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Research paper

# Barriers to implementation of smart grids and virtual power plant in sub-saharan region—focus Botswana

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## HIGHLIGHTS

- Smart Mini Grid Model and Smart system design for segregating loads.
- Feeder segregation for residential and industrial load with allowance for demand growth.
- Grid tied inverter can be used to ensure integration to the central grid.
- Ensure Public–Private Partnership.
- Optimally spread framework across the chain guarding and minimizing the investors from risk needs to be implemented.

## ARTICLE INFO

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## ABSTRACT

If Vision 2030 of UN to provide electricity to everyone be achieved, it is essential that over 40% of Botswana's population living without electricity be looked into from different perspectives and new models. In all smart grid models, it is often emphasized that the residents and the consumers play a vital role in electricity management of Supply and Demand and are expected to be co-producers of electricity. This article looks into the various challenges and success that Botswana has achieved in terms of implementing new technologies and what needs to be done to provide electricity to the rest of the 40% of the community without electricity. This article goes on to describe how a small smart mini grid could serve as a purpose to aid in village development.



## 1. Introduction

As of 2016, over 5 million people across the globe have been living without electricity, and this poses a significant challenge to many developing nations. The grid infrastructure across many countries still operate in the same manner, and not much has changed in its outlook. The same holds good for the generation part of the energy. One of the primary reason for the above is the inability of the Governments to focus on advanced technologies (Fangxing, Fran et al., 2010; Clement and Kevin, n.d.). According to WHO, global health observatory, WHO, Global Health Observatory (n.d.). "Earth's population has become abundant, but the number of world inhabitants living in cities has not surpassed people living by the countryside until recent years". Therefore, the demand for energy is expected to grow significantly and considering the limited resources, it becomes a bottleneck on the fossil resources and depleting natural resources. It is therefore essential to tap the renewable and alternative energy resources to lower the impact on the planet (Rodríguez-Molina et al., 2014).

The entire region of Sub-Saharan insurmountable challenges in the form Energy and Climate change and the Socio-Economic growth of the region remains in its ability to harness energy, which is critical to its growth. As indicated in Fig. 1, lack of access to critical commodity, 'electricity' is an essential determinant of poverty in Sub-Saharan Africa (Deichmann et al., 2011). According to world energy outlook report 2014, Sub-Saharan Africa has more than 620 million people without access to electricity, that is nearly half of

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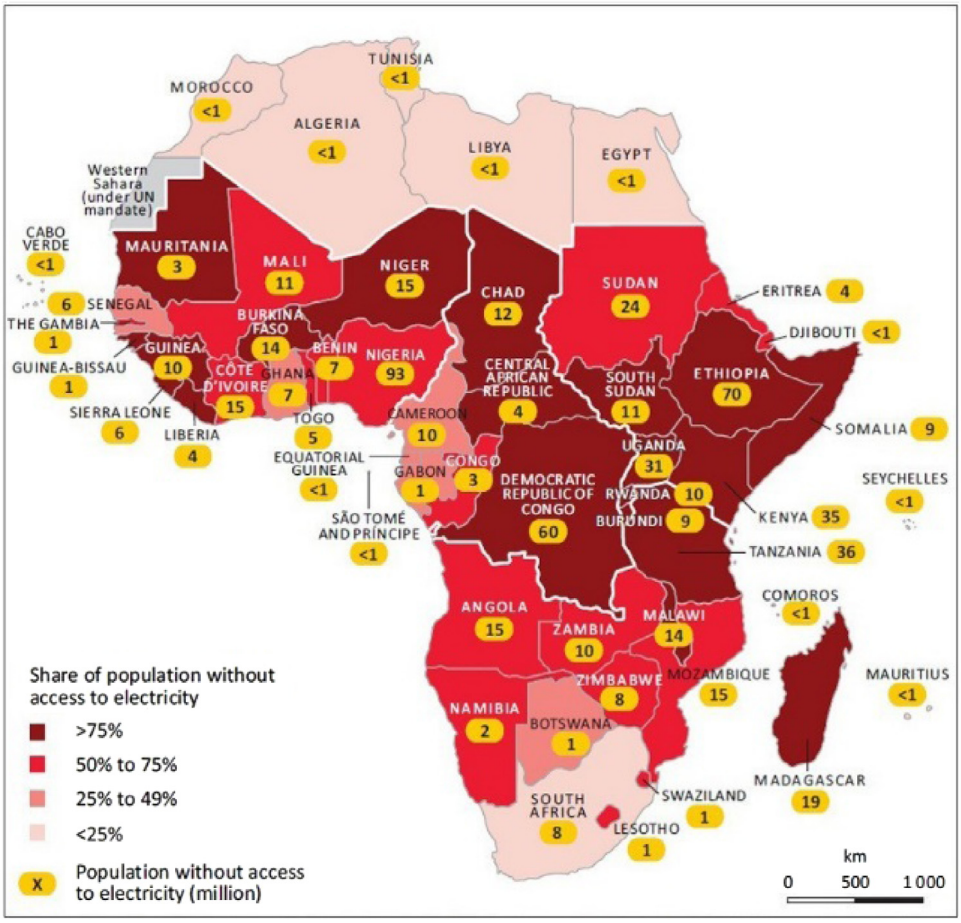


