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The Dilemma, Challenges and Prospects of Hydropower Generation in West Africa

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Abstract
Hydropower – energy which is generated from a large body of water is a major potential source of energy in Africa, which is capable of meeting the industrial, commercial and domestic energy and electricity requirements of the continent. The paper discusses the hydropower potential of the West African region and the current constraints in the exploitation of the valuable resource. The paper highlights the current trends in the exploitation of the hydropower resource in West Africa which currently stands at 10 – 12%, which indicates that there is a huge potential for further development in the sector, considering the energy deficit in the sub – region and the low electricity connectivity access in the major countries in West Africa. The paper further discusses the many constraints and challenges confronting hydropower development, particularly small hydropower development in West Africa. Some of the challenges identified include climate change, policy and instrumental barriers, as well as environmental and public health issues. The paper concludes by highlighting the potentials in mitigating the problem including research collaborative by two major universities within the sub – region to provide solution to this ever daunting challenges and constraints.

Keywords
Hydropower–Energy consumption–West Africa–Africa

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1. Introduction

There has been rising demand for power in Africa due to rapid economic growth, population growth and urbanization. Hydropower is a major and vital source of energy for meeting this increasing electricity demand particularly in the industrial, domestic and service sectors of the economy. Sustainable electricity supply not only supports social and economic development processes but also environmental and global climate change management and hence its importance in attainment of the Millennium Development Goals.

The West Africa region has great hydropower potential that can provide for the energy requirements of the region in an affordable, sustainable and secure manner, regardless of the existing challenges of climate variability. A long-term vision is therefore needed to make the best use of the available domestic resources, given the long-lasting nature of hydropower energy infrastructure. However, if this electricity is generated unsustainably and the trend is not controlled, it could aggravate the environmental and climate change management problems which the world is currently experiencing.

2. Electricity Demand in Africa

It is estimated that even though Africans constitute approximately 15% of the world's population, the total primary energy consumption of Africa is only about 3.1% of the total world primary energy consumption (British Petroleum Statistical Review, 2015) This however, does not include fuels such as wood, peat and animal waste which constitutes the principal source of energy for Africans. Africans are therefore deprived of the use of commercial and efficient sources of energy, which play a significant role in the development process. The paradox of this situation is that Africa is endowed with significant

energy resources, which have remained largely undeveloped.

Africa currently has 147 GW of installed capacity, a level comparable to the capacity China installs in one or two years. The average per capita electricity consumption in sub-Saharan Africa (excluding South Africa) is just153 kWh/year; this is one-fourth of the consumption in India and just 6% of the global average (IRENA, 2015). For instance, Ghana's total electricity generation was 10,232.11 GWh in 2010, with 68% generated from hydropower, 31% from thermal power plants and the remaining 1% coming from imports(Gyamfi, Modjinou, & Djordjevic, 2015)

In 2009, about 587 million Africans lacked access to electricity (IEA, 2011). For instance, about 62% of the urban population have access to electricity, compared with 4% of the rural population in Ghana (Iyke & Odhiambo, 2014). At the same time, limited and unreliable energy access is a major impediment to economic growth. Currently, over 600 million people in Africa lack access to electricity. Many African countries who even claim to have electricity experience electricity blackouts on daily basis, West African countries such as Ghana and Nigeria are clear examples of countries where the situation exist and it has been termed as 'dumsor' in Ghana. The general public has shown negative sentiment with regard to this development and many people have resorted to demonstrations to register their displeasure to the government and the energy service providers across African countries like Ghana.

Figure 1. Public Concerns!–Ghana

Faced with this situation, people and enterprises often have to rely on expensive diesel power generation to meet their electricity needs, costing some African economies between 1% and 5% of GDP annually(IRENA, 2015.). Unreliable electricity supplies impose direct costs on African economies in terms of lost productive output; while lack of access to electricity imposes significant costs on households and can limit economic, educational and social activities.

In Ghana for instances, companies and enterprises which are unable to afford other means of energy such as fuel have to close down their industries as result of erratic electricity supply. Also, majority of people who were employed in these industries have been laid off and rendered jobless as a result as of expensive fuel for power generation.

Also, there is an increasing use of electrical gadgets such as electric iron, computers and others by the majority of Africans living in the urban cities and towns. To compound the situation, glasses are used as windows and doors for most of the modern structures in African countries which demand air-conditioning systems for cooling and provision of ventilation.

There is also an uneven distribution of electricity with concentration in few countries and concentrated mostly in the urban areas.

