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SOLAR ENERGY POTENTIAL FOR BOTSWANA

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ABSTRACT

Renewable energy sources are easily accessible and clean to the environment. Solar energy is one of the best forms of renewable energy, particularly for a country such as Botswana. Paradoxically, Botswana finds herself importing electricity and experiencing power cuts, yet it has abundant sunshine almost all-year round that could be converted to electric power. This paper seeks to investigate through literature search, the potential for Botswana to convert her copious solar radiation into solar energy. Particular attention will be drawn to the case of Australia which has experience in use of solar energy and has a similar climate to that of Botswana. Findings from literature search reveal that Botswana stands a great chance of using solar power to improve the livelihood of its people and businesses. Recommendations to policy makers and the private sector are that there is urgent need to put in place policies, regulations and frameworks to support solar generation and reduce reliance on electricity importation and coal production which is not sustainable. The authors propose a conceptual model to help policy makers in implementing solar energy projects in Botswana.

Keywords: Solar energy, Botswana, Australia, renewable.

1. Introduction

In the past few years, there have been power outages in a number of African countries including unexpected countries such as South Africa and Botswana. South Africa would not be expected to have power shortages because it is a major energy (electricity) producer and exporter. Botswana would not be anticipated to suffer power shortages because of the building of the coal-powered Morupule B. Power Plant, which project has delayed and failed. Furthermore, Botswana has abundant availability of solar radiation that could be converted into solar power (BITC, 2016). Without enough electric power, the country's productivity declines – industries operate below expectation, people lose jobs, and there are shortages of products on the market and inflation increases.

There is acute shortage of literature on solar energy in Botswana. Therefore, the researcher had to rely mostly on international sources (databases), of which there are few peer-reviewed journal articles on the subject. This means that this study will possibly contribute to the body of knowledge on renewable sources of energy.

Apart from common non-renewable sources of energy such as hydro-electricity, renewable sources of energy are more cost-effective and meet the world's demand for clean energy (UNDP, 2012). Boidus (2014) wrote an article "How solar can power Botswana." In the article, the author mentioned that renewable energy sources include wind, gas, water and solar. Botswana, however, does not have abundant wind, gas or water. Rather, Botswana has copious solar radiation, available almost throughout the year.

According to BITC (2016) Botswana has limited exploitable energy resources. Furthermore, Botswana relies on electricity and petroleum products' importations. Available energy resources include solar, coal and bio-energy (biomass and bio-fuels) (UNDP, 2012). In the past year or so, however, South Africa, the main electricity supplier to Botswana has been experiencing serious power shortages resulting in electricity outages in Botswana. This has negatively affected production in domestic homes and industries alike.

Botswana has a warm climate which affords the nation abundant solar energy potentials. Unfortunately, the country is suffering the same power challenges as other countries that do not even have abundant sunshine that could potentially be turned into solar energy. Botswana is one of the most privileged countries in the world to use renewable energy because of the abundant solar radiation.

According to Boidus (2014) there are a number of pilot solar projects that have been implemented in Botswana, such as the Phakalane project and the 20kw University of Botswana project in Mokolodi. However, Boidus (2014) argues that what Botswana needs is a commercial approach to provide energy to the demand of 700-800MW to the country. Authors of the current study posit that if Botswana takes a commercial approach to solar production, this could fast-track the national economic diversification drive (launched in 2010) and the economic stimulus program launched in 2016.

The conclusions of Boidus (2014) are that Botswana should create a conducive environment by coming up with "policies, regulations and framework that allows implementation of renewable energy and activities" and consider commercial projects "based on a business model to say 'yes we are putting up a power station that will generate so much power and the end user of that project is going to pay so much.'" While there has been discussions around solar energy generation at micro level (AfDB, 2009), Botswana needs to consider major solar projects as has been done successfully in countries such as Australia and the United States of America.

This paper aims to review literature and investigate the potential of Botswana generating solar energy at both individual home/industry level and commercial level to alleviate power shortages and support uninterrupted industrial development. Thus, the main objective is to make recommendations from the study, which are hoped to help policy makers and the private sector to convert the solar radiation opportunity into solar energy which can even be exported and increase national revenue. The rest of the paper is organized into review of literature, methodology, results and discussion, conclusion, recommendations, acknowledgements, study limitations, and references.

2. Literature Review

Overview of Botswana's electrical supply

According to Botswana Investors' Handbook (2014: 14), *"Botswana's energy is mainly from coal-fired plants. Small diesel generators are used to power rural areas. The bulk of domestic electricity production is generated by the Morupule coal-fired station."* This is a clear sign that Botswana currently relies on the limited coal energy which it augments with imported electricity from South Africa. Notably, Botswana does not have hydroelectric generation, as it is mostly desert land (84% of Botswana's surface area of 581 730km^2) (Botswana Investors' Handbook, 2014: 13) which does not have much water for pumping hydroelectricity. As a result Botswana imports majority of electricity from ESKOM (South Africa) (Bloomberg, 2014; Ofetotse & Essah, 2012).