**Fig. 1.** Population without access to electricity.
*Source:* IEA (2014a, b).

total global figure and is rising day by day due to rapid population growth. Though the overall access to electricity rate for the region improved to 23% in 2012, the access to electricity remains a distant dream for many (IEA, 2014a, b). UN 2030 agenda for sustainable development reports includes an agenda on energy. As adopted it envisions to eradicate global energy poverty by providing access to affordable, reliable and sustainable energy to all (UN, 2015). It is essential for the region to attain 100% electricity access to its people while mitigating the impact of climate change and reducing the carbon print across the region. Technologies like renewable energy system for generating electricity storage has far-reaching socio-economic benefits. It is essential that the Governments play a pivotal role in encouraging the use of renewable energy sources to develop its energy infrastructure (Hoeven, 2014). In Sub-Saharan energy, the report estimates 423 Twh in 2010 including self-generation, such as diesel generators (Castellano et al., 2015). The International Energy Agency (IEA) expects the total demand for electricity in Africa to increase at an average rate of 4% a year until 2040 (IEA, 2014a, b). There has also been increasing attention on poverty alleviation through energy access improvement among international organizations in the energy field (Kanagawa and Nakata, 2008). To meet this growing demand in the region, it is essential that the nations must double up significantly and expand their generation capacity. While upgrading it is essential that the infrastructure regarding the transmission and distribution network also be upgraded with latest technologies. To achieve the vision of UN, it is critical that the rural areas in the Sub-Saharan African region be targeted for rural electrification. Academicians define rural electrification as a percentage of rural population with access to electricity (Paul, 2011; Trotter, 2016). Kanagawa and Nakata (2008) highlight a critical factor for increasing access to rural electrification by stressing the importance of higher literacy rates by upgrading school and higher education. Within Sub-Saharan Africa, there is a great disparity that exists in both rural electrification and urban electrification (Trotter, 2016). This inequality is critical to understanding when electrification takes place in the areas.

Except for South Africa in Sub-Saharan Africa, the rest of the Nations rank last among global regions in energy consumption per capita (DHS, 2009). While many rural areas and villages have practically no access to electricity except for the power relatively owned by affordable entities, it is critical to understand the reason for the areas starved. In understanding the comparison between the rest of the globe, (Latin America and the Caribbean) the urban and rural distributions for the Sub-Saharan Africa is relatively decidedly less, in fact so low that they hardly overlap (Deichmann et al., 2011). The key to solving the energy crises and the climate challenges in the region is through renewable energy. However, the limiting factor is useful policy frameworks, technical, financing and education to its clients and citizens and to enable the region to develop these resources (Avila et al., 2017).

The Department of Energy Affairs (EAD) within the Ministry of Minerals, Energy & Water (MMEWR) leads the country's national energy policy in Botswana. MMEWR through Botswana Power Corporation (BPC) is the main decision maker for the power generation, transmission, and distribution. EAD administers the Electricity Supply Act, which latest amendment promotes IPP's participation (USAID, 2016) to achieve security supply in power