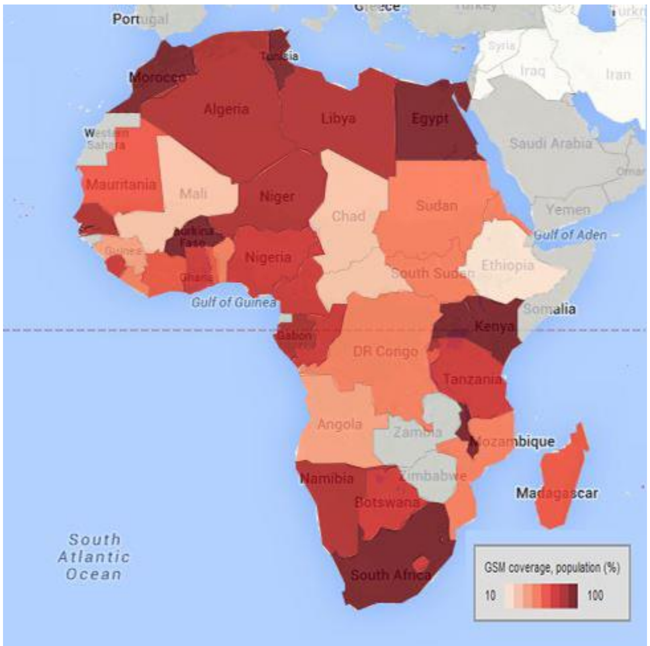

Fig.9. *Percentage of the total population of African countries covered by GSM [27]*

Based on this high coverage of GSM, we propose the reuse of the existing GSM networks as the main communication channel between smart meters and utilities. This means that smart meters would share the network infrastructure with mobile subscribers of a particular network. So for a particular cell site; i.e. the area covered by a particular Base Transceiver Station (BTS), the BTS would relay messages to and from smart meters and mobile subscribers. The manner in which the underlying network infrastructure is shared would be dependent on the prevailing conditions. Table 4 lists the possible conditions that may exist for each cell site and the proposed low cost model to be adopted by the utility in sharing the network resources.

TABLE 4: LIST OF POSSIBLE CONDITIONS THAT MAY EXIST AT CELL SITE

Model	Prevailing Condition
Model I	Ratio of BTS-to-subscribers not exceeded and far from reaching limit. Little/no congestion would exist with increasing traffic.
Model II	Ratio of BTS-to-subscribers not exceeded but close to reaching limit. Congestion may exist with increasing traffic. Traffic Class Prioritization allowed by MNO.
Model III	Ratio of BTS-to-subscribers not exceeded but close to reaching limit. Congestion may exist with increasing traffic. Traffic Class Prioritization not allowed by MNO

A. Model I

In this model the BTS treats all smart prepaid meters in its coverage area just as it treats the existing mobile subscribers. There is no differentiation between the two and no prioritization; all resources are shared equally. When consumption data are to be transmitted to utilities, smart prepaid meters transmit the messages like ordinary mobile devices would do. This model is a best fit for areas where there is a relative abundance of network resources; the ratio of mobile subscribers-to-BTS is far from the maximum limit. For such reasons, adding up a certain number of smart prepaid meters to the system would hardly affect the network's performance, thus reliability to some extent is assured. This is very typical of most rural settings in Africa. This model is cost effective and easy to deploy.

B. Model II

This model is targeted for areas where the addition of traffic from smart prepaid meters to the existing network may affect the network's performance; thus affecting reliability of message transmission. This is very typical of growing urban areas. Considering the fact that consumption data from smart prepaid meters and control data from utilities are to be transmitted in real-time or near real-time, there is the need to ensure that such messages are delivered in a timely manner. In this model, utilities and MNO's come to an agreement that smart prepaid meters and utility messages are given higher priorities on the public network. This Traffic Class Prioritization is done by changing the Quality of Service (QoS) class from the default Best Effort (BE) service class, which is common to mobile subscribers, to one of the following higher classes [28]:

- Non-real-time Polling Service (nrtPS)
- Real-time Polling Service (rtPS)
- Extended-Real-time Polling Service (ertPS)
- Unsolicited Grant Service (UGS)

By upgrading the QoS class the BTS would give preferential treatment to messages to and from smart prepaid meters. This is to ensure that such messages are given a higher reliability rate.