Figure 2. Percentage of Population Living in Urban Areas in Africa.

The projection from the figure 2 above suggests that, there will be percentage increase of the population living in the urban areas of most African countries by 2035. Also, the projection clearly suggests that, there will be rapid population growth, economic growth and urbanization leading to high demand for electricity in West African countries by 2035. It is therefore very urgent for African countries to raise the level of investment in its power sector in order to meet the growing demand of electricity by 2035.

3. Hydropower Potential in Africa

The total technically feasible hydropower potential of Africa has been estimated as 1,750,000 Gwh/year (2001 World Atlas and Industry Guide – International Journal of Hydropower and Dams). However, only 4.3% of this has so far being exploited, which shows clearly in figure 3 that the continent has over 92% of its hydropower underdeveloped.

Hydropower has dominated renewable power investment across the continent, but only generates 5% to 10% of the total technical potential, equivalent to 10% to 20% of the total economically feasible potential. The remaining hydropower technical potential is between 100 GW to

150 GW, but will require significant investment in transmission lines to connect projects to demand centers, and special attention to sustainability aspects (IRENA, 2015, E.A.K. Kalitsi, Kalitsi and Associates, Ghana (2003). Only seven sub-Saharan countries now have electricity-

Figure 3. Hydropower Potential in Africa

access rates exceeding 50 percent: South Africa (85%), Ghana (72%), Gabon (60%), Namibia (60%), Côte d'Ivoire (59%), Senegal (57%), and Cameroon (54%). Others such as Nigeria has access rate of 40%. The rest of sub-Saharan Africa has an average grid access rate of just 20%.

Also, more potential for Small Hydropower (SHP) generation exist in Western part of Ghana and other southern part of West African counties which have not been developed as shown on figure 4 below. In 2001 out of a total installed hydroelectric capacity of about 20.3 GW in Africa, only 0.3 GW were from small-scale plants (less than 10 MW). This is about 1.5% of total hydro installed capacity in Africa. For the world, as a whole small hydro capacity is 3.5% of total installed capacity (E.A.K. Kalitsi, Kalitsi and Associates, Ghana (2003)). Africa therefore needs to examine further possibilities for exploiting its small hydro potential. This is because of its potential to service the energy needs of Africa's dispersed rural population. The capital requirements for small hydropower development are generally lower than for large scale hydro power development. The modular nature of small hydro technologies allow even the poorest countries to begin a phased energy investment programme that does not strain their national financial resources or draw funds from other basic needs.

Figure 4. Small hydro Sites in Ghana (Kalitsi & Kalitsi and Associates, 2003)

4. Existing Hydropower Systems

According to the BP Statistical Review of World Energy for 2002, out of Africa's total primary energy consumption of 280.6 Million tonnes of oil equivalent (toe), hydroelectricity contributed only 18.3 Million toes. The total primary energy consumption of 280.6 million toes does not include biomass mainly in the form of fuel wood, charcoal and animal dung which is the principal source of energy in Sub Saharan Africa.

Hydropower promises enormous contribution to boosting the energy base of West Africa. However, over 60% of the community's electricity generation is running on diesel and heavy fuel. The overall hydroelectric potential in ECOWAS countries is estimated at around 25,000 MW; however, only 16% of the potential has been exploited(IRENA, 2015). The figure 5 below shows some of the existing hydropower sites in West Africa.

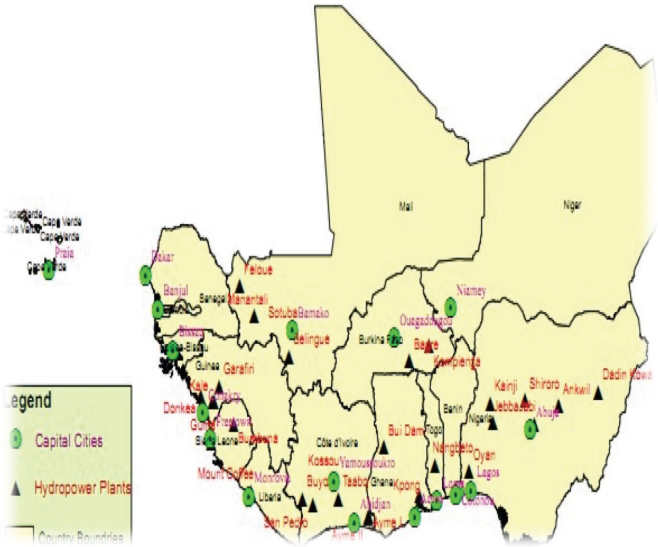

Figure 5. West African Hydropower sites

5. Some Challenges to Hydropower production in West Africa

The major challenge to hydropower generation in West Africa is climate change. Climate change according to the IPCC is defined as a significant and lasting change in the statistical distribution of weather patterns over periods ranging from decades to millions of years. It refers to any change in climate over time, whether due to natural variability or as a result of human activity.

