The prospects & submissions for small hydropower development in sub-Saharan African

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Abstract. Despite the fact that hydropower development provides great opportunities, it also comes with complex challenges and risks that differ considerably by the type, place, and scale of projects. Sub-Saharan African has had a long and successful experience in the operation of large hydropower. Hydropower provides the highest % in total electricity generated in the Region. However, hydropower development has slowed. Today, various Governments in the Region are taking renewed interest in the development of hydropower of all sizes, comprising small hydropower, which is realized to be a national resource that can be developed by local entrepreneurs, with least environmental and social impact. This presentation is to add to the discussion on how to establish agenda for elevation of economically, socially and environmentally viable small hydropower development in Sub-Saharan African. The following important issues and challenges are discussed in this document thus; the potential of small hydropower in sub-Saharan African, what prevents its development in the Region, how policies in the Region can help to promote small hydropower development and suggested possible solutions to overcome these challenges. Conclusions are drawn on important strategies that can help in develop potential small hydropower sites in sub-Saharan Africa. This paper adds to the information base on SHP technology which is quite lacking in the region.

1. Introduction
The demand of energy resources increases with the economic development. Excessive exploitation of non-renewable energy resources and excessive reclamation of forest land will result in water and soil losses and destruction of the ecological environment. This cannot ensure the sustainable development of our economy. Developing small hydropower is an important way to cope with energy resource and environmental problems. Hydroelectricity is one of the most reliable and cost-effective forms of electricity production based on the following observable advantages:

   Compared to other electricity power, the “fuel” of small hydropower is water, which generates neither air pollution nor other liquid and solid waste; The demand for power grid response is in a timely manner, so it can bear the base load, and also the peak load; The development of hydropower can also be combined with water supply in the dry season and flood protection in the wet season, as well as paying more attention to improving the multiple benefits of climate and ecology. Small and micro hydropower stations are mainly run-of-river power stations, requiring only a small reservoir or no reservoir. Small hydropower is one of the renewable energy technologies with great potential in the sub-Saharan African
region. Renewable energy empowers countries to make improved lives for their people through the provision of lighting streets to decrease crime, providing electricity for making local goods, as well as housework and providing portable water all over the countries. An insufficiency of energy has effectually inhibited the development of sub-Saharan Africa with an estimation of about 70% of the people within the region deprived of reliable access to electricity. As stated by the African Development Bank [1], industrialists within the region experience an average of 56 days of power cut per year due to power outages [2]. For example, in Gabon and Nigeria, industries find it difficult in their production since electricity remains costly and unreliable. Sub-Saharan Africa will need more than $30 billion in investment to attain widespread electricity by 2030 [3]. As the potential for small hydropower (schemes with an installed capacity of less than 10 MW) is typically found away from the larger population areas it is a very suitable energy source for rural electrification purposes. It can be used either as standalone power source or in hybrid systems with other energy sources.

2. Energy access in sub-Saharan Africa
Access to energy is essential to reduce poverty. Globally, 1.06 billion people do not have access to electricity and more than 3 billion still use fuels like wood, charcoal, coal and dung for cooking and heating [4]. Limited access to electricity is currently a significant constraint to sustained economic growth across the African continent. In sub-Saharan Africa, the problem is particularly in short supply. About two-thirds of sub-Saharan African Population Almost 600 million people are without access to electricity Because of limited infrastructure for power generation. This lack of modern energy services poses a harshly treats to educational opportunities as well as economic growth and causing danger to the health of the people especially School children. Those without electricity often use polluting and expensive lighting sources such as kerosene lamps or candles, the fumes of which can cause serious health problems. The agricultural sector is still largely ignored, though it is still the largest sector in sub-Saharan Africa Economy, accounting for 20% of GDP and employment of 65%. This department has the potential to be considerably more productive with sustainable energy sources [5]. Along with the IEA’s new policy scenario in the world energy outlook, demand of electricity in sub Saharan is anticipated to triple by 2040, reaching 1300 TWh under Current and proposed government policies and measures. Industrial demand will double as residential demand will grow by more than five times current levels at a rate of 6% per year. Electricity demand growth will therefore exceed GDP growth throughout the future 23 years 2040 [six]. By 2040 with expected quadruple total power generation capacity of 385 GW. Average additional Capacity of 7 GW per year till 2020, then increase to about 10 GW per year in the 2020s and with more than 13 GW in the 2030s. The electricity sector in sub-Saharan Africa is expected to develop with time, even though it will lag far behind other developing countries [5]. Modern, high-quality off-grid lighting and energy products offer a real and sustainable alternative to the off-grid population.
Figure 1. A group of students shift from kerosene studying lamp to solar for a brighter and safer light.

Figure 2. A group of school children with kerosene lamp.

