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Zambia's Perpetual Energy Insecurity: Socio-Economic Implications and Opportunities for Renewable Energy Diversification

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Abstract: **Perpetual acute electricity crisis in Zambia is not a new phenomenon; it is a decade long cycle of load-shedding and blackouts that continue to undermine economic development. While Zambia's hydropower infrastructure has aged, inefficient and unreliable, the variables of climate change appear to pose even greater challenges. Hydropower production capacity is declining as prolonged periods of drought intensify and increasingly posing new challenges to the efficiency of hydroelectric. Therefore, it is imperative for the Zambian government to develop a climate resilience and adaptation energy security policy. One that could enable utilisation of alternative renewable energy options resilient to climate change, and promote the implementation of distributed generation to expand the investment base to include small-scale investors.**

Keywords: **Zambia; Electricity Crisis, Climate Change, Hydropower Power, Renewable Energy, Energy Security.**

I. INTRODUCTION

Zambia's energy mix is predominantly hydroelectric. Hydropower is renewable in nature, it is affordable and a cheaper source of energy. The challenge, however, is the intensifying variable of climate change - prolonged periods of drought that appear to undermine the efficiency of hydroelectric. As the climate continues to change, the decline of hydroelectric is inevitable. With Zambia's insufficient hydroelectric, surging industrialisation, and the population rapidly growing (with more than 15 million population growth in 2015 of which, 60.5 percent live in rural areas and 39.5 percent in urban areas), demand for electricity increases. Between 2000 and 2010, the urban population grew at a rate of 4.2 % per annum, compared to 1.5 percent population growth between 1990 and 2000. Moreover, population density remains higher in urban areas where people depend on electricity for their livelihood (Zambia Central Statistics Offices, 2016).

It is vital to acknowledge the unwavering and resilient efficacy of the Zambian people in overcoming social inequalities; including low standards of living, unbalanced health care, and inadequate education system, to mention a few. However, perpetual acute electricity crisis of daily load-shedding seem profoundly intolerable as it negatively impacts on households, small businesses, commercial businesses, and principally, the economy (Hill, 2016). Electricity shortages upscale the cost of running businesses, decrease production output, and therefore, undermine profit capacity. These inevitable outcomes exert pressure on strategic markets, especially the mining sector - the largest consumer of electricity and contributor to the Zambia's economy. When production output decreases in the mining industry, the only practical measure to sustain financial capacity is laying off workers or resort to casualisation of employment, as the case of Glencore, to be discussed in the following paragraphs. Equally, small businesses struggle to run their businesses to sustain income. Therefore, they turn to costly and unsustainable sources of energy to keep their businesses afloat (Jeffrey, 2015).

Even more concerning, Zambia's water resources are facing challenges. Water levels in rivers and dams fluctuate from season to season as a result of persisting drought. Regardless, the Zambian governments past and present seem to have undervalued the importance of diversifying sources of electricity by encouraging sound investments in alternative renewable energy such as solar, wind, geothermal and gas, among others, to broaden the energy mix. Even with solar and wind power intermissions, a robust, well-balanced energy mix could alleviate electricity crisis and prevent the country from continually plunging into a vicious cycle of power cuts threatening not only small business and households but economic development that relies on energy security to thrive.

While the Zambian government have embarked on refurbishing various ageing hydropower infrastructures, with the construction of more hydropower plants underway, a lack of innovative diversification foresight presents dire prospects for an inefficient, unprepared and less adaptable energy sector. The paper argues that the efficiency of hydropower is at risk as prolonged periods of drought persist. Rainfall pattern appears to be changing, with erratic rainfall each rain cycle; causing inefficient water levels in strategic hydropower dams and rivers. Therefore, undermining electricity production capacity and negatively impacting on economic growth as the manifestation of the 2015 and 2016 economic outlook. This assertion begs the question; could Zambia's energy security be achieved by increasing the number of hydropower plants?

The paper examines intermissions in Zambia's current energy mix and highlights fundamental issues underpinning consequences for heavy reliance on hydropower in the climate change environment. The article is not intended to discuss the scientific aspect of climate change but rather provides an accurate picture of how Zambia's poor energy mix puts the country in a vulnerable position economically. It further discusses sustainable solutions the country could adopt to build a resilient and reliable energy sector. This paper utilises existing literature, statistics from government websites, think tanks, news articles and personal observations to support the hypothesis.

