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A Case Study of Status and Potential of Small Hydro-Power Plants in Southern African Development Community

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Abstract

The Southern African development community is having a major challenge in connection with desires for energy in the region. There is the need to increase energy security and admittance to modern energy services immediately, particularly in the rural areas as well as addressing the challenges posed by the current energy systems on human health and the environmental. The rapid growth of renewable energy capacity in the region contains all the potentials that can answer to quite a lot of problems for instance: rapidly increasing electricity saturation, including remote areas detached from the grid infrastructure. Old resources need to be replaced as well as producing new once to adequately generate to meet the growing demand. Renewable energy and energy-efficient technologies in addition to services are an essential part of the new energy dynamic in the region. To meet these demands, the region needs to, rapidly develop and connect existing renewable energy resources and embrace energy efficiency, as a matter of priority. The existing potential sites in the region are mentioned and Small-scale hydropower is one of the most cost-effective energy technologies to be considered for electrification in the countries since it has low environmental impacts and can have a significant benefit if implemented in rural areas for electricity production. There is therefore the need for all development community, policy makers and regulators, local and global investors, developers and project promoters to support by providing funds, making good policies to protect the energy sector in other to solve the problem.

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Keywords: Alternative Energy Sources; Energy Conversion/systems Energy; Storage Systems Power (Co-) Generation

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1. Introduction

Small hydropower is one of the renewable energy technologies that have great potential within the sub-Saharan African region. Admittance to current, 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 in the sub-Saharan regions. An insufficiency of energy has effectually inhibited the development of sub-Saharan Africa with an estimated 70 percent of people deprived of reliable access to electricity. For example, Gabon and Nigeria, industries find it difficult in their production since electricity remains costly and unreliable. 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]. on the word of the International Energy Agency [3], sub-Saharan Africa will need more than $30 billion in investment to attain widespread electricity by 2030. Rural areas will need the highest amount of the funds, with more than 85 percent of the inhabitants requiring access to consistent electricity. The complex nature of the energy sector further hinders the growth of rural electrification and in turn small hydropower development in SADC. Overlapping responsibilities between ministries such as the Ministry of Energy and Mines, the Ministry of Communal Development and the Ministry of Development Planning and Finance (which is responsible for investment planning and coordination with foreign donors), slows down the growth process of small hydropower. Fiscal barriers to small hydropower development consist of a lack of incentive for foreign investments and high transportation costs for equipment's. Lack of small hydropower surveys and data availability as a basis to carrying out is also a major constraint is the continent. Local hydropower sources can play a very important role in the electrification of rural areas in Southern African Development Community to ensure the sustainability of hydropower. 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. Depletion of fossil fuel and the inability to meet the rising demand of electricity are some drawbacks for the economic development of Africa. This paper focuses on the potential of small hydropower in the Southern African Development Community due to its numerous rivers and canals providing off-grid power to the remote areas and also to the areas that are still outside the main grid network. It further reflects on the current energy scenario within the region, the need to provide the establishment of widespread small hydropower that can help overcome the current power crisis and play a role in the economic progress of the Countries.

1.1 Definition of Small Hydropower

No internationally agreed definitions exist for the different sizes of hydropower. A generic distinction between 'large' and 'small' hydropower is that the latter can be seen as installations up to 10 MW of installed capacity. Most countries in Sub-Saharan Africa use this limit to define small hydro, although Mozambique uses 25 MW as the upper limit for small hydro [4]. The upper limit is usually taken in line with the World Commission on Dams as 10 MW of installed capacity though large countries like China and India tend to put the limit higher at 50 MW and 25 MW respectively. The definitions can vary based on manufacturers and countries. In Africa the general term for installation less than 10MW (OR1MW), in feeding local grid (10,20kv) is termed small hydropower [5], However, a capacity of up to 10 MW is a generally accepted norm by the European Small Hydropower Association (ESHA), the European Commission, and UNIPEDE (International Union of Producers and Distributors of Electricity). Small hydropower is a recognized and mature technology with good records in Africa. A lot of African countries have a great history of small scale hydropower, but most of these stations over time are in poor condition. Some for the reason that the national grid reached their location and some due to lack of maintenance.