Figure 3. Rural electricity Access in sub-Saharan Africa, (% of rural population)

Figure 4. Electricity access by region in sub-Saran African in the new policies scenario

2.1. F Potentials for Small hydropower plants in sub-Saharan Africa

Hydropower is the world’s largest source of renewable energy, accounting for almost a fifth of global electricity. In sub-Saharan Africa, where the energy access deficit is greatest, less than 10% of hydropower potential has been tapped. Representing 400 GW of undeveloped power enough to increase fourfold the existing capacity in the continent. Multipurpose hydropower projects can improve local water resource management, and increase water security, as well as offering irrigation and flood management services. Hydropower projects can therefore make important contributions to both climate change mitigation and adaptation [7]. According to Nicolaas Loretz project director of Hydropower Africa, the South African provinces of Kwazulu-Natal, Mpumalanga and the Eastern Cape are endowed with the best potential for the development of small hydropower plants. He cited Bethlehem Hydro power projects as an example of such projects which supplies electricity to the entire town of Bethlehem. It also generates income thru the selling of the electrical power and capacity under a long-term power
purchase agreement [8]. Ethiopia is one of the sub-Saharan African Countries’ with some richest water resources, it has a hydropower potential of 45,000 MW. In December 2016, they inaugurated Gilgel Gibe III, Ethiopia’s largest hydropower project in operation, presenting the world’s tallest RCC dam. Ethiopia is the leader in Africa in terms of installed hydropower capacity, exceeding 4,000 MW. Hydropower currently accounts for 90% of total power generation in Ethiopia, it is their target to increase total installed capacity to over 17,000 MW by 2020, thus about 9,000 MW of new hydropower, alongside solar, wind and geothermal [9]

Figure 5. Potentials of Small hydro power and installed capacity in selected sub-Saran African countries

3. Review of existing and valid projects of development of small hydropower plants

According to World Bank report, Kenya has been listed as the leader among countries in sub-Saharan Africa in terms of putting in place policies on access to energy, energy efficiency and investment in renewable sources. The Regulatory Indicators for Sustainable Energy (RISE) report shows Kenya is taking progressive measures, having about 60% access to electricity followed by Tanzania at 36% and Uganda at 27% [10]. Power Africa in 2016, brought out a road map, which stated that solar schemes are forecast to provide 18,000 to 22,000 MW of extra power in sub-Saharan Africa by 2030. The road map noted that there is expectation of 11,000 to 14,000 MW energy generation to come from new projects consisting of solar, geothermal, wind, hydroelectric and natural gas, along with a few thousand more MW from making existing power supplies more efficient [11].

In Zimbabwe, Honde Hydro Power Consolidated (HHPC) has played a vital role in the development and management of hydro power stations in Honde Valley, Eastern Highlands of Zimbabwe with establishment of five 74.296 MW mini hydro plants located on rivers in the Nyangani massif. The schemes that are operational and transmitting electricity into the national grid comprise 1.1 MW Nyamingura Scheme on Nyamingura River, commissioned in 2010; 2.2 MW Duru scheme on the Duru River commissioned in 2013; 2.7 MW Pungwe A scheme on the Nyamombe River commissioned in 2013; 15 MW Pungwe B scheme on the Pungwe River commissioned in 2015; and 3.8 MW Pungwe C scheme on the Chiteme River commissioned in 2016 [12]
3.1. **Lesotho Highlands Development Authority appoints Polihali Dam consultant.**

LHDA has appointed the Matla a Metsi joint venture to design and oversee the construction of the Polihali Dam. The dam is one of the two main water transfer components of Phase II of the Lesotho Highlands Water Project (LHWP). The LHWP is described as a multi-phased project to provide water to the Gauteng region of South Africa and to generate hydroelectricity for Lesotho. The Polihali dam is design to take an estimated period of 18 months for construction upon commencement in December 2019 or January 2020, with an expected completion in 2023. Phase II of the Lesotho Highlands Water Project which was built in in 2003, which supplies water to the Gauteng region of South Africa and also uses the water delivery system to generate hydropower for Lesotho. This Phase II will increase the recent supply rate of 780 million cubic meters annually to more than 1 270 million cubic meters per annum. At the same time also increase the quantity of electricity generated in Lesotho which is an additional phase in the process of securing an independent electricity source to meet Lesotho’s domestic requirements. [13]

3.2. **Namibia: 5MW wind project near to completion.**

According to Jan-Barend Scheepers the 5MW Ombepo Wind Farm in Southern Africa, is expected to be connected to Namibia’s national electricity grid by the end of JULY 2017. The construction of the $13.6 million wind power project at Lüderitz is being built by Namibia-registered company will Provide Solutions to Electricity Situation in The Country as well as save money since Namibia spent billions of dollars on importing electricity from neighbouring countries such as South Africa and Zimbabwe [14].

3.3. **Rwanda: PPP launches Musanze hydropower plant.**

According to ESI Africa, a new Musanze hydropower plant is to be constructed in Rwanda. This hydropower plant is expected to add about 3.6MW to the national electricity upon completion in 2018, connecting over 100,000 households to the grid. The Musanze hydropower plant is being supported by the German and US governments as part of the US government-led electricity access initiative [15].

4. **Barriers**

While hydropower development offers great opportunities, it also comes with complex challenges and risks that vary significantly by the type, place, and scale of projects. Factors such as resettlement of communities, flooding of large areas of land, and significant changes to river ecosystems must be carefully considered and mitigated. Most of the challenges facing small hydropower development are not to hydropower but normally cuts across all types of renewable energy and rural electrification projects. Some of these barriers include the Lack of clear policies on renewable energy, inadequate funds to create an enabling environment for mobilizing resources as well as encouraging private sector investment, lack of long-term implementation models which will ensure distribution of energy to
customers at affordable prices as the sustainability of the industries are also taking into consideration. On the side of specifically at small hydropower development, the following barriers can be identified:

Policy and regulatory framework: uncertain or absence of policies and regulations which oversee the development of (small) hydropower in most of the Countries in Africa is one of the challenges. Hydropower development in most countries are under no regulations at all or might be part of the general bigger regulatory framework for rural electrification in other countries.

Lack of Finance: One of the biggest challenges facing Africa on small hydropower development is financing. Funds are not available for the feasibility studies on these potential site as well as construction and maintenance. Almost all the new developments on the continent are relying in one Way or the other on donor financing. Development of alternative financing models, such as tapping into alternative funding sources are required to facilitate small hydro developments. Ability to plan, build and operate hydropower plants: there are very low or no knowledge on the awareness of the small hydro power potential for rural electrification at both national and regional levels in Most Countries. Such as knowledge at political, government and regulatory units, along with knowledge on local production of parts and components.

Lack of Data on hydro resources: Information on the potential sites where small hydropower can be developing in these countries such as water availability flow rate head and production capacity are not available in most of these countries with those having being minimal. As politicians and the power utility often lack interest in SHP development and also lack the appropriate capacities and budgets, public data on potential SHP sites is often not available. Such as lack of sound basic data (e.g. on mid-to long-term hydrological, geographic, geologic data and figures on the current and future demand for electricity and social infrastructure, but especially on effects of seasonal and long-term river flow variations), poses a major barrier for private investors in SHP. Increasing climate variability and the destruction of rainfall catchment areas are making investment in hydropower systems a risky venture.

Another challenge is that in some countries the developers are expected to have finished a feasibility study before getting the right to a site. In other countries, a site can be allotted to a developer on condition that the appropriate fees are paid, irrespective of their technical or financial capability to develop the scheme. Therefore, one may identify a good site, but the rights are being held by someone else who wants a significant, and unrealistic in most cases, payment to hand over their site. Good examples comprise of Uganda and Kenya who are far advanced in the incorporation of small hydropower their regulations which has encouraged their small hydropower potential development.

5. Conclusion and way forward

Hydropower has played a major role in driving development in countries such as Brazil, China, Norway and the United States. In carrying out small hydro projects, middle or high head sites should be considered instead of low head sites. Low head sites are comparatively costlier to construct; besides they stand the risk of flooding. Nevertheless, in depth analyses on the effect of flooding should be carried out by qualified hydrologists before proceeding with plans to construct dams of 5 to 14 m of head on these rivers. The various Governments in the Region together with the Energy Agencies and the Public Utilities Regulatory Commission (PURC) have to make available a clear regulation and attractive price for supplying Energy into the national electricity grid in order to attract private sector investors and other renewable energy sources investors to invest into the small hydropower energy generation projects. Development and promotion of new business models for the maintenance of SHP development for rural electrification should also be mainstreamed both on national scale and global. Supportive inducements at the local level, when combined with energy sector reform, can become a powerful lever for private investment, but they must be specific, beyond the political correctness of high-level statements.

Public support must be consistent in the medium and long term, which is challenging because of the undesirable position of many governments in areas such as public accountability and political stability. Development of proper policy framework, pricing and tariff environment as well as improving managerial and technical capabilities should be taking into consideration.
The development of small hydropower and construction requires a series of systematic policy, policy research and multi-party cooperation mechanism. Series of scientific research should be carried out to take positive measures to strengthen the small hydropower construction in order to avoid conflict between small hydropower development and environmental protection as well as climate change.

Acknowledgments
Authors wishing to acknowledge National Natural Science Foundation of China form their financial support.

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