C. Model III

This model is a best fit for areas where there is a fast growing population of subscribers, where the ratio of subscribers-to-BTS is fast approaching its limit. This is very typical of highly populated urban areas where MNO's often carry out network maintenance and expansion activities. In such areas MNO's cannot afford to give higher priorities to utilities; i.e. giving utilities and smart meters more access to the network channel than their subscribed users. To do so would mean losing their subscribers to their competition.

In this model, the paper proposes the adoption of a Mobile Virtual Network Operator (MVNO) business model, which operates on the principle of outsourcing, as a method of cutting cost in setting up the network. An MVNO is wireless communications service provider that does not own the underlying networking infrastructure [29]. The MVNO, which is the utility, enters into an agreement with an MNO or a group of MNOs to lease the infrastructure to the MVNO to meet its network traffic requirements. So in this model, the MNO(s) sets up a dedicated channel or a Mobile Virtual Private Network (MVPN) for the utility to transmit its data. The utility does not make any investments in the infrastructure but pays for its usage at wholesale rates. Also the utility is in control of its expenditure since it would only request for services it can afford.

These suggested models can help African developing countries easily setup a network that meets their budget. Fig. 10 shows a relative comparison of the three suggested models in relation to cost of network setup, ease of deployment and reliability of network.

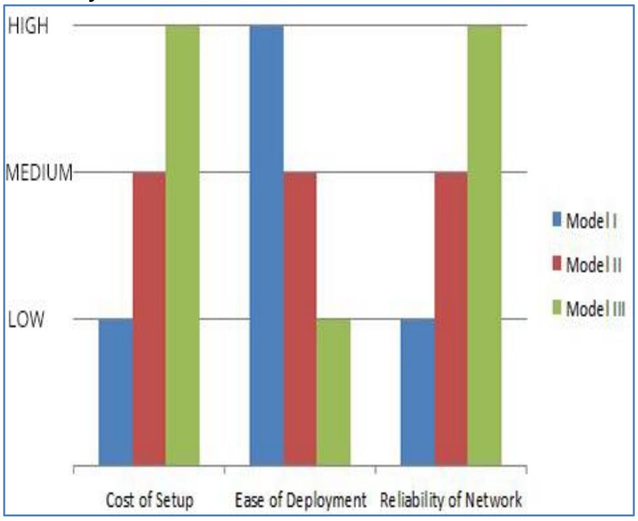

Fig.10. *Relative comparison of proposed low cost network setup models*

XI. Proposed Low Cost Data Management

After consumption data is transmitted to the utility, there is the need for the data to be critically analyzed and stored for future use. Regarding the fact that data is being transmitted from every corner of the utility's network every 30 minutes or less, data is bound to grow almost exponentially. So for 1 million users there would be 48 million transmissions of meter data at the end of each day. Apart from requiring terabytes to petabytes of storage space it would require the workforce of experts who can easily transform such large volumes of data into actionable points for qualitative decisions to be carried out in a timely manner.

Bearing in mind that these processes are not part of the utility which is about migrating's core functions, the initial setup cost would be on the high side, as depicted earlier in tables 1 and 2 above. This is because the utility would have to make huge investments in the systems and experienced human resources needed to run these systems. By adhering to the principle of outsourcing, we propose that African developing countries can carry out these processes at a low cost by adopting the following strategies:

- Using a cloud model service to store and manage data
- Outsourcing data analysis to a trusted third party

A. *Using a Cloud Model Service*

Cloud Computing is a delivery of services which are hosted over the internet [30]. By virtue of cloud computing, companies spend less time and resources in getting a service compared to the traditional ways of obtaining such services. For example, by paying a fraction of the cost of setting up and managing a custom data storage server, utilities can store their data in the cloud.