If things had gone according to plan, Botswana's electricity problems would be over by now. Botswana started a power generation project called Morupule B. Power Plant, 2010/2011, which has not been successful. The AfDB (2009) reports that Botswana's Morupule B. Power Plant which is situated next to the old Morupule Power Plant, about 280km north of Gaborone the capital city. The project was initiated by Botswana Power Corporation (financing part of the project) and the government of Botswana, with the financial help of the World Bank and African Development Bank (AfDB). Unfortunately, the project did not go according to plan, resulting in the contractors failing to deliver. According to Republic of Botswana (2014), with effect from the first of January 2014, a German company took over the maintenance and operation services of Morupule B Power Station from China National Electric Equipment Corporation (CNEEC) (SADOCC, 2014).

The project was expected to be completed by October 2012 with four units churning 150MW of electricity each. However, to date only two units are in operation as the contractor faced delays and machine breakdowns (Bloomberg, 2014; Republic of Botswana, 2014; Ofetotse & Essah,

2012). Therefore, Botswana's electricity needs remain at bay. Thus, there is the need for an alternative energy source such as solar power.

Overview of natural energy sources

Botswana has no known petroleum reserves. That leaves the country dependent on the following natural energy sources: coal, solar and bio-energy (UNDP, 2012; BITC, 2016: 33-34). Wind would have been another alternative energy source, but Botswana's wind speed is only limited to 2.0-3.5 m/s. Obviously, this level of wind speed is not sufficient enough for any viable wind based power generation project (Department of Energy, n.d.: 3). Natural gas has been discovered on the coal beds at Morupule Plant. While the gas could be a good source of energy, UNEP RISO Centre (2012) argues that the mining of the natural gas has been very slow. This throws doubt at the possibility of natural gas being able to rescue Botswana from the current electricity shortages.

Coal

[3] BITC (2016) suggests that Botswana has coal reserves of approximately 212 billion tones (Department of Energy, n.d.: 3; BITC, 2016: 33-34). UNEP RISO Centre (2012: 9) expresses it this way, "*Botswana is also rich in coal reserves and coal has been mined at Morupule near Palapye since 1976 and estimated to amount to 212.8 billion tons.*" Morupule mine is the major deposit mine for Botswana's coal, supplying Morupule Power Station, BCL Smelter and Botswana Ash (BIDPA, 2012). There are other coal deposits in the country which are not yet exploited – Dukwe, Foley, Bobonong, Serule, Dutlwe, Ncojane, Letlhakeng, Mmamantswe, Mmamabula and Moijabana. This means that coal deposits could possibly be used for power generation in the long-term. Nevertheless, coal is not a clean form of energy as compared to solar energy. Furthermore, while coal deposits can get depleted, solar radiation is expected to last for as long as the earth is available. Thus, solar radiation is a better source of energy than coal.

[4] On the other hand, BIDPA (2012) wrote a paper to assess the opportunities and risks of coal mining. In their findings, they discovered that coal mining in Botswana is probably the largest coal reserve in Africa. But coal mining could be in jeopardy due to declining commodity prices and changing global setting with regard to fossil fuels. Therefore, BIDPA (2012) recommended that the Botswana government should quickly construct a railway to the coast to carry the coal, development of national water grid, and supporting industrial policy. Failure of this would mean that coal energy and coal export revenue would be lost. In 2016, it has become evident that none of the suggested plans of action by BIDPA (2012) was put in place, hence, with world falling prices of commodities; coal is not the hope for Botswana, but probably solar energy.

The authors of this current study therefore deduce that coal is a vast resource in Botswana, as indicated by the many coal fields in the country; coal's four major drawbacks compared to solar energy are that coal is (i) costly to mine compared to sunshine which just needs to be attracted; (ii) coal pollutes the environment while solar is green and safe for the environment; (iii) coal is

heavy and thus, costly to transport compared to sunshine; and (iv) coal is non-renewable, that is its deposits can get depleted; whereas sunshine is almost eternal.

Due to the above mentioned drawbacks of coal over solar, solar needs to be explored as an alternative power choice for Botswana.

Bio-energy

According to Department of Energy (n.d. 3), Botswana has woody biomass loading that ranges from 3.6-4.3 tonnes per ha per annum of shrub savanna to 4.8-10.6 tonnes per ha per annum of dense forest. Bio-energy on its own in Botswana could meet 1/3 of the country's national energy needs, especially for open-fire cooking; of which approximately 74% of rural population depends on (BITC, 2016: 33-34; Department of Energy (n.d.: 4).

While bio-energy is easily available especially among rural communities, it has four major drawbacks compared to solar energy which are that bio-energy is (i) an air pollutant as compared to sunshine which is green and safe to the environment; (ii) cutting of trees results in deforestation and land degradation which ultimately culminates in disturbances in the water cycle and natural ecosystem; (iii) wood is heavy and thus, costly to transport compared to sunshine; and (iv) wood is non-renewable, that is trees can get depleted; whereas sunshine is almost eternal.

While bio-energy could help solve one third of Botswana's energy demands, solar stands a better chance. Due to the above mentioned drawbacks of bio-energy over solar, solar needs to be explored as an alternative power choice for Botswana.

Solar

Botