Challenges and Possible Solutions to Electricity Generation, Transmission and Distribution in the Gambia

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ABSTRACT:- The Gambia government recognizes the critical need to provide sustainable, affordable and environmentally sound energy services to all Gambians. The current electricity power generation, transmission and distribution is facing serious challenges which are hampering the entire socio-economic development of the country. The challenges are wide range including institutional, policy, strategy, manpower, technology and finance related among others. As a result, this article identified short, medium and long –term solutions needed to restore the Gambia's electricity generation, transmission and distribution performance. The possible solution need comprises of the rehabilitation of existing HFO plants, significant investments in T&D to reduce losses and the installation of smart metering system among others. The short-term investment needs include building a new HFO power plant and further T&D network improvement investments. Medium-term investments consist of regional interconnections that provide access to clean and low-cost electricity imports while the long term investments should include additional technical training for generation staff and speed up the process of upstream exploration as well as adoption of energy efficiency measures for end user benefit. Timely and efficiency investments of resources into these suggested solutions will help mitigate the current challenges and attainment of power energy goals highlighted in the National Development Plan of the Gambia.

Keywords: Electricity Generation Transmission & Distribution, The Gambia energy policy, Challenges, Possible Solutions, Electricity Road Map, National Water and Electricity Company (NAWEC).

I. INTRODUCTION

The Gambia is one of the smallest countries in mainland West Africa, surrounded by the Republic of Senegal on three sides. The country stretches approximately 400 km eastwards and its width varies between 80 km at the Atlantic and about 28 km in the inland east. The country is divided horizontally by the River Gambia and the total land area is 11,295 square km, 50% of which is arable land. Most of the population (57%) is concentrated in urban and semi-urban centers. The key long-term development challenges facing Gambia are related to its undiversified and highly import driven economy, inadequate modern sustainable energy for all Gambian among a host of others [1].

The energy sector encountered its triple challenges of low energy access, insecurity and low efficiency which is having an impact on all Gambians. The supply of modern energy services plays a significant role in the development of the Gambian economy. The availability of modern energy provides for greater opportunities in the productive sectors, in value addition services, in service production as well as other informal sectors all contributing to economic growth. Conversely, the absence or limitation in modern energy supply restricts economic growth of these sectors. By extension, inadequate supply of energy and its high cost is seriously limiting investment in The Gambia especially in productive sectors such as the agro-processing and manufacturing sectors [2].

The Gambia government recognizes these challenges of modern reliable and efficiency supply of energy. As a result, one of the key objectives of the National Development Plan of the Gambia is to ensure a reliable and adequate generation, transmission and distribution of electricity at affordable prices to all [3].

Currently, electricity generation is carried out by National Water and Electricity Company (NAWEC) - a state owner utility corporation which have two main Heavy Fuel Oil (HFO) plants plus seven small diesel provincial plants. In addition to NAWEC, there are two Independent Power Producers and a regional cross border interconnection, together supplying half of the current electricity generation. The current total installed electricity capacity of The Gambia is just over 100 megawatts (MW) with actual generation level of 50MW and thus excess demand of 50 MW. However, transmission and distribution still remains exclusive domain of NAWEC [4]. This clearly shows that the Gambia's power sector is in a precarious situation with the capacity of supplying only half of energy needed. This erratic situation is characterized by high dependence on imported fossil fuels, undiversified sources of energy in the country's power supply, low access to modern energy services, limited investment in new assets and inadequate maintenance of old and ageing power facilities [5]. With no immediate suitable plan in place to diversify energy production mix, it is therefore prudent and timely to evaluate the challenges of current power generation, transmission and distribution as well as offer tangible

solutions that will maximize electricity production through modern technology efficiency measures [6], thus the motivation and purpose of this article.