1.2 Overview of small hydropower worldwide

Currently, small hydropower plants with a capacity of 10 MW, exist in 148 countries or regions worldwide with additional four other countries known to possess resource potentials. The discoveries of World Small Hydropower Development Report (WSHPDR) 2016 shows that small hydropower potential has globally increase from the approximated 173 GW in 2013 as indicates by World Small Hydropower Development

Report (WSHPDR) 2013 to 217 GW, an increase of about 24% with an estimated installed capacity of 78 GW in 2016 also an increase of approximately 4% compared with 75 GW from WSHPDR 2013. This means that about 36% of the total global SHP potential was developed as at 2016. The number is attained by totalling data from a wide range of sources with potential compromise of data integrity to varying degrees [6, 7]. For example, research data on economically feasible potential were more readily available in developed countries than those in the least developed or developing countries. More than half of the world's known hydropower potential is located in Asia, around one third can be found in Europe and the Americas as can be seen in figure 1 below [5]. It is possible in the future that more small hydropower potential might be identified both on the African and American continents. Globally, the share of renewables in the power sector is increasing gradually and this is also same in the case of the SADC region. although the pace and scale of the contribution of renewable energy is anticipated to be smaller, for the reason that the region has major fossil fuel resources (mostly coal and some gas) that are already a significant source of power and are expected to grow in status. The current share of renewable energy in the region's power capacity is around 23.5%, including commercial biomass and hydro. This compares with 28.5% renewable capacity in the ECOWAS region. [8, 9] figure 1 and 2 shows the Global Small Installed capacity and hydropower resource potential up to a capacity of 10 MW by regions respectively.

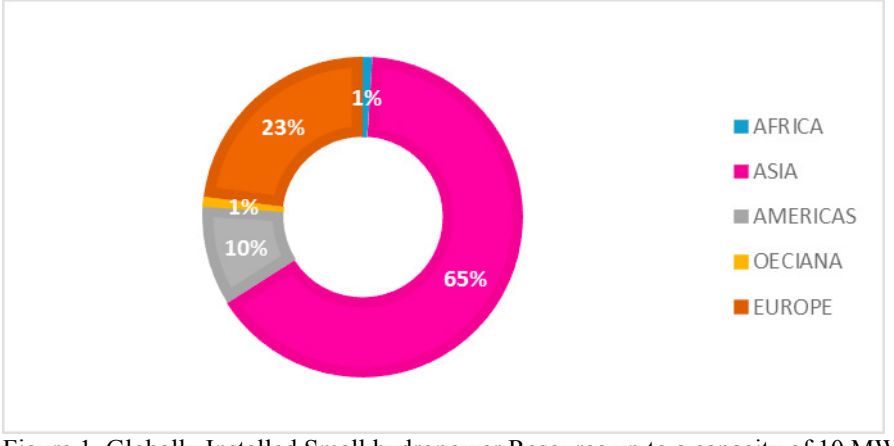

Figure 1. Globally Installed Small hydropower Resource up to a capacity of 10 MW by region