There are 3 types of cloud service models: Infrastructure-as-a-service (IaaS), Platform-as-a-service (PaaS) and Software-as-a-service (SaaS) [30]. Depending on the service requirements of the utility, it can adopt one or more of these service models for data storage from leading providers like Amazon Web Services (AWS), Google Compute Engine, IBM/SoftLayer and Microsoft Azure. Some of the advantages utilities can benefit from using these services include:

- Pay for only what they use
- Make little/no investments in hardware, software, human resource training, upgrades, licenses, power, maintenance and security
- Easily scale to handle growing needs (Highly scalable)
- Access services from any location

B. *Outsourcing Data Analysis*

To cut down cost on critically analyzing meter data in order to carry out qualitative decisions, utilities can outsource this task to trusted data analytics or scientists such as IBM, Accenture or Deloitte. This often comes at a considerable low cost as compared to employing the services of an expert. By outsourcing data analysis to analytics utilities can also enjoy the following benefits:

- Fast predictive and descriptive analysis of data which would help improve efficiency of the utility's operations
- Objective data analysis by trusted external parties
- Focus on utility's core business makes them get better at what they do.

By following the above proposed low cost alternatives, utilities in African developing countries can successfully and speedily migrate from a postpaid standalone metering system to a smart prepaid metering system. By migrating to this new system they would be capable of raising the capital needed for dealing effectively with the issue of energy crises.

XII. Conclusion

In this paper we establish the fact that energy crises in African developing countries can only be curtailed by investing more capital into the energy sector. We suggest the implementation of the smart prepaid metering system as an additional effective strategy of raising the needed capital. Finally, we propose low cost alternative procedures for the early adoption of the smart prepaid metering system in African developing countries. In our next paper each low cost procedure would be optimized further to meet extremely low budgets. We would also provide a detailed cost benefit analysis for each procedure.

References

[1] Energy Sector Management Assistance Program (ESMAP), "Implementing Energy Efficiency and Demand Side Management - South Africa's Standard Offer Model", *Briefing Note*, South Africa, July 2011.

[2] APR Energy, "A View on Global Energy - Africa Energy for Progress", APR Energy, LLC, 3600 Port Jacksonville Parkway, Jacksonville, FL 32226 USA, January 2013.

[3] Eliel Keelson, Isaac Ghansah, K.O. Boateng, "A Smart Quota System for Rationing Power in African Developing Countries", *International Journal of Computer Applications (0975 – 8887) , Volume 103 - No.15,* October 2014

[4] Edwin Appiah, "Government needs $4bn to solve energy crisis", *Myjoyonline*, http://www.myjoyonline.com/business/2013/october-24th/government-needs-4bn-to-solve-energy-crisis.php, October 2013

[5] Parliamentary Commissioner for the Environment – Te Kaitiaki Taiao a Te Whare Pāremata, "Smart Electricity Meters – How Households and the Environment can Benefit", Netherland, June 2009.

[6] Public Utilities Regulatory Commission (PURC) of Ghana, "Approved Electricity Tariffs Effective 1st October 2013", http://www.purc.com.gh/purc/node/142, November 2014

[7] Deloitte, "Evolving measures for the effective implementation of Prepaid Metering in the country", Report to 'Forum of Regulators' on Pre-paid Meter, pp. 43-52, December 2011

[8] ESI Africa, "Zimbabwe cancels pre-paid meters with immediate effect", http://www.esi-africa.com/zimbabwe-cancels-pre-paid-meters-with-immediate-effect/, October 30, 2014

[9] A Joint Project of the EEI and AEIC Meter Committees, "Smart Meters and Smart Meter Systems: A Metering Industry Perspective", *An EEI-AEIC-UTC White Paper*, pp. 5-10 March 2011.

[10] Vinod Vasant, Kamte,ERP Lead Consultant (SAP IS-U Competency), "Smart Metering", *Mphasis Corporation, Whitepaper*, pp.3, June 2012.