II. LITERATURE REVIEW

2.1 Role of Energy in National Development of the Gambia

As highlighted in the National Development Plan and earlier development programmes, The Gambia needs to scale up its energy services both in quality and quantity to meet the country's social and economic development needs [3]. Present per capital electricity consumption is 136 kilowatt-hours (kWh) per year against African plus global averages of over 575 kWh and 2770 kWh respectively [7]. This makes the average Gambian citizen among the lowest consumers of electricity in the world. About 58% of the population lacks access to electricity, and the level of suppressed demand in the national power sector is significant [1]. This implies that The Gambia needs to close the gap between electricity demand and supply quickly in other to give rise to sustainable development. More than 90% of Gambian households rely heavily on traditional biomass to meet their basic energy needs [8]. This comes at a significant price. It means poor fuel quality with the associated health impacts as well as an unnecessary amount of time spent in collection, though this is comparatively modest compared to other countries. Thus, energy is regarded as an essential factor for the development of the Gambia because it stimulates and supports the economic growth of the country [9].

2.2 Electricity Supply and Demand in the Gambia

The key stakeholders of the Gambia electricity sector are National Water and Electricity Company (NAWEC), the Public Utilities Regulatory Authority (PURA), the Ministry of Petroleum and Energy (MoPE). Electricity, Water and sewerage services in The Gambia are provided by NAWEC, a vertically integrated public utility corporation that handles generation, transmission and distribution of electricity as well as water production and distribution in addition to sewerage. The MoPE is responsible for the implementation of Government policy in relation to electricity supply and distribution [10].

The total installed electricity capacity of The Gambia is just over 100 megawatts (MW) with actual generation level at approximately 50MW and excess demand of 50 MW. Nationwide, about 42 percent of Gambians have access to electricity, leaving significant room for growth in the energy market to bolster economic activity throughout the country [4]. The National Water and Electricity Company (NAWEC) manage the supply and distribution of electricity in The Gambia. Transmission and distribution remains the exclusive domain of the government and is also where the largest challenges lie. In the rural areas only 13 percent of the population has access to electricity, whereas 71 percent of urban dwellers have access to electricity [10]. The Electricity Act of 2004 partially liberalized the energy market, specifically opening up electricity generation to independent producers. Currently, there are two independent power producers (IPPs) operating in The Gambia, supplying approximately half of the power generated in the country together with the cross boarder - interconnection from Senegal [4].

Nearly 44% of the electricity produced is consumed by households. Small-scale industries, hotels and larger industries use approximately 39% and commercial entities about 8%. The remaining 9% is consumed by government and NAWEC [7]. Demand for power continues to rise drastically. In 2012, generation amounted to 232 Gigawatt hours (GWh) against an estimated electricity demand of 621 GWh and is expected to exceed 800 GWh by the end of 2020 [11]. This gap between demand and supply is further exacerbated by system losses of about 22% as of 2017 [4]. The electricity market structure in the Gambia can be view in terms of consumer population, power sales, system losses as well as power and energy demand [11].

2.3 Electricity Generation, Transmission and Distribution in the Gambia

Electricity in the Gambia is produced using Heavy Fuel Oil (HFO) in the Greater Banjul Area and diesel oil for the provincial operations. All the fuel used in electricity production is imported at a great cost to the economy. Not only is the foreign exchange involved a major issue but the country is vulnerable to the price volatility of the oil prices [5]. This amongst other factors led The Gambia to having one of the highest electricity tariffs in the sub-region. Presently, there are two major HFO power plants own by NAWEC in the Gambia, in the Greater Banjul Area namely Kotu (25 MW at peak load) and Brikama (26 MW). In addition, NAWEC also maintains seven smaller diesel engine generator stations in all the provincial operations [10].

The overall energy supply from NAWEC's power plants remains low due to mechanical breakdowns [10]. Currently, there are two Independent Power Producers (IPPs) namely Global electric Group (GEG) and Karp Power ship besides the West Africa Power Pool (WAPP) regional cross boarder -interconnection from Senegal, supplying approximately half of the power generated in the country.



Figure 1: Shift in Electricity Generation, Transmission and Distribution in the Gambia

Source: PURA, 2018

There mode of electricity production is similar to the NAWEC Kotu and Brikama power station that uses HFO [7]. A huge investment is currently on going in the electricity generation in the Provinces through rural electrification project phase 1 & 2 as well as the Gambia River Basin Development Organization (OMVG) hydro-electric power regional project via dams connecting Senegal, Guinea, Gambia, and Guinea-Bissau [6].

Transmission and distribution remains the exclusive domain of NAWEC, where the largest challenges also lie. The transmission and distribution grid in the Gambia is currently divided in two subsystems: the interconnected grid, serving the Greater Banjul Area (GBA), and the isolated grids in the provinces [10].



Figure 2: Electricity Grid Infrastructural Map in the Gambia

Source: The Gambia Electricity Sector Roadmap, 2017

Currently, the interconnected grid system is composed of low voltage in 0.4 kV and medium voltage (MV) in 11 and 33 kV with just 5 transformers. Table 1 summarizes the existing transmission and distribution infrastructure at NAWEC. Technical losses are mainly due to overloaded substations and a weak distribution network. The average electricity transmission and distribution loss in the Gambia is 22% as of 2017. Electricity from the two main HFO power plants (Kotu and Brikama) is transmitted via five radial 11 kV feeders and three 33 kV feeders and also 250 km of 30 kV transmission lines are installed in the provincial grids plus 135 km of mV/LV lines and 94 km of LV overhead lines [7].

Existin	Existing T&D installations							
	Lines							
		33 kV	km	260				
		11 kV	km	250				
		0.4	km	940				
	Transformers							
		33/11 kV	piece	5				
		CSS	piece	149				
		PMT	piece	90				
	Switchgear							
		33 kV	piece	22				

Table 1: NAWEC's existing T&D infrastructure

Source: Gambia Energy Data, 2018

2.4 Electricity Costs and Tariffs

According to the energy data report, in the last two decade electricity tariffs in The Gambia were increased up to 17% [4]. Presently, consumers pay the highest electricity tariffs in the West Africa region at USD 0.28/kWh (table 2). This situation can be partially explained by the country's reliance on imported fossil fuel for electricity generation as well as its poor transmission and distribution infrastructure. Electricity generation and transmission cost are passed onto consumers resulting in high tariffs. Though, tariffs are not reflective of costs and the utility has been experiencing major financial difficulties [5].

Resources allocated to cover operation and maintenance costs are inadequate. The typical distance of villages from the grid in The Gambia is 5-25 km. The cost of transmission lines to connect these communities with low electricity demand to the grid could amount to USD50, 000-100,000/km. While this is a financial liability for the utility, it also opens a window of opportunity for decentralizing energy generation [7]. Comparison of tariff affordability in select West African countries is highlighted below.

Table 2: Tal III Comparison of Select West African Countries							
Country	Effective	Monthly	% of monthly per				
residential tariff		per capita	capita GDP spent				
	(US cents) @	GDP (USD)	on 100kWh of				
	100kWh/month		electricity				
The Gambia	28.0	98	21.7				
Senegal	23.8	139	17.2				
Burkina Faso	20.0	103	19.5				
Cote d' Ivoire	11.9	134	8.9				
Ghana	8.2	128	6.4				

Table 2: Tariff Con	parison of Select	: West African	Countries

Source: World Bank 2017, NAWEC 2017

Furthermore, grid connection fees can amount to USD 230-1800 (with a median cost of USD 600). This is a prohibitive cost for low-income households [11].

2.5 Challenges of Electricity Generation, Transmission and Distribution

According to New Electricity Road Map Document, Some of the key obstacles that pose challenges to progress include NAWEC's unsustainable debt levels, inadequate spending on maintenance of HFO engines and

low tariffs rates which leaves NAWEC exposed to external shocks beyond its control. These obstacles are explained in more detail below.

2.5.1 NAWEC is highly indebted and essentially bankrupt. For years, collected revenues have not covered accrued costs forcing the utility to expand its debt to cover short term operating costs in addition to investment needs. Despite a 12 percent tariff increase in January 2015 in addition to government backed debt restructure in March 2015 through a form of consolidated bond which aggregate NAWEC debt to around 9.5 billion dalasis (approximately \$215 million), equivalent to four times the annual utility revenue or around 20 percent of GDP. The debt is so large that loan default threatens the stability of the nation's banking system, often forcing the government to bail out NAWEC [5, 6].

2.5.2 In addition, due to a constrained financial position, NAWEC has been unable to carry out all of its routine maintenance activities, thus significant reduction in the generation capacity of the corporation and increase in T&D losses. Even if NAWEC collected 100 percent of its billed revenue, cash collected would not be sufficient to cover costs; the current tariff levels are inadequate to cover accrued operational cost of NAWEC [4, 7, 9, 10].

2.5.3 Furthermore, the tariff structure leaves NAWEC exposed to external shocks beyond its control. For example, between 2000 and 2016, the Gambian Dalasi depreciated 200 percent against the US dollar. There is no automatic pass through mechanism in the tariff structure to respond to these shocks, and no minimum period within which tariff reviews need to happen. The utility therefore remains exposed to global oil price shocks and exchange rate fluctuations which are beyond its control [5, 7].

2.5.4 Besides NAWEC remains a small and traditional vertically integrated state owned utility due to limited investment in new assets and inadequate maintenance of old and ageing power facilities [7, 10].

2.5.5 Also, the Gambia's electricity generation is characterized by high dependence on imported fossil fuels. Thus, give rise to low access to modern energy mix services [4, 5, 6, 7, 8, 9, 10, & 11].

2.5.6 Moreover, inadequate technical staff competent, high cost of spare parts, old and obsolescent generators and transformers have all hampered the scaling-up process of electricity in Gambia. NAWEC is not able to adequately solve these problems because of high overhead costs [4, 7, 9, & 10].

III. METHOLODOGY

According to [12] "Gap Analysis Model" is a research methodology that premised on the fact that service quality is dependent on the size and direction of the gap between expected service and perceived (actual) service (Q = P-E). Later studies on the model [13, 14, 15, 16] revealed that service quality include both "technical quality or outcome quality of a service"; and the "functional quality or process quality of the service". These studies were based on the modified blended model from the pioneer model .Therefore, this article conduct rapid assessment technique through a comprehensive desk review as well as stakeholder consultation covering government ministries and departments, utility corporations and development partners in The Gambia energy sector.

IV. DISCUSSIONS ON THE POSSIBLE SOLUTIONS TO THE CHALLENGES

Electricity in the Gambia has key challenges in terms of quality and access. The existing power infrastructure is dilapidated and urgently needs modernizing and refurbishing. Voltage fluctuation, spikes, blackouts, brownouts and other disruptions create concern for industrial, commercial and residential customers. The continued dependence on imported fuel for generating electricity is also taking its toll on the wider economy. In short, the energy system has become a burden on the Gambian economy and society – part of the problem of development rather than the solution. The status quo is unsustainable. By extension, The Gambian government considers the provision of electricity to all as critical inclusive economic transformation. The Gambia's current electricity generation, transmission and distribution is characterized by the following features: i) High dependence on imported fossil fuels , ii) The dominance of traditional biomass sources in the country's energy mix , iii) Low access to modern energy services , iv) Limited investment in new assets and inadequate maintenance of old and ageing power facilities. This shows that the power sector is in a precarious situation and needs a modern sustainable energy production solution. Some possible solutions to this erratic situation are discussed below.

4.1 The most urgent basic solution to this erratic power supply in the Gambia is to rehabilitate and modernize the existing HFO plants in Kotu and Brikama. This short-term investment needs include new power plants to run on HFO and further T&D network improvement investments.

4.2 In additional, NAWEC need to restructure its debt through developing a debt sustainability plan by putting in place a strong financial management and control system to avoid the situation repeating itself.

4.3 The energy stakeholders should address the challenge by developing a policy framework and functioning business models that attract investment into a mix of on- and off-grid electricity generation. To meet these requirements, the government should formulate several strategies with objectives of rapidly expanding the

current installed electricity capacity, thus expand and upgrade the current generation, transmission and distribution capacity.

4.4 The energy sector in The Gambia faces vexing problems. This sector has a budgetary constraint due to its dependence on imported fuel and weak electricity infrastructure to support the desired economic and social development. This difficulty is more pronounced in rural where there is a widespread of poverty, low income, low electricity supply and the inherent disadvantage of being further from the grid. To this effect, energy stakeholders can increase generation capacity through Independent Power Production off-grid connected power to provincial communities especially renewal sources of energy is the way forward. This will enhance decentralized energy sources to meet the emerging local energy needs.

4.5 Furthermore, NAWEC and other key energy stakeholders should develop and implement Least Cost Power Development Plan (LCPDP). The LCPDP will provide guidance to the government on how to expand the electricity sector to meet the needs of customers while minimizing total system cost, it will also help to diversify the energy mix to reduce NAWEC's exposure to oil prices and transition towards cleaner energy sources in line with The Gambia's COP21 commitments.

4.6 Substantial investments are needed to meet infrastructure and plant modernization costs, although the greatest proportion of operating cost emanate from high fuel cost. A parallel strategy is also important to meet the needs of low energy - consuming communities located far from the grid. The Gambia has the opportunity to create a more cost-effective off-grid renewal energy supply system. This could play a major role in reducing the nation's dependency on imported fossil fuel, diversifying the electricity mix and increasing access to energy services.

- **4.7** It is critical to improve the management of NAWEC by signing a service contract between NAWEC and Gambia Government. The service contract should also implement a revenue protection plan, design a new IT system for finance (commercial and HR) and support the separation of accounts for the various service lines (Electricity, water, sewerage). It can equally provide advisory support to the key management functional areas such as Finance, Commercial and Technical. In addition, a Performance Contract may also be introduced between the State and NAWEC to enhance the operational performance of NAWEC. Furthermore, unbundling the utility into separate companies according to service line should be the next step energy service institutional reforms.
- **4.8** Limiting energy losses along the power system chain, i.e., from generation to end-use is critical. This should form part of The Gambia's future energy strategy. This can be solved through adoption of energy efficiency demand-side measures through investing in end-user energy efficiency (through technology intervention and awareness-raising) which will increase the availability of system-wide electricity generation and transmission capacity for uses.

V. CONCLUSION

The Gambia's power sector is in a precarious situation. Merely 50MW of generation capacity is available compare to 100 MW demand, meaning blackouts are pervasive. Moreover, the national electricity and water utility (NAWEC) is not financially viable as manifested by its mushroomed debt of 9 billion dalasis (approximately US\$200 million). However, there is real reason for hope. There are potentially game changing developments on the horizon such as the ability to import low-cost power via a regional interconnection. The new political chapter in The Gambia provides a fresh start to the sector with fresh leadership. This provides an opportune moment to reassess the country's power sector and offer tangible solutions to the current challenges, thus the aim of this article. The Gambia's current power sector is currently facing several challenges including inadequate business model, operational problems, inadequate technology and finance related among others. These challenges give rise to unsustainable debt levels, inadequate spending on maintenance of HFO engines and tariffs rates that are too low and thus exposed NAWEC to external shocks beyond its control.

These challenges are seriously hampering the adequate, reliable plus affordable electricity generation, transmission and distribution and therefore need urgent practical solutions. This article suggested solutions are that, energy stakeholders need to restructure NAWEC's debt by developing a debt sustainability plan which will put in place a strong financial management and control system to avoid the situation repeating itself. NAWEC should also renegotiate its fuel supply contract with Gambia National Petroleum Company (GNPC), rehabilitate its existing HFO plants, invest in T&D to reduce losses and improve electricity network infrastructure. Also, energy stakeholders should invest in new power plants to run on HFO and improve the capacity of generation staff through training. These recommendations are aim at solving Gambia's current power challenges base on Least Cost Power Development Plan (LCPDP).

The judicious implementations of these suggest solutions will avail the Gambia government the opportunity to generate, transmit and distribute adequate, reliable, affordable and sustainable energy for all Gambians.

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Author: MUSA MANNEH

93 | Page