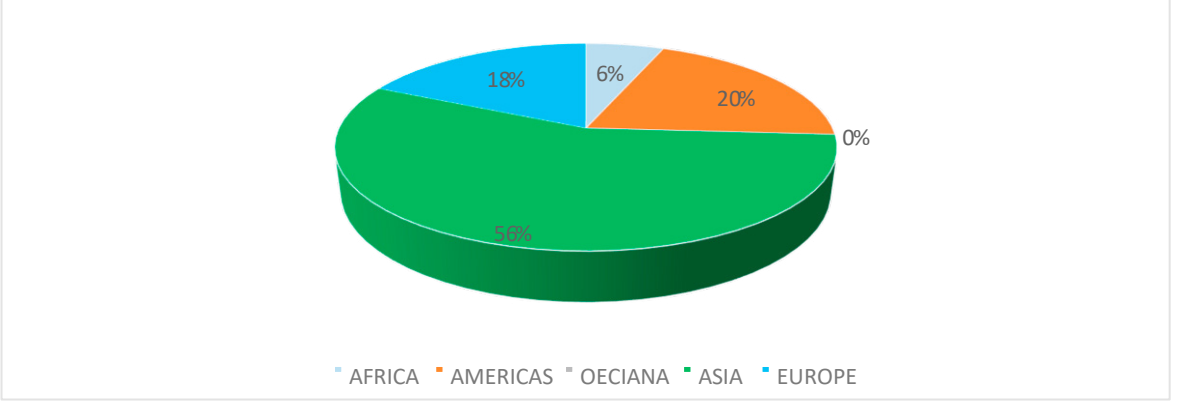

Figure2 Global distribution of small hydropower resource potential up to a capacity of 10 MW

2. Status of Hydropower in Southern African Development Community.

Hydropower is the world's largest renewable source of energy, generating about 16% of all electricity and over 80% of renewable electrical power. It is the most flexible power generation source can answer to the

demand rise and fall in minutes, distribute base-load power and (in reservoir installation) store electricity over weeks, months, seasons or even years [10, 11]. Currently, potential of hydropower resources in the SADC region is 41000 MW (which includes only Inga III and not "Grand Inga"). A number of which are very large-scale and are considered to be life-threatening to the region's power development. Nevertheless, there are significant progress in detecting potential small hydropower as well as in the restoration of old small hydropower dams abandoned in the rush to use fossil fuels to generate electricity in the past period. Figure2 shows the potentials and Installed capacity of small hydropower in the region Total installed hydro capacity in the region is just over 12,000 MW, representing about 21.5% of total
Electricitycapcity [12, 13].

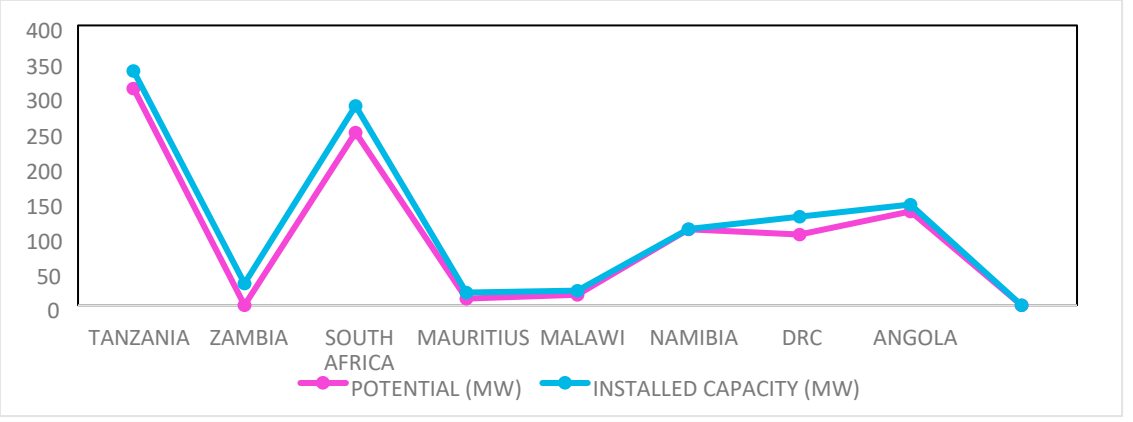

Figure 3Potentials and Installed Capacity of Small Hydropower in The Southern African Development Community.

