Smart Grid Technologies and Future Motivators Influencing Change in the Electricity Sector in Tanzania

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Abstract: ***Power sector in Tanzania which includes generations, transmissions and utilizations faces with number of challenges that are unparalleled since the advent of widespread of electrical utilizations. These challenges include climate change, escalating energy prices, energy security and energy efficiency are converging to drive fundamental changes in the way energy is produced, delivered and utilized. Electrical power system of the future must produce and distribute electricity that is reliable, affordable and clean. In order to reach out these goals both the electricity grid and the existing regulatory system must be smarter. In this paper I have explore smart grid technologies, distributed generations systems, R&D efforts across the Country Tanzania and East Africa in general, and technical, economical and regulatory barriers facing modern utilities. Climate change, Distributed generations, Electricity Sector and Smart grid are the main issues in this paper.***

Keywords: Climate Change, Distributed Generation, Electricity Sector, Smart Grid

1. Introduction

Tanzania is the largest country in East Africa. Tanzania has a population of more than 47,800,000, of which only 24**%** has access to electricity. At present the Tanzania Electric Supply Company (TANESCO) is the sole vertically integrated electricity supplier in Tanzania. However, several IPPs supply power to TANESCO (with a current installed IPP capacity of 282MW in 2008).The total installed electricity capacity is 11129MW,of which 50% isthermal,49% is hydro and 1% is co-generations, Distributions from power stations occurs via 2986km of 220kv transmissions line,1971km of 132KV lines and 554km of 66 kV lines. Currently 2% of the rural populations and 39% of the urban population have access to electricity, which leads to peak demand of 1031MW while the available capacity has been dropped to 650MW due to fault generating equipment, Climate change, energy security and energy efficiency. Several new coal, gas and emergency HFO fired power station projects financed by various sources are underway. The government recognizes that there is a need to promote and enhance private investment in electricity generation, transmission and distribution projects, which should be based on rational exploitation and management of resources, and protection of the environment.

Moreover, changes in the Electricity sector must also concentrate towards capitalizing on intelligent electronic infrastructures, international standards and decentralized substation automation initiatives in order to reach a robust and capable smart grid future. Smart grid technologies are capable of rapidly detecting, analyzing and responding to various perturbations in the network by integrating advanced control methods and flexible AC Transmission System (FACTS).This paper aims to provide a state-of-the-art analysis of the principal issues that influences future change in electricity sector; engineering challenges associated with the coordination and integration of smart grid technologies; and an illustrative view of distributed generations.

2. Factors Influencing Change in Electricity Sector

Electricity and power sector as a whole faces lots of challenges; in my paper I have highlighted some of the key issues influencing the electricity Sector both at the present and in the foreseeable future. Although many of these issues are interconnected in some form or other they are intentionally discussed separately in order to establish a better insight into their influences each individual concern has on electricity market below are key factors influencing change in electricity sector.

2.1 Generations

The existing power system in Tanzania is divided into two distinct parts, interconnected grid power system and the isolated power system. There are about 1082MW of installed capacity in the interconnected grid system and a further 21.6MW of available capacity in the isolated grids. A further 15MW of generation's capacity is available through imports Uganda and Zambia

2.2 Climate Change

The threat of Climate change in Tanzania and Eastern countries is the main contributing factor prompting change in the electricity sector. The governmental panel on climate change classifies climate changes as the variation in the global atmospheric properties, either directly or indirectly caused by anthropogenic influences systematic efforts executed through statistical analysis, R&D efforts and financial supports is essential to establish new and innovative methods to reduce greenhouse gas emissions. If such mitigations actions are not taken seriously, then price wars instigated by the scarcity of fossil fuels, oil and gas resources will become apparent.

