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HYDROPOWER DEVELOPMENTS IN SOUTHERN AFRICA: AN OVERVIEW OF SIX COUNTRIES IN THIS REGION.

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Abstract

Renewable energy is a critical clean resource for sustainable economic, social and environmental development. Southern African countries are endowed with ample of renewable energy resources, which potential can reduce greenhouse gases emissions, create green job opportunities and promote industrial growth. Despite the abundant renewable energy sources, southern African countries are faced with persistent electricity power outages and this deters sustainable development. The near depletion of fossil fuels, make it an option for the southern region to embrace hydroelectric power energy to provide sustainable energy solutions. This current paper reviews hydropower developments in selected South African countries namely Zambia, Zimbabwe, South Africa, Mozambique, Eswatini and Lesotho. Using the Web of Science, search engine and Google Scholar, the author identified 126 articles and went through journals abstracts collected by searching for “hydropower developments in Southern Africa”. The researcher filtered the abstracts of articles from 126 to 59 according to whether they addressed the research objective. Overall, southern Africa countries face several challenges in the development and operation of hydropower plants. However, countries that include

Zambia and Mozambique have made remarkable progress in developing hydropower stations.The current paper provides a timely and unique input to the academic field on hydropower developments in the southern region and measures, to enhance the use of hydropower energy.

1. Introduction

Renewable energy is a critical resource for economic, social and environmental development. Southern African countries are endowed with ample of renewable energy resources, which potential can reduce greenhouse gases emissions, create green job opportunities and promote industrial growth and economic productivity [1,2]. Southern African countries has among the largest untapped potential for hydroelectric power development in the world. Despite the abundant renewable energy sources, the southern African region faced with persistent electricity power outages and this deters sustainable development [1,2,3,4]. The near depletion of fossil fuels, make it an option for the region to embrace hydroelectric power energy to provide sustainable energy supply to consumers [2,3,5].

Access to reliable, affordable and clean sources of energy is a major goal of sustainable development and a socioeconomic indicator for gauging how effectively a particular country is moving away from energy insecurity. Hydroelectric power presents an opportunity for economic development and the realization of the United Nation's Sustainable Development Goals [3,4]. In the face of widespread energy supply insecurity, there has been growing environmental lobby groups for governments in the southern African region to adopt environmental friendly methods of generating electricity. The overall hydropower potential in southern African countries is approximately 1,080 terawatt hours /year [6]. However, the capacity being utilized at present is estimated to be 31 TWh/year [6]. According to the International Renewable Energy Agency (IRENA), hydropower energy potential exceeds current and medium term demand in Africa and electricity cost from hydropower remains among the economic and environmentally friendly renewable energy sources globally [2,4].

The southern African region has not yet been comprehensively studied as far as the hydroelectric developments are concerned. Some of the most recent studies focused on Hydropower generation in the Middle East, Central Africa, North Africa and West Africa[7,8,9,10,11]**.** Most published summary articles are outdated and address the history of hydropower development in Africa [12,13,14,15]. The current review paper provides a timely and unique input to the academic field on current hydropower developments in selected southern African countries and measures, to enhance the use of hydropower energy.

2. Methodology

The paper summarizes a review of peer reviewed journal articles. Using the Web of Science, search engine and Google Scholar, the author identified 126 articles and and went through journals abstracts collected through searching for “hydropower developments in Africa”. The researcher filtered the abstracts of articles (from 126 to 59) according to whether they addressed the research objective. The researcher further filtered this pool to select articles that are empirically informed and comprehensive regarding hydroelectric power development in selected southern African countries. The author finally reviewed each of the 59 articles using the criteria above to produce the final set of articles used in this review paper.

3. Country Review

This section reviews hydropower developments in southern African countries namely Zambia, Zimbabwe, South Africa, Lesotho, Eswatini and Mozambique, where electrification levels remain low and electricity energy is a threat.

Zambia

Zambia is endowed with approximately 40% of southern Africa’s water resources [16]. Hydropower is the country’s main electricity source contributing to approximately 85% of its total installed capacity. The national generation capacity currently stands at 3, 456.8MW against a peak national demand of approximately 2,300MW [17]. The country has a surplus of about 1,156 MW[17]. Zambia trades the electricity surplus within the interconnected network in the southern African region.

The main hydropower stations in Zambia include Kariba North Bank Power Station (1.08MW), Kafue Gorge Power Station (750MW), Victoria Falls Power Station (108MW), Lunsemfwa and Mulungushi Hydro Power Stations (56MW), Itezhi Hydro Power Station (120MW), Chishimba Falls Power Station (15MW). Lunsemfwa and Mulungushi hydropower stations are owned by Lusemfwa Hydro Power Company Limited (LHPC), an independent power producer that supplies all the power generated to Zambia Electricity Supply Company (ZESCO), the national utility company [18,19,20,21, 22].

Hydro projects on the pipeline include Batoka Gorge Hydro Electricity Scheme (BHES), a 2.4GW hydroelectric project located across the boundary between Zambia and Zimbabwe [17,18,20,22]. The project was initiated in 2020 and is targeted for completion in 2016. It is anticipated that the BHES will buttress the Southern African Power Pool (SAPP) while providing reliable clean power supply at a low cost to both Zambia and Zimbabwe [17,18,20]. A 120MW base-load hydropower plant is being developed at Itezhi Tezhi dam on the Kafue River [22].

The energy policy in Zambia has been transformed to allow both public and private to invest and contribute more effectively to the renewable energy sector. The Renewable Energy Feed-In Tarrif (REFIT) policy enables the government to purchase renewable energy at predetermined costs, reducing price vitality and attracting significant private sector investment to hydropower [18,20,22,22].

Climate variability has posed new challenges for the hydropower sector in Zambia. In 2015, a prolonged period of drought lead to lower water levels at the Kariba Dam [20]. Power generation capacity was estimated to have decreased temporarily by around

300MW causing electricity load shedding as a short-term measure. The Kariba dam is undergoing rehabilitation scheme since 2017 to shape the plunge pool and refurbish spillway gates. This is meant to erosion control, improve structural stability and ensure sustained water supply to both the Kariba North Power Station and Kariba South Power Station in Zimbabwe[19,20,21].

Zimbabwe

Energy supply in Zimbabwe is a combination of hydropower (70%), coal (29%) and other renewable energy sources [23] . Zimbabwe has one hydropower plant and four coal-fired generators, with a total combined capacity of 2,240MW, sufficient to meet the country's demand of around 2.200 MW. Kariba South Power Station is a 1.050MW hydroelectric power plant located on the Zambezi River at the Kariba Gorge [24]. It is presently the biggest power plant in Zimbabwe. The Kariba South Power Station was originally developed with six generating units commissioned between 1959 and 1962. The facility was expanded by two additional units of capacity in 2018 [24,25]. The Kariba hydroelectric power has been the biggest source of electricity supply in power-starved Zimbabwe that depend on electricity imports from other countries like Mozambique and South Africa [26,27,28,29,30].

In Zimbabwe, power shortages are rampant owing largely to lack of investors in this sector. The country's estimated demand 2.240GW is far behind its available capacity of 1.6GW [23,24,25]. Recent, severe drought have caused operational hurdles at the hydro dam, divulging the fragility of Zimbabwe's power sector. The ongoing drought in this country has meant that water levels at Kariba dam have fallen to just over 30% [31] . Ageing infrastructure, entrenched corruption, fluctuations, high production costs, inadequate transmission and distribution infrastructure, length and complex administrative approval processes and inadequate training of technical personnel have been identified as major obstacles in the development of renewable energy projects in Zimbabwe [29,30, 32].

The Kariba dam is under rehabilitation since 2017, in order to ensure structural stability. The rehabilitation process is envisioned to increase the efficiency as well as prolong the operational life of the dam [33].

Zimbabwe has a number of private mini-hydro power plants that include Nyamingura Power Station (1.1MW), Pungwe A and B Mini Hydro Power Stations (2.7MW and 15MW and respectively), in Honde Valley Manicaland, Duru Mini HydroPowerPlant (2.2MW), Kupinga Power Station (1.6MW) in Chipinge Manicaland, Hauna Power Satation (2.3MW) in Honde Valley Manicaland, Tsanga B Power Station (3.84MW) and Claremont Power station (250kW) in Nyanga Manicaland [34,35,36] Initiatives to add more mini-hydo plants to support Kariba Hydro Power Station need to be fast-tracked as these mini-hydro plants are much cheap to develop.

South Africa

Electricity Supply Commission (ESKOM) operates four large stations (42MW Colley Wobbles, 3660MW Gariep, 11 MW Second falls and 240MW Vanderkloof and two micro hydropower stations (6MW First falls and 1.6MW Ncora). The Thaba Chweu Local municipality owns a grid-connected station (2.6MW Lydenburg), while the private sector owns four stations connected to the national grid (300kW Clawilliam, 222MW Freidenheim, 4MW Merion and the 3MW Sol Plaatje0. Kwazulu-Natal and the Eastern Cape also have a number of mini and micro hydropower systems that primarily supply individual farms only without providing electricity to neighbouring communities [37]. The City of Cape Town operates hydropower turbines at four of its water treatment plants (700Kw Blackheath, 1.475Kw Faure, 3440kW Steenbras and 260kW Wemmershoek).

South Africa’s electricity infrastructure has been degrading in the past decade, with both scheduled and unscheduled power outages on the increase. The country experienced 1130 hours of planned power cuts in 2021. Challenges for hydropower development in South Africa include:

- policy and regulatory framework are unclear on the development of micro hydropower, access to water and water infrastructure, and payments of water;
- financing constrains as hydropower development are associated with high start-up;
- data on hydro resources are limited; and
- legislative procedures such as Environmental Impact Assessments delay the implementation of hydropower projects [37].

Several studies have revealed that South Africa has a good potential for micro and even mini-hydro systems [38,39]. In a bid to bridge electricity shortfall, the government of South Africa has eased power production licensing requirements to make it easy for investors to set up power plants of up to 100MW. The bill aims to boost small scale electricity production [40]. This has led to several mining companies, local authorities and other private entities to set up their own power generating plants. The government is considering exempting the contruction of renewable plants of as much as one gigawatt in size to curb electricity supply woes in South Africa [41].

Mozambique

Hydropower in Mozambique accounts approximately 81% of installed capacity in Mozambique. Despite the huge potential, only 29% of the population has access to electricity, owing to limited transmission and distribution networks, and unfavourable market conditions for new hydropower generation establishments [42]. Mozambique has ample of energy resources with an estimated hydropower potential of 12,000MW. The country has a total installed capacity of 2.780MW of which hydropower contributing 2.189MW [43].

There are six working hydropower stations across the country. The largest hydroelectric plant is located in the Tete province and is operated by Hidroelectrica de Cahora Bassa (HCB). HCB is responsible for most of the hydroelectric generation, with a capacity of 2.189MW [44,45]. Currently, six hydropower stations are connected to the national grid in Mozambique, while a several of off-grid systems also exist. At least 10 systems, with an installed capacity of around 250Kw, are operational next to three stations at Chiuraire, Maajaua and Rotanda are currently being set up by Fundo de Energia (FUNAE). There is mounting interest in Mozambique to promote and develop small hydropower for isolated rural communities [44,45]. The 75kW Honde scheme, for example, is using small hydropower to provide electricity to the local community. Non-Governmental Organizations (NGOs) and bi-lateral donors for example, Practical Action and Kwaedza Simukai Manica are investing in micro hydropower in Mozambique . The Mphanda Nkuwa 1.500MW hydropower project is under construction to meet the growing demands in Mozambique and transform the country into a regional hub [45,46]. The project is expected to be completed in 2031. The International Finance Corporation (IFC) signed an agreement with the Mphanda Nkuwa Hydroelectric Project to develop this US $4.5 billion project [47].

However, climate variability presents immense challenges to water resources sector in Mozambique. Climate change is likely to alter the frequency of precipitation, floods and drought events. Precipitation is projected to decrease while evapotranspiration is likely to increase in Mozambique [48,49,50, 51, 52].

Lesotho

The electricity sector in Lesotho is relatively small (3% of total energy consumed). The country rely on energy imports from neighbouring countries to meet its demand. Lesotho has approximately 150MW peak power and imports more than 70MW mainly from Mozambique. Nearly all locally generated electricity is hydropower-based, mostly form the 72 MW Muela plant which is owned and operated by the Lesotho Highland Development Authority [53,54,55].

While there are five small-scale hydropower plants in Lesotho, namely Katse (540KW) Mantshonyane (2MW), Semonkong (180Kw), Tlokeng (6700Kw) and Tseoelike (400Kw) only the Katse and Semonkong plants are currently in operation. The systems at Tlokoeng and Tsoelike both suffered from technical problems and siltation. Both stations had been decommissioned and their service areas connected to the main electricity [53,54,55].

Lesotho is conducive to developing small hydropower systems due to adequate existing hydropower resources and a settlement pattern in rural areas that favours decentralised energy systems [53,54,55]. New energy legislation allows independent power producers to generate electricity for the national grid and establishment of the National Rural Electrification Fund by the government to support small hydropower projects [56].

Eswatini

The Energy sector in Eswatini is guided by the National Energy Policy of 2018. Since then, the country's energy sector has been undergoing transformation to encourage private sector investment. The Eswatini Electricity Company operates four hydropower plants that provide 60.4MW of power and contribute 15 to 17 percent of the total energy consumed in Eswatini. Eswatini Electricity Company operates the grid connected Edwaleni (15MW), Ezulwini (20MW), Maguduza (5.6MW) and the Maguga (19.8MW) installations [57]. In 2010, the SEC decommissioned the small-scale 500kW Mbabane station built in 1954, due to unprofitability [57]. The first hydropower station in Eswatini was a 52.5Kva turbine installed at Mliwane. Since then, several public and private hydropower plants have been installed [57, 58,59].

Eswatini's electricity supply has largely been dependent on imported electricity from neighbouring countries like South Africa and Mozambique. The country faces the challenges of power security supply and realiability. To enhance energy security, the Government of Eswatini has has established an Independent Power Producers (IPP) Policy that aims to increase the utilization of local renewable energy resources [59].

4. CONCLUSION

Zambia and Mozambique have the potential to strengthen the Southern African Power Pool (SAPP) by providing reliable clean power supply at a low cost to other SADC countries. The two countries have made remarkable progress in developing and maintaining hydropower stations. However, in Zimbabwe, South Africa, Lesotho and Eswatini power outages are rampant. Overall, southern African countries face several challenges in the development and operation of hydropower plants. These include:

- policy and regulatory framework that are unclear and non-existent to govern the development of micro hydropower;
- financing constrains as hydropower development has high upfront costs;
- lack of investment;
- climate change;
- ageing infrastructure;
- deep-rooted corruption among officials involved in hydropower projects;
- inadequate transmission and distribution infrastructure; and
- Lengthy and complex administrative approval processes and inadequate training of technical personnel.

Southern African countries have a good potential for micro and even mini-hydro systems. Small hydropower projects can play a vital role in future energy security in SADC countries as they are cost effective, emits less greenhouse gas and can be replenished over a period of time.

5. SUMMARY MEASURES

Hydropower projects developers are extremely deterred by several challenges that include financial, environmental, social, regulatory and infrastructural issues. However, these problems can be handled effectively through socio-political intervention and applicable regulatory framework. The researcher proposes the following measures:

i. long term funding for hydropower projects should be directed through an energy policy;

ii. public awareness programs should be done emphasizing why hydropower is safe and sustainable for green development;
iii. policies and institutions need to be developed in capital markets to promote long-term debt instruments matching the life span of hydropower plants;
iv. hydropower-specific EIAs should identify potential impacts, along with prevention measures and a development plan for long term sustainability;
v. development of other renewable fuel source projects such as solar and wind; and
vi. when developing hydropower projects it is necessary to take into account climate change as it affects river runoff and evapotranspiration.

DATA AVAILABILITY

Data supporting the research is available upon request from the Author.

CONCLICTS OF INTEREST

The author declare no conflict or interest.

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