(Note: Data on Angola and the DRC are from media reports and have not been corroborated; data from Madagascar are taken from the SREF Expression of Interest and are approximate. There has been an improvement on the access to power grids within the SADC member states Over the past ten years, Figure 4 illustrates the share of the population with access to electricity in rural as against urban areas of SADC member states as at 2012. [3] Table 1 shows the change in electricity access over the 12year period from 2000 to 2012. With a few exclusions, member states have displayed rise in electricity access over this period. [14]

3. FUTURE POSITION OF THE ENERGY SECTOR IN SADC REGION

The major source of renewable energy for electricity generation within the Southern African Development

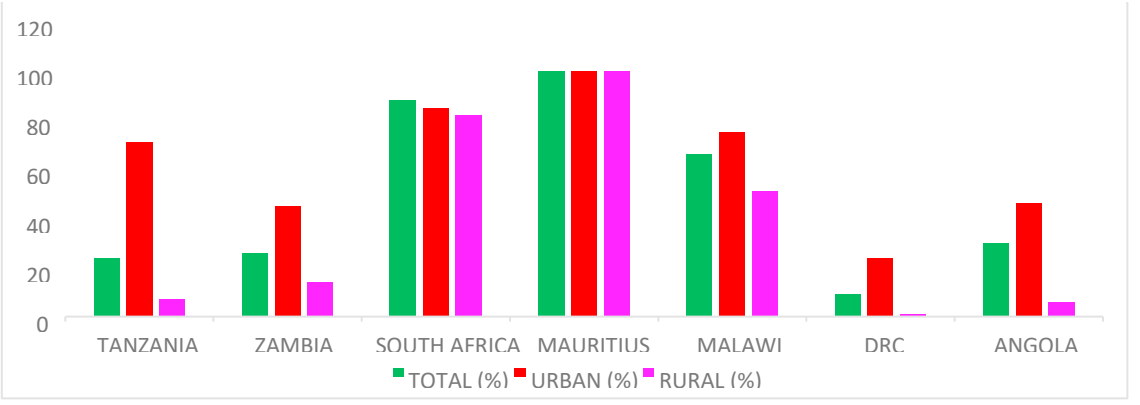

Figure4. Share of electricity access in rural as against urban areas in SADC member states, 2012

Community Renewable energy use in the SADC region power sector is growing speedily as they now account for approximately 23.5% of generation, including commercial biomass and hydro, of which hydro is undoubtedly the major [15]. Current potential hydro resources in the region total 41,000 MW (not including major expansion on the Congo River) with an installed hydropower capacity just under 12,000 MW which Represents about 21.5% of total electricity capacity; with 97.6% being large-scale hydropower. The existing projects and those planned for development in the six riverine countries such as Angola, the DRC, Malawi,

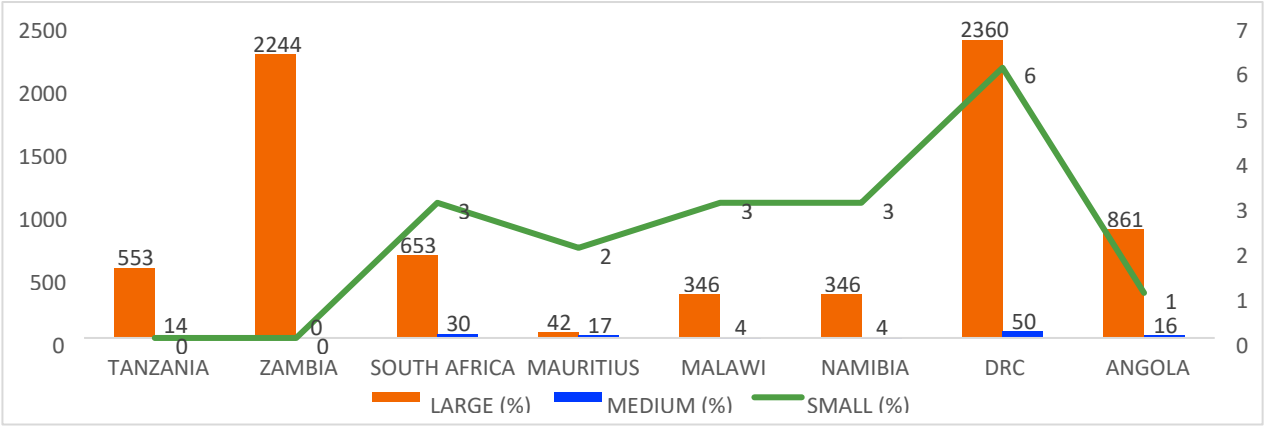

Figure 5. Renewable Energy capacity in SADC member states, 2014

Mozambique, Zambia and Zimbabwe with a total potential capacity of 21,580 MW out of which 61% is currently undeveloped. The largest operational projects are Cahora Bassa in Mozambique (1,920 MW), Inga I and II in the DRC (1,775 MW), Kariba Dam shared by Zimbabwe and Zambia (1,470 MW), Kafue Gorge in Zambia (900 MW) and Capanda Dam in Angola (520 MW). Lesotho, Mauritius, Malawi, Zimbabwe, South Africa and Swaziland are all actively developing small-scale then micro hydro resources. [16,17]. Quite a lot of countries such as the DRC, Lesotho, Malawi, Mozambique, Zambia and Zimbabwe are already having significant renewable energy contributions to electricity capacity and generation, mainly because of the development of large hydropower stations as shown in Figure 5 [18]. The Zambezi River basin alone almost certainly provides enough capacity to power the whole region, if connected. It was estimated by The SAPP that even though the Zambezi could produce more than 20 000MW, [19] at the moment only 23% is being connected, most of it from the Kariba Dam between Zambia and Zimbabwe and the Cahora Bassa Dam in Mozambique. [20] The Grand Inga hydropower project on the Congo River in the DRC provides a further opportunity for regional integration. It is a multi-phase hydropower station that might generate as much as 40 000MW, sufficient in powering half of Africa. Similarly, Namibia, Tanzania and Swaziland have equally high levels of generation from hydropower sources (i.e.67%, 66% and 40%, in that order). Based on a feasibility study conducted between 2011 and 2013, Grand Inga will be constructed in six development phases, with the Inga III Dam and hydropower project being the first of these phases. When completed, Inga III will produce 4,800MW of electricity. [21] However, these countries continue to use a large number of fossil fuel power generation. Generally, table 2 reflects the huge gap between large hydropower and small hydropower energy resources in the SADC region. It should be noted that empty or zero means either the technology use in the country is absent or very small and couldn't therefore register statistically [15]. There have been an established of priority list by the Southern African Power Pool (SAPP) for small (<1,000 MW) and large (>1,000 MW) generation projects based on SAPP definition. With [22] the 4 highest-ranked large projects being hydropower and 11 others being small hydropower projects as can be seen in table 2 including the highest-ranked project, Kariba South Extension in Zimbabwe. [23] The importance of the integrated power grid in SADC is obvious and all the four large-scale hydro projects are directly linked to the SAPP network. The governments and utilities in the region have agreed that the extent of hydropower expansion is the easiest and fastest way of achieving momentous renewable energy increase. Therefore, SAPP's attention has mainly been on integration, i.e., firming up the regional grid in preparation of added large increases from hydropower projects. Even

though there are difficulties, SAPP has committed to attain at least 32% of renewable energy mix in the regional grid of by 2020 and 35% by 2030. [19]

4. Challenges and Way Forward

Absence of access to electricity is a fundamental brake on several parts of Africa's development precisely within the Southern African Development Community. As at 2015, almost half of those without access to electricity around the world was from the African continent; with a larger majority coming from the sub-Saharan Africa specifically the Southern African Development Community. Based on the available potential resources and increase in the development of most of these resources, it is estimated that about 1 billion people should gain access to electricity in Africa by 2040 with 950 million of them coming from The Southern African Development Community. This projection shows that current efforts to attack this problem needs to set off in order to achieve universal access by 2030, the target of the Sustainable Energy for all initiative.

The Grand Inga hydropower project on the Congo River in the DRC provides additional opportunity for regional integration. It is a multi-phase hydropower station which may produce as much as 40 000MW, which will be good enough to power half of Africa. Development to this level of output will desire a phased approach. A treaty has been signed between South Africa and Democratic Republic of Congo providing a framework for facilitation of power generation and delivery to South Africa by the Democratic Republic of Congo; the third phase of Grand Inga (Inga 3) will provide 2 500MW to South Africa while contributing to regional integration, energy security and economic growth in an environmentally sustainable way [24]. In addition, Zambia and Zimbabwe are together in search of funding for Batoka Gorge (1,600 MW), which is upstream of Kariba and has been the subject of vigorous debate over its possible impact on system hydrology. Mozambique has completed a preliminary financing agreement for Mphanda Nkuwa (1,500 MW), downstream of Cahora Bassa. But because these projects are extremely large and have significant political and economic risk associated with the [25]. It is therefore suggested that proper policies should be set out to curb these risk since the generation can help solve the power crises in the region.

The Southern African Development Community presents a very heterogeneous energy landscape with great country-by-country differences in resource endowments, consumption patterns and policy challenges. But there are some conditions that needs to be met for the positive contribution of energy to be in the majority. Inadequate access to electricity is a fundamental weakness in Southern African Development Community's energy system and a gigantic barrier to development: this condition can be improving by policies, fuels and technologies and also help the energy access gap being closed quickly. Again, Traditional use of solid biomass for cooking accounts for the largest part of household energy consumption within the Region, but has momentous health and environmental impacts: it is therefore necessary for the continent to quickly realize a transition to cleaner alternatives. South Africa is diversifying a heavily coal-dominated electricity system, with renewable energy playing a much larger role: what are the policies, costs and benefits involved? It is therefore necessary to get proper policies go govern all our resources as well as spelling out clearly all the cost and benefits involved. Mention must also be made on the following challenges faced by the region;

Health and Environment: According to the World Health Organization, about 212 million people or 71% of the population within the SADC region (apart from Mauritius and Seychelles) are affected by household air pollution from inside smoke, small particle pollution, carbon monoxide and nitrogen oxides, mainly due to cooking. There are about 153,229 people who dies every year due to cooking or heating with solid fuel with approximately 45% of them been children Together with effects of domestic air pollution not forgetting a wide range of coal use impact by several SADC countries on total environmental quality [25,26]. For example, Botswana and South Africa are still heavily reliant on the generation of coal and their use of coal Power generation and industrial heat generating a huge Potential health effects of air pollution and, also increasing the emission of greenhouse gases.

Energy security: Energy security is one of the biggest challenge within The Southern African Development Community region which needs to be addressed. Energy security can be improved by increasing electricity interconnections among Member states of the southern African development community through the improvement of dependable existing power systems. Currently, cross-border Connection is the most important factor to strengthen energy Safety, nevertheless, the presence of regional power pools thus the South African power pool (SAPP) has assisted to make sure that such links are increasingly implemented on the basis of the

lowest cost. Regardless of a long history of small hydropower in the Southern African Development Community regions local skills to manufacture, operate and maintain the plants are not well developed. The schemes built in the years ago were fully controlled and managed by foreign experts. In addition, Small- and micro-hydropower equipment and components are not available off-the-shelf in local market. Comparatively low return on investment is currently discouraging individuals and private investors in small hydropower development, but cooperatives with members that will benefit from getting access to electricity may be potential developers, since their primary motive is not return on investment.

5. Conclusion

The Southern African Development Community's demand for energy, as well as a large number of substantial and unexploited renewable resources indicates where the continent should be heading to in the development of its energy sector and infrastructure. The speedy growth of renewable energy capacity in the Southern African Development Community encompasses all the potentials requires in solving quite a lot of problems such as : speedily increasing electricity saturation, including remote areas detached from the grid infrastructure so far; to reduce dependence on expensive imported fossil fuels and considerable risk of dependence in hydropower on exposure to drought by some countries and lastly to increase clean private investment including the international carbon market introduced from abroad.SHP has the greatest answer to the rural electrification increment, which carries access to consistent and clean energy to individuals as well as assisting in reduce poverty, both of which are very fundamental in the region. Also, the industrious use of electricity from SHP plants in rural areas must also be well developed and systematically reported so as to share lessons learnt and improve inclusive sustainable industrial development. 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. In addition, 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. Finally, a serious public commitment at the local level is required.

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