2.3 Escalating Energy Prices

Currently in Tanzania tariff is very high due to high technical and non-technical losses and scarcity of electricity, hence many people are unable to afford electricity cost. Keeping all this into account driving the utility company to be financially sick and unable to invest more for the future load growth demand. Energy prices since the turn of the millennium have increased drastically as direct result of higher fossils fuel demand and constraints in productions growth. Resources such as crude oil and natural gas have significantly soared in price, but coal in particular has skyrocketed in value due to restrictions in mining.

2.4 Financial Aspects

Tanzania or its Electricity Company (TANESCO) experiences poor financial positions. Each of the main causes is discussed in the following subsections.

2.4.1 High Transmission and Losses

Transmission losses in Tanzania continue to be among the highest in the world, and reducing losses or improving transmission efficiency is the main concern in the electric power sector. Since 49% of electricity is generated by hydro and all the hydro-power stations are located in the southern part of Tanzania while most load centers are in the northern part of the national grid is experiencing transmission and distribution losses of about 25% with frequent power outages. High power losses in the distributions systems are mainly due to aging systems, with inadequate investments over the past year resulting in unplanned extensions of distributions lines and the overloading of the system equipment such as transformers conductors

2.4.2 Revenue Losses

High revenue loss in Tanzania power sector is mainly contributed by general inefficacy in management, poor billing system due to low metering accuracy, theft, corruptions and unreliable power services. As results there is lack of investments in generations in generation capacity, repair and maintenance program. This increases the load enough income to support them selves

2.4.3 Load Growth Outstripping Supply

Current national maximum load demand is 1031MW, very close to the installed generation's capacity of 1082MW. However the average available capacity has been dropped to 650MW due to prolonged drought, lack of spinning reserve (not infrequently with no reserve margin).The situations is expected to get worse according to the demand forecast of the country for the next 15 years to come. If this forecast actualizes, it will require a triple of Tanzanian's existing generation's capacity in the next 15 years. Therefore, it is important for TANESCO expand generations capacity to meet load growth while reducing the losses and suppressing the load.

3. Smart Grid Technologies

Smart grid technologies are advanced electrical networks that support new generation's interactive energy and communications services for the final customer. The electrical networks must be live, available interconnected and coupled with real-time communications. Smart grid technologies are version of the future delivering various benefits to society in order to accomplish sustainable energy development.

The main advantages of smart grid implementation in terms of utility benefits include reduced perturbations and outages; minimal power losses and blackout prospects; lower maintenance and operational cost; lower greenhouse gas emissions; increased energy efficiency; increased large scale renewable energy and distribute generation integrations; enabled micro-grid applications and Energy Management Systems (EMS); Due to global need of energy conservations, carbon emission reduction, green energy, sustainable development, supply reserve margin, reduction of transmission of assets, many countries are devoting time and resources to smart grid technologies. The economic growth of developing countries like Tanzania depends heavily on reliability safety distribution and consumption points. Pricing and billing systems would also need to be amended to ensure that everybody is paying their fair share and reduce electricity theft corruptions and wasteful use. With this it is expected that smart grid will change the conventional concept of energy management and operations in Tanzania Power system. Some of the key requirements of the smart grid are summarized below;

- Allow for the integrations of renewable energy resources to address global climate change.
- Allow for better utilization of existing assets to address long term sustainability.
- Allow for optimized energy flow to reduce losses and lower the cost of energy.
- Allow for the management of distributed generation and energy storage to eliminate or defer system.
- Expansion and reduce the overall cost of energy.
- Allow for the integrations of communication and control across the energy system to promote.
- Interoperability and open systems and to increases safety and operational flexibility.
- Allow for active customer participation to enable far better energy conservation.

3.1 Smart Grid Frameworks

There are seven important areas that need to be addressed to make the grid Smatter these include bulk generation, transmission, distributions, customers, operations, markets and service providers. These seven areas employ many diverse elements such as Smart Meters, Advanced Metering Infrastructure (AMI), Data Management Systems, Two way Communication Networks FACTS, SCADA, Digital Sensing and Distributed Automation Systems. These sections will outline each area in order to appreciate smart grid implementation.

3.1.1 Bulk Generation

Figure 2 depicts a bulk generation site that generates power from renewable and non-renewable energy sources in bulk capacity. Bulk generation is the most crucial process used to communicate, share and exchange information with market domains. Typical Applications include control-Managing system power flow and reliability such as using phase regulators;

- Measure-Providing data collection of system performances through SCADA
- Protect-Maintaining high quality response to faults that might causes power disruption
- Asset Management-Identify equipment due dates for maintenance, operational history and device life expectancy;
- Record-Records data for evaluation and forecast purposes.

To meet the increase in energy demand as projected in the power system Master plan, TANESCO needs to tackle the present problems first and then plan for significant new in investment in generation, transmission and distribution assets. In line with the projection, the Tanzanian government recognizes that it is time to act on all those challenges in order to move toward a stronger and more secure more efficient power grid. Efforts to do so are motivated by several goals with the aim to deliver electricity to customer reliably, safety, and cost effectively and in sustainable manner.

3.1.2 Transmission

Transmission network is used to delivers electrical power to distribution network through long distance high voltage power lines and substations. These applications require real time control devices to record and optimize data through local or wide area networks. A typical example of transmission network incorporation smart grid technologies is that of a Phasor Measurement Unit (PMU). These units are installed to facilitate in Regional Transmission Operation's (RTO) and take control during faults disturbances.

3.1.3 Distributions

The reliability of the distributions system depends on its structure and the degree to which they communicate to each other. In Tanzania distributions systems are still radially configured with little telemetry, and almost all information exchanges within the system are performed by humans. The primary installed sensor base in this system is the customer with a telephone, whose call initiatives taken by Tanzania government to modernize all sub transmission and distributions systems should help in strengthening and reducing technical losses within the distributions systems. Therefore it is anticipated that

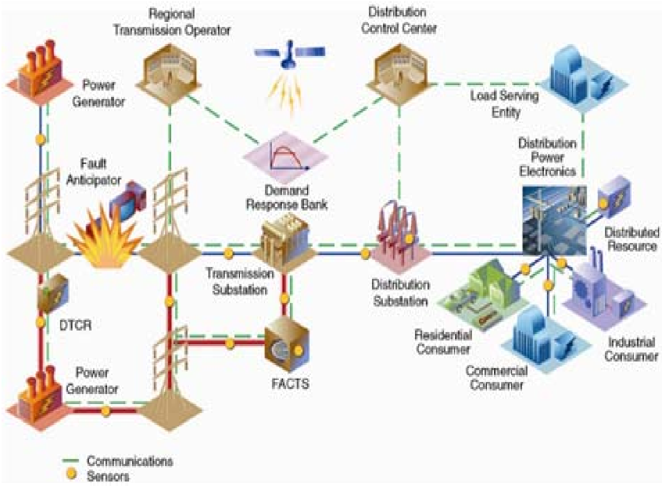

Figure 1: Architecture of integrated smart grid communications platform

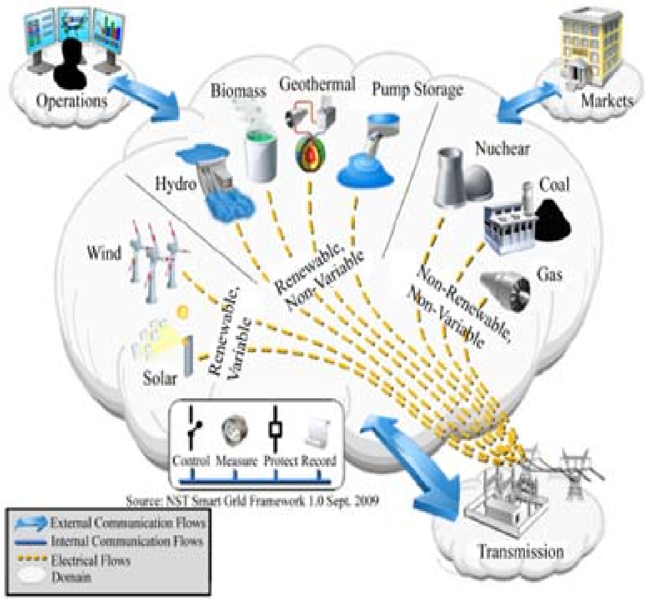

Figure 2: Bulk Generation

The modern distributions system will be able to distribute the electricity to and from the end customers in a smart way where distribution network will connect the smart meters and all intelligent field devices and manage control them through a two-way wireless or wired communication network. It may also connect to Energy storage facilities and alternative.

3.1.4 Customers

TANESCO has set a target to connect an additional 100,000 customers each year, providing further stimulus for growth. When all these customers are connected to the end- users of electricity (home, commercial/ building and industrial) are connected to the electric Distributions network through the smart meters, because Smart meters provide real-time information about electricity usage and cost to and in home display or software application that allows customers to make choices about energy use and save their electricity cost. Therefore, with this scenario, customers are becoming more proactive and are being empowered to engage in energy consumptions decisions.

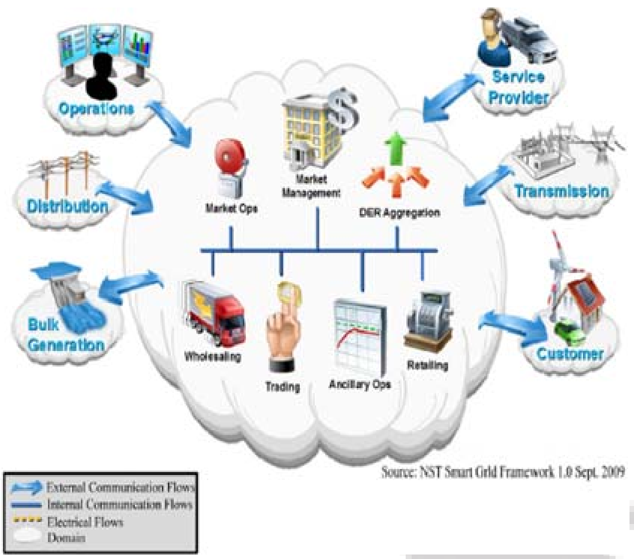

Figure 5: Markets Domain [22]

Figure 4 depicts a distribution network that delivers power from a bulk generation to the customer. Most distributed networks are radial and unidirectional (i.e. during a fault scenario the operator manually restore power to customers). This under distributed generation will become a thing of the past particularly since electricity demand continues to rise. New applications must be integrated with advanced Distribution Management Systems (ADMS) and Distributed Power Flow Restoration (DPFR) to accomplish real time communication. However ADMS and DPFR require communication protocols between distributed networks, operation and markets domains to exchange data for meter billing and energy trading. This means standards such as Distributed Network Protocols (DNP) will need to be replaced by protocols like IEC61850 seeing as the former does not support smart grid application

Electricity customers typically are divided into commercial, industrial and residential areas consume electricity in different ways and essentially contributed to energy efficiency.

Smart application and control panels;

- Smart meters
- Advanced Metering Infrastructure (AMI);
- Meter Data Hub
- OLTP for power companies;
- Interface between Meter Data Hubs and OLTP;
- Interface between SCADA and OLTP;
- Interface between OLTP and AMI

However, from a customer's point of view these real time Energy Management Systems enable end-users to receive precedential information about their electricity consumption and history allowing them to make intelligent decision on how to manage their electricity. The framework can only be implemented if a flexible open and secure infrastructure is available. Zigbee caters for these requirements and support IEEE 802.15.4 standards.

4. Smart Grid Barriers

Smart grid frameworks offer great promise enhancing environment compliance. However the transitions from centralized power system network to decentralized power system networks will create major barriers when implementing smart grid technologies. These barriers considered include technical, regulatory and economical.