II. ZAMBIA'S CURRENT ENERGY MIX

Hydropower represents 19 percent of electricity produced globally. As for Zambia, 95 percent of its energy mix is hydroelectric with 5 percent combination of geothermal, coal and biomass. The current energy mix only services 25 percent of the Zambian population leaving 75 percent of the population with no access to electricity (Energy Regulation Board, 2009; International Hydropower Association, 2015, p. 2). Most of Zambia's hydropower plants are state-owned through the Zambia Electricity Supply Corporation (ZESCO) which produces 80 percent of electricity. ZESCO owns four main hydropower plants; Kariba North Bank, Kariba North Bank Extension, Kafue Gorge and Victoria Falls power stations and some mini-hydropower plants with several isolated diesel power plants in the rural areas. A few of hydropower plants are owned by Independent Power Producers (IPP), Ndola Energy Company Limited (NECL), Zengamina Power Limited (ZPL), Lunsemfwa Hydro Power Company Ltd (LHPC), the first IPP in Zambia, Kalahari GeoEnergy, Copperbelt Energy Cooperation (CEC), an emerging IPP currently under transmission and distribution of electricity purchased from ZESCO (Energy Regulation Board, 2005; Energy Sector Report, 2014, p. 3- 5; International Hydropower Association, 2015).

Even with ZESCO's 2,337 Mega Watts (MW) total installed capacity and the participation of the IPP, the energy sector remains unsustainable and inefficient. Major hydropower plants installed capacity is equally ineffectual. Kariba North Bank has 720 MW installed capacity, Kariba North Bank Extension 360 MW, Kafue Gorge 990 and Victoria Falls 108 MW. The explanation to Zambia's inefficient energy sector is twofold. One is the country's overreliance on hydroelectric in the climate change environment and the second explanation is insufficient investment in alternative sources of renewable energy. These assertions are supported by perceptible decline in electricity production capacity in the recent past. Even the Energy Regulation Board claim of an increase in hydroelectric production is inaccurate given the impact of power shortage in 2015 and 2016 (ZESCO Generation Projects; Energy Regulation Board 2014, 3).

Withal, small hydropower plants contribution to the national grid is minimal due to inadequate production capacity. Mulungushi power plant has 32 MW installed capacity, Lunsemfwa 24 MW, both owned by LHPC with combined installed capacity of 56 MW (SN Power Zambia). Musonda Falls has 5 MW installed capacity, Lunzua 14.8 MW, Lusiwasi 12 MW, Chishimba Falls 6 MW, Shiwa Ngandu 1 MW, Zengamina 0.7 MW (off ZESCO grid). Itezhi-Tezhi power station, which was commissioned on 6 March 2016, has 120 MW. Other contributions include; 80 MW thermal power, 11 MW diesel powered plants, 50 MW Heavy Fuel Oil (HFO) and 0.06 MW Solar (International Hydropower Association, 2015, p. 2 -3; ESI Africa Power Journal, 2016; Energy Regulation Board, Energy Sector Report, 2014, p. 3 -

7). Even with the recently commissioned hydropower projects, various hydropower plants operate at minimum capacity, especially during dry season, due to the scarcity of water resources to facilitate hydroelectric generation. Fluctuation of water levels is evidence of intensifying effects of drought, and therefore, a robust investment initiative in alternative renewable energy remains imperative. (Magadza, 1994, p. 165-167)

III. THE IMPACT OF CLIMATE CHANGE ON HYDROPOWER

Hydropower is certified under the clean development mechanism of the Kyoto Protocol and it is widely used. As a result, the effects of climate change are not isolated (UNFCCC). Before the United National Intergovernmental Panel on Climate Change (UNIPCC) climate change assessment, researchers had predicted effects of climate change well into the future - less rain and severe droughts (IPCC, 2014, p. 13). In 2013, the World Bank reported that more than 25 countries in the Sub-Saharan Africa were in the midst of energy crisis. The 2014 United National Intergovernmental Panel on Climate Change (UNIPCC) found the African continent to be the most vulnerable to prolonged periods of drought. Nonetheless, the effects of climate change are being felt in most parts of the world (William, 1989, p. 83; International Rivers; World Bank, 2013).

In 2015, California in the United States of America (USA) recorded a four-year drought as the worst of all time with hydropower plants ceasing to run at full capacity. The same year, hydropower plants in Sao Paulo Brazil that generate 70 percent of the country's electricity reported a near to zero function of its hydropower capacity that resulted in the deactivation of facilitates. In 2016, Tasmania' Lake Gordon in Australia also known as a jewel in the crown of Tasmania's hydroelectric scheme was at a record low with 6.7 percent capacity due to reduced rainfall (Appleyard, 2015; Eastley, 2016). While developed countries possess different energy capabilities, and therefore, can withstand severe impact from declining hydropower, developing countries face the challenge of diversification into alternative renewable energy.