There are a lot of grey areas in the body of knowledge on how climate is changing within West African region and even at country levels. Evidence that climate is changing in the region is based on unreliable pieces of information on weather-related changes and events from countries and results from global circulation climatic model simulations. It is therefore difficult to extract concrete conclusions about the influence of climate change at a country level from these global models since they are not able to fully give clear impression of the impacts of climate change at the country level. However, for planning purposes, the global analysis results on how climate change affects level of precipitation and hence hydropower generation can provide some useful lessons.

Globally, climate change is expected to increase precipitation and hence runoff as a result of snow melting due to the increased global average temperature (Lumbroso, Woolhouse, & Jones, 2015; Madsen, Lawrence, Lang, Martinkova, & Kjeldsen, 2014; Popescu, Brandimarte, & Peviani, 2014; Wang, Liang, Zhang, Wang, & Wei, 2014, Hamududu & Killingtveit, 2012), thus, a positive outlook for the hydropower sector. Also, simulation studies by (Hamududu & Killingtveit, 2012) point out that there will be significant regional changes at worldwide level in river flow volumes and timing as a result of changes in precipitation and runoff. However, their simulation shows a reduction in hydropower resource potential with the exception of East Africa for the African Region. The impacts of variation in rainfall and temperature patterns in West Africa and even other parts of the world is a major threat to hydropower development. The projections by researchers has revealed that, there will be decreasing trend of rainfall pattern coupled with increasing trend of temperature in West Africa for the next decades(World Bank 2010, IPCC, 2008, IPCC, 2007).

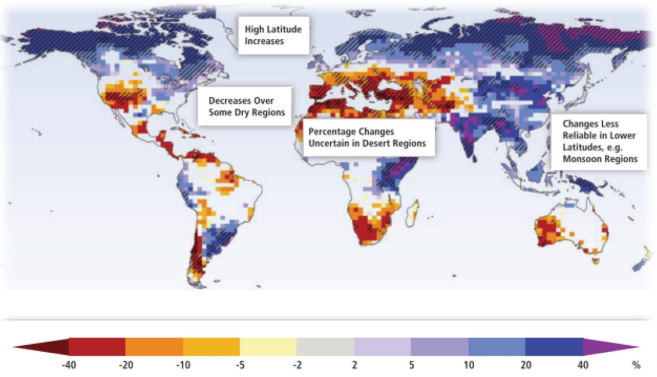

Figure 6. Global Climate Change

Possible changes in rainfall and river flow are already impacting hydropower production in West Africa; a clear example is the variation of the volume of water in the Akosombo dam in Ghana(Ghana News, B&FT, 2014, IPCC 2014, Laurent, Jobard, & Toma, 1998).

It is therefore urgent for serious mitigation measures to be made on the part of West African governments and environmental scientist to avert the negative impacts of climate change on hydropower development in West Africa.

Also, ECOWAS countries do not take full advantage of their technically and economically feasible hydropower potentials due to the following challenges:

Firstly, financial barriers which can be seem in the form of lack of long term financing mechanism by West African governments. Hydropower projects in Africa over the last centuries have been undertaken with public financing supported by loans raised from multilateral and bilateral public sources. The World Bank has featured very prominently in this effort. For instance, the World Bank contributed significantly to financing the Akosombo hydropower development in Ghana. There is however, severe shortage of public finance for power development both at the level of African Governments and from the World Bank and other multilateral and bilateral aid agencies, which had supported hydro dam development in the past. The financing for hydropower projects in West African countries have to also contend with challenges

such as competition with other development projects, such as health and education, lack of political commitment, negative perception arising from population displacement and destruction of agricultural lands and animals.

Secondly, technical barriers are also other challenges facing hydropower development in West African countries. Technological challenges including lack of local human capacity to plan, design, manufacture, install, and operate hydropower projects are quite pronounced in many countries in the West African region.

Finally, policy and institutional barriers are other challenges. West African countries mostly lack clear and consistent policy and regulatory framework to guide the development and implementation of the hydropower systems. Insufficient regulatory framework leads to unhealthy situations in hydropower development in West Africa.