4.1Techniacal Barriers

Technical barriers deal with integration issues related to automation, measurement utilities, sensors, advanced power electronics devices and standard operations. Most device installation is incompatible therefore resulting in technical barriers. Interoperability is the ability to share information that has been exchanged between two or more systems. These systems may consists of Power Quality Monitoring (PMQ), Wide Area Measurement Systems (WAMS), SCADA and various intelligent controls.

4.2 Economical Barriers

Smart grid technologies offer various benefits for utilities and consumers to manage their energy consumption. Smart grids provide flexibility for new integration of distributed generation. However, the implementation of smart grid technologies requires significant investment to upgrade the existing power system infrastructure as many devices are still expensive. Furthermore, smart grid applications moreover allow selling of small amounts of energy in liberalized market.

5. Discussion

Across the globe, certainly in Tanzania there is surely an enthusiastic push to transform the existing electric power systems through smart grid initiatives. The smart grid may mean many things to different audiences, but the smart grid in Tanzania is envisioned to meet extraordinary economic and environmental challenges, critical needs for grid security, as well as energy sustainability. It may be characterized by its objectives as summarized in the following;

- Smart transmission lines-the future transmission losses will be reduced, transmission capacity will be maximized and reliability and quality of grid power will be significantly improved.
- Smart distributions lines-the modern distribution system will be able to distribute the electricity to and from the end customers in a smart way,
- Where distribution network connects the smart meters and all intelligent field devices and manage and control them through a two-way wireless or wired communication network. It may also connect to energy storage facilities and alternative distributed energy resources at the distributed level.
- Loss reduction program-the occurrence of load-shedding will be reduced. This will increase the avenue collections and financial position to TANESCO.
- Revenue collection increases-this will allow TANESCO to improve its financial position, and therefore develop system with an adequate reserve capacity margin that can

support the development of future Tanzania power system in the most effective competitive and sustainable manner.

- Smart meters technology-the metering efficiency will be improved to enable proper energy counting improved billing system and collection
- Environmental protections-the deforestation due to excessive use of fire-wood and charcoal will be curbed and the carbon emissions will be reduced which is the urgent global priority.

With all those taken into account in the Tanzania future scenario model, it is anticipated that smart grid will resolve TANESCO challenges and enable unprecedented opportunities for growth by transforming electric power infrastructure. However, TANESCO faces a lot of challenges in findings capitals in order to refurbish and expand the system and increase access to electricity, because it has been operated mainly by getting capital from its revenue collection through tariff settings, grants fund and loan fund. Thus, the government has instructed EWURA to set tariffs adequate to meet cost of services of TANESC-O and also to ensure that the utility expenditure goes well with its cost and service (COS).The implementation of these plans may be sufficient to cover the TANESC-O COS and provide confidence to donors the meet TAN-ESCO can meet its repayment obligation.

6. Conclusions and Future Scope

With all the challenges that Tanzania faces in electric power sector, this paper has presented visions towards future Tanzanian power grid, and observations that the global smart grid initiatives should be taken in Tanzania to modernize the present power grid and boost the economy. This research has developed feasible scenarios to support planning and integration of the diverse components of the Smart Grid. The developed scenarios are envisioned to be a framework for the government at all levels to develop and evaluate public policy goals and business opportunities in modernizing the nation’s electric power infrastructure and building a clean energy economy. Following such assessment research on distributed generation systems and smart grid technologies was emphasized concentrating on previous R&D efforts across Tanzania and East African countries in general. Finally, a brief impression on smart grid barriers including technical, regulatory and economical was discussed. Positive and negative impacts were also mentioned including improving system reliability preventing under voltage drop, influencing transient stability and harmonic distortion during connection or disconnection of these technologies. Distributed Generation Systems, Smart Grid Technologies and Future Motivators Influencing Change in the Electricity Sector are currently an important issue. There- fore, since it has become a leading concern in the field of power system in particular with the development in the industrial nations worldwide, this paper will greatly valuable for further understanding in these subjects.

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