The 2015 drought left Zambia with a 560 MW power deficit. The same year, Tanzania shut down all of the country's hydropower plants due to low water levels in the dams, as a result of prolonged periods of drought, with some dams completely dried out (The Telegraph, 2015). Zimbabwe was also experiencing long hours of daily blackouts and load shedding. Botswana's electricity deficit situation was not dissimilar to its neighbouring countries. Electricity shortage compelled the government to implement a supplementary budget to deal with water and power shortages following the people's demand for reinstitutionalised stable electricity and water supply. In contrast, the Zambian governments' long-term ambitious approach to resolving power deficit has been more focused on refurbishing ageing hydropower infrastructures and building new ones, rather than investing in other renewable energy technologies (Dzirutwe, 2015; Kozacek, 2015; Graham, 2015; Hoedt, 2008, p. 80; Makoye, 2014; Reuters Africa, 2015).

IV. IMPACT ON ECONOMIC GROWTH

In the past ten years, the Zambia's economy had been growing at an average rate of 5 percent; with a steady surge in industrialisation, agriculture production, rebound of manufacturing, and stable production in the mining sector. However, erratic electricity supply to these industries has had an adverse effect on the country's economic growth. On September 24, 2015, the Mopani Copper Mine (owned by Carlisa Investments Corporation, a joint venture with Glencore International AG (73.1%) and First Quantum Minerals Ltd (16.9 %), and ZCCM (10%) with minority shareholders around the world) officially notified the Zambian government of its intentions to lay off about 3,800 workers. Equally, the Konkola Copper Mines PLC (KCM) (a subsidiary of Vedanta Resources) reduced its workforce. The Mopani and KCM's (two largest employers in Zambia's mining sector with a workforce of more than 10,000) drastic measures to address profit deficit appear to have sent the Zambian currency - Kwacha into freefall, with an enormous value, drop to 17 percent record low. As a result, fundamentals of the economy were undermined (Hoffman & Hill, 2015).

It is indisputable that measures taken by First Quantum and Glencore were partly as a result of China's economic slowdown that led to the fall of global metal market prices. However, it appears that Zambia's 2015 electricity crisis which contributed to the increase in Copper production costs in the country was also in part the reason for the Mining sector's measures to safeguard their fiscal responsibilities. Withal, by the end of 2015, power cuts exacerbated and further threatened fundamentals of the country's economic growth as inflation skyrocketing to 19.5 percent record high (Reuters, 2015; Jamasmie, 2015).

While International investors have the proficiency and capacity to rescue their business from collapse, small businesses have no such capabilities. Small businesses have little capacity if at all any, to absorb unplanned costs and losses, and rescue their businesses from collapse. They neither have the ability to secure alternative reliable and sustainable sources of energy to run their businesses that primarily depend on electricity. Small businesses such as welding, mechanics, to mention a few, are impacted by daily load-shedding that last more than eight hours. Operations halt whenever power is out; causing income losses, increasing hardship and widening poverty levels. Power cuts also undermine food security - food prices rise and leave low-income earners to struggle to sustain their livelihoods. Thus, poor economic performance becomes a reality. The cost of doing business increases, and the rate of economic crime (increased 45 percent in 2014 compared to 61 percent in 2016) goes up (Jeffrey, 2015; Price Waterhouse Coopers Global, 2016; Sinyangwe, 2016).

V. EFFORTS TO ADDRESS ELECTRICITY DEFICIT

The United States Agency for International Development (USAID) assessment shows that 70 percent of the Sub-Saharan Africa population has no access to electricity (Crowley, 2015). The 2012 World Bank report also indicates that power deficit reduces annual economic growth by 2.1 percent (World Bank, 2012). Therefore, addressing power deficit in the Sub-Saharan Africa demands a forward-looking energy policy that takes into account climate change and its long-term effects. As the consequences of climate change have become evident, it is indisputable that alternative renewable energy is the future force of a sustainable energy sector. Zambia has made modest strides in moving towards alternative sources of renewable energy besides hydropower, albeit rather patchy.

Furthermore, the Southern African Development Community (SADC) initiative to address electricity deficit in the region through the Southern Africa Power Pool (SAPP) appears to fall short of a collective effort to spur various renewable and sustainable clean energy developments. SAPP has 55, 000 MW installed capacity, mostly in hydropower, with members countries comprising of Zambia, Zimbabwe, Botswana, Democratic Republic of Congo (DRC), Angola, Malawi, Lesotho, Tanzania, Mozambique, Namibia, South Africa and Swaziland. The recorded SAPP capacity shortfalls in the recent past are indicative of the lack of innovation. Arguably, SAPP fails to meet growing demand for electricity in the region due to member countries unequal supply capacity. Zambia has the lowest installed capacity with the highest consumer demand. In 2016, Zambia's demand for electricity exceeded 2,000 MW leaving the country with electricity deficit of 560 MW, and, therefore, a contribution to SAPP initiative remains microscopic. Thus, Zambia needs to regard SAPP as a short-term power supplement measure to its sluggish energy sector rather than a long-term national solution (Zambia Development Agency, 2014, p. 4 – 5; Energy Regulation Board, 2014, p. 22).

Notwithstanding, SAPP initiative investments in regional power infrastructure and cooperation with national electricity companies within the SADC region, its purpose appears to be more focused on trade rather than skills and technology transfer to promote stand-alone capability for individual states striving to address national electricity deficits. Even though SAPP has integrated electricity grids into a regional power pool encompassing the entire region, it is not a reliable source of electricity (South African Power Pool, 2016; South African Power Pool; Energy Sector Report, 2014, p. 23). SAPP initiative is dominated by South Africa's Eskom power company which contributes 45 percent of electricity. Consequently, in times of power shortages in South Africa, Eskom takes the best interest of South Africa to the fore. Therefore, Eskom has the responsibility to turn off electricity supply to SAPP member countries to sustain the national demand. These measures leave member countries dependent on SAPP's power supplement in dire straits.

If Zambia could move towards heightened investment in alternative sources of renewable energy, it could well increase the energy sector's capability to supplement the diminishing efficiency of hydropower rather than depending on electricity imports (Energy Sector Report, 2014, p. 23; Eskom Company Information, 2016). In September 2015, Zambian began to import 148 MW of electricity produced by a Scottish (Aggreko Company) ship docked at the Port of Beira in Mozambique. The Zambian government also spent 18.2 million U.S dollars to import 200MW from the moored Turkish power ship in Nacala Port and 300 MW from South Africa through the SAPP transmission lines. Even with these short-term measures, Zambia's energy deficits continue to widen (Macauhub, 2015; Zitamar, 2016).

Efforts to address electricity deficit in the Sub-Saharan Africa have not been short of external support. The former President of United States of America (USA) Barak Obama announced the Power Africa Initiative (PAI) through the United States Agency for International Developments (USAID) in Cape Town in 2013. PAI was signed into law in February 2016, with the aim of supporting African governments develop energy regulations to boost investment in the

energy sector and expand electrification rate. President Obama announced the commitment of $7 billion to complement private sector investors that committed more than $9 billion towards the Sub-Saharan energy sector (Herscowitz, 2015, p. 1; BBC Africa, 2016; USAID, 2016).

The Symbion Ubungo thermal power plant in Tanzania is representative of PAI support to public-private partnerships to compliment Sub-Saharan Africa governments' efforts to address electricity deficit. With Symbion's commitment of $1.8 billion in Sub-Saharan African energy sector investment between 2013 and 2018, President Obama's Power Africa Initiative (PAI) has the potential to encourage technology and skills transfer into renewable energy in the region to complement existing projects (The Economist, 2016; Raval, 2015; White House Briefing, 2013)

VI. GOVERNMENT AND PRIVATE INVESTMENTS

An efficient and reliable power sector is pivotal to Zambia's economic development. The mining industry being the largest consumer of electricity and generator of a significant percent of revenue that stimulates the economy should be encouraged to play a role in addressing power deficit. The mining sector back up about 110 MW of electricity they generate, which appears insufficient to power their businesses (Energy Regulation Board, 2005). It is imperative for the Zambian government to promote a favourable environment for the mining sector to increase their investment in the energy sector, in particular, renewable energy, to create a reliable and sustainable energy sector. A robust public and private stakeholders' Investment in alternative renewable energy could allow diversification in sources of energy, increase efficient electricity production and supply to consumers to restore the economic trajectory and stimulates economic growth.

In Zambia, the ancillary of the PAI is the Renewable Energy Feed-In Tariff (REFIT) policy; a mechanism supported by USAID in collaboration with Zambian Ministry of Mines, Energy, and Water Development. REFIT mechanism is intended to create an inclusive system to enable the Zambian government to buy renewable power from small-scale independent power producers at pre-determine prices. It is also designed to reduce price volatility and increase renewable energy uptake in Zambia (ESI Africa Power Journal, 2015). The REFIT mechanism is favourable to commercial and photovoltaic (PV) solar and wind power investments than hydroelectric which is volatile to climate change. RFIT also encourages small-scale investment in the energy sector, unlike hydropower that discourages small investments. While Zambia's energy policy has made progress in including private investments, these investments are dominated by large hydroelectric companies. Therefore, impedes on small-scale investments in the energy sector and strains the value of RFIT (International Hydropower Association, 2015, p. 3).