[11] Energy Sector Management Assistance Program (ESMAP), "Implementing Power Rationing in a Sensible Way - Lessons Learned and International Best Practices", *Report 305/05*, August 2005

[12] "Gross domestic product", *Wikipedia*, http://en.wikipedia.org/wiki/Gross_domestic_product, February 2015

[13] Chinwendu, Sustainable Conversations, "The World Bank and Energy in Africa", http://sustainableconvos.com/fact-sheet-the-world-bank-and-agriculture-in-africa-background/, September 2014

[14] Anton Eberhard, Vivien Foster, Cecilia Briceño-Garmendia, Fatimata Ouedraogo, Daniel Camos, and Maria Shkaratan, Africa Infrastructure Country Diagnostic (AICD), "Underpowered: The State of the Power Sector in Sub-Saharan Africa", World Bank, June 2008

[15] Electricity Company of Ghana, "Proposal for Review in Distribution Service", pp. 47-57, June 2013

[16] Maxwell Owusu-Asiedu, Ataa Pokuaa, Evelyn Sarfowaa Ntiamoah, Joan Ofoli-Tibboh, Evelyn Joan Owusu, " The Impact Of Prepayment Metering On Customer Energy Usage(A Case Study Of Ashanti East Ecg)", Christian Service University College, June 2011

[17]Odipo Riaga, Kachwanya,"Daily Nation is inaccurate on Kenya Power PrePaid Meters", http://www.kachwanya.com/daily-nation-inaccurate-kenya-power-prepaid-meters/, October 2014

[18] Thomas B.Smith, "Electricity theft: a comparative analysis", Energy Policy 32 (2004) 2067–2076, pp. 1-4, December 2004

[19] The Ghanaian Times, "30 Per Cent of ECG Power Lost through Thefts — M.D", http://www.ghanaiantimes.com.gh/30-per-cent-of-ecg-power-lost-through-thefts-m-d/, November 2014

[20] Africa Energy Indaba, Press Release ,"Africa Energy Indaba ups the ante with new side events for 2015", Solutions for Africa Conference and Exhibition, August 2014

[21] Ghanaweb, Buzztrick, "ECG loses 12.4% revenue due to non-payment of bills", http://buzztrick.com/buzz/2014/09/11/ecg-loses-124-revenue-due-non-payment-bills, September 2014

[22] East African Business Week, Comtex, "Kenya Power Owed U.S. $1 Billion As It Goes After Defaulters", http://www.moneyhub.net/scripts/cgiip.wsc/globalone/htm/news_article.r?vcnews-id=1036745, All African Global Media, September 2013

[23] "Smart Meter", Wikipedia, http://en.wikipedia.org/wiki/Smart_meter, June 2013.

[24] "Advanced Metering Infrastructure and Customer Systems", US Department of Energy, Office of Electricity Delivery and Energy Reliability, https://www.smartgrid.gov/recovery_act/deployment_status/ami_and_customer_systems, February 2015

[25] Eliel Keelson, K.O. Boateng, Isaac Ghansah, "A Smart Retrofitted Meter for Developing Countries", *International Journal for Computer Applications (0975 – 8887), Volume 90 – N,* March 2014

[26] "List of mobile network operators of the Middle East and Africa", Wikipedia, http://en.wikipedia.org/wiki/List_of_mobile_network_operators_of_the_Middle_East_and_Africa, March 2013.

[27] "GSM Coverage Population", Mobile for Development Impact, https://mobiledevelopmentintelligence.com/statistics/67-gsm-coverage-population, January 2015

[28] "IEEE 802.16", Wikipedia, http://en.wikipedia.org/wiki/IEEE_802.16, December 2014

[29] Comarch Telecoms, "MVNO Business – Creating a Win-Win Model", A short guide for MVNOs and mobile network operators, *Comarch , White Paper,* June 2010

[30] Krishnadas Nanath, Radhakrishna Pillai, "A Model for Cost-Benefit Analysis of Cloud Computing", *International Information Management Association, Incorporated, ISSN: 1543-5962-printed copy*, pp. 93-113, June 2013