Environmental and public health issues are other areas of concern for the development of hydropower projects in West African countries. The construction of dams to create reservoirs for hydropower developments always results in changes in the natural ecosystem of the area within which the river is located. The environmental issues that arise with the development of hydropower projects are many and varied. These issues need to be carefully examined and managed in order to ensure the viability and sustainability of hydropower project in West Africa. In Ghana for instance, significant environmental and social issues were faced with the development of the Akosombo Dam and the recent Bui Dam on the Volta River for hydropower generation and other multi-purpose uses. The creation of both dams and the regulation of the floodwaters of the Volta River brought numerous negative impacts on the lives of the communities living upstream and downstream, arising from the dislocation and resettlement of large population, and public health issues such as insect-borne diseases like malaria and sleeping sickness and water borne diseases like bilharzia. In general, displacement of human settlements when constructing dams and competition for water usage between power generating station owners and surrounding communities in the dam catchment area are some of the main social challenges associated with these hydropower developments in West African countries.

Lack of appropriate hydrological data is another challenge to hydropower development in West Africa. There is lack of current and reliable weather and hydrological data covering the African continent. Most African countries do not have a complete up-to-date national inventory of the potential sites for the installation of hydropower systems in terms of flow rate, firm power output and power investment cost.

The other challenge facing the development of hydropower generation in West African countries is political instability and civil strife resulting into military activities. This clearly poses as a barrier to the development of hydropower in those countries. During military activities most of the infrastructures that support essential services are targeted for vandalism and looting as being part of the weapons of war. Other challenges are poor revenue collection and low and uneconomic tariffs.

6. Prospects for the Future Development of Hydropower in West Africa

It is estimated that small scale hydropower could contribute with 787 MW (38%) of renewable energy capacity by 2020 in West Africa. Source: ECREE 2013

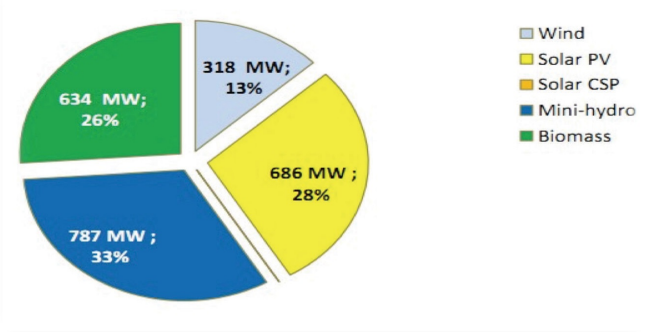

Figure 7. Energy Potentials in West Africa

West Africa and to a larger extent, the entire African continent is endowed with vast untapped hydropower energy resources that can provide electricity for all at an affordable cost. Large hydropower is the least-cost renewable energy solution for the African continent.

Africa also faces a unique opportunity with respect to hydropower development globally. This is because, the continent can benefit from the recent global progress and cost reductions in renewable power generation technologies taken by the industrialised countries, follow their development path and move directly to a renewable-based energy generation systems.

Although, hydropower generation technologies alone cannot meet Africa's energy challenges,

nevertheless, if proper policies supporting the deployment of hydropower generation options are complemented by increased efforts in the efficient use of electricity, and sufficient upfront investment in hydropower generation by both public and private sector as well as other stakeholders, it is possible to rapidly expand the supply of hydropower based electricity and achieve universal electricity access in Africa to meet the electricity needs of a larger number of African citizens in the next two to three decades.

7. Future Collaboration and Proposal for Sustainable Hydropower Development

It is envisaged to setting up a Virtual Institute of IKEM in West Africa. The Department of Energy and Environmental Engineering of the University of Energy and Natural Resources and the Department of Mechanical Engineering, University of Ibadan, Nigeria are currently joining hands in collaboration to undertake research into hydropower development in West Africa in order to offer lasting solutions to the energy challenges facing the region for sustainable energy generation. UENR and UI will organise training on energy and environment in West Africa and invite experts from IKEM to facilitate the training.

8. Conclusion

Climate change and high financial upfront investments are the major challenges facing the development of hydropower energy generation in West Africa; the challenge is to come up with mitigation measures for hydropower operations and designs against the effects of climate change. West Africa is blessed with vast untapped hydropower energy resources that can provide electricity for majority of ECOWAS countries at an affordable cost. Also, it will require the collaborative efforts of the public, government and political commitment, private, environmental scientists, policy makers, energy experts and other stakeholders to solve the hydropower energy challenges confronting the African continent.

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