VII. UTILISING ALTERNATIVE SOURCES OF ENERGY

The 2015 - 2016 economic outlook revealed that reliable power supply is pivotal to Zambia's economic development. Therefore, it is vital for the Zambian government to review the energy security policy to enhance preparedness and resilient capabilities to enable adaptability in the changing environment. Climate change milieu has brought with it one advantage, extended periods of sunshine. Energy experts have found that Zambia could increase its electricity capacity to more than 6000 MW from its untapped renewable energy resources to meet demand (Zambia Invest).

Solar Power:

Even though solar power has its daily and seasonal intermissions, the sunny daytime peak could provide a significant boost to electricity production. The 2013 assessment by the International Renewable Energy Agency found that Zambia has an average solar isolation of 5.5-kilowatt hours per square meter (kWh/m2) with about 3000 hours of sunshine annually. In other words, Zambia has an estimated solar PV generation potential of 178.9 terawatt hour (TWh) and 156.9 TWh solar thermal (IRENA, 2013, p. 16 - 21). Long seasons of sunshine provide the relative potential for the country to utilise solar power resources. Even with intermittent seasonal variations, Zambia's long sunny, dry season could generate reliable solar energy to supplement hydroelectric in times of low water levels in dams as a result of prolonged periods of drought.

Withal, small off-grid power generation technologies such as solar PV could provide a long-term solution. Solar energy encourages "distributed generation", also known as an on-site generation (SG) or district/decentralised energy. It increases the ability of individual homes and business to generate electricity onsite, thereby, easing pressure off of the

main grid. Distributed generation could be an option for the rural communities. The Rural Electrification Authority (REA) mission to utilise solar energy and increase access to electricity in the rural communities has been remarkable, albeit a rather slow expansion process due to unsustainable investments (Bloomenergy, 2016; Rural Electrification Authority; Virginia Tech, 2007).

Wind Power:

Wind energy is a fastest growing source of electricity in the world today. Even though the wind may not always blow to generate reliable power, especially in most parts of Zambia due to low altitude, it could be a viable alternative to supplement the struggling hydropower scheme. The 2013 International Renewable Energy Agency (IRENA) report identified Chongwe area east of Lusaka and Muchinga escarpment in Muchinga province as areas with higher altitude for potential wind power hotspots. IRENA (2014) also found that Zambia has an estimated wind energy potential of about 15.102 MW at 20 percent Capacity Factor (CF) and 4.416 MW at 30 percent CF (Miketa & Merven, 2013, p. 21; Shukman, 2014).

Given Zambia and China mutual partnerships in many sectors of the economy, and considering that China is the world's largest wind energy producer, Zambia could establish joint ventures with China to expand Zambia's wind power (Shukman, 2014). A joint venture in wind energy could not only potentially increase Zambia's capacity to address its electricity deficit; it could enable skills and technology transfer for future wind infrastructure installations, maintenance, and management. As two potential wind sites are located in the rural areas, this could be an opportunity to expand electrification to the countryside, and thereby, supporting localised electricity production and supply.

VIII. CONCLUSION

Zambia's challenge to address its electricity deficit is real. Insufficient energy mix - overreliance on hydropower, the impact of climate change and a lack of sustainable investments in alternative sources of renewable energy remain the prime hurdles in achieving energy security. Unreliable electricity supply undermines fundamentals of the economy and impedes on growth as evidenced by the 2015-2016 economic outlook. However, with Zambia's access to SAPP and PAI resources through the existing REFIT, the government could increase its energy sector capacity by encouraging and supporting small-scale investments in alternative sources of renewable energy. Creating a favourable investment environment could enable prospects of accelerated utilisation of distributed generation which allows households and businesses that are consistently hit by daily eight-hour load-shedding and blackouts to generate their electricity, and possibly feed into the main grid.

Short-term measures such as expensive importation of electricity from SAPP and other countries seem not to address power deficit. Challenges are substantial; prolonged periods of drought appear to intensify, rainfall partner is changing and water in reservoirs diminishing. With the population rapidly growing and the demand for electricity surging, increasing the number hydropower plants in the climate change environment is a short-sighted approach that cannot overhaul the energy sector and achieve energy security in the long run. Therefore, it is imperative for the Zambian government to shift their focus from over-dependency on hydroelectric and find a sustainable balance to the country's' energy mix and pivot towards a robust, forward-looking strategy that could enable implementation of innovative technologies and increase utilisation of alternative sources of renewable energy such as solar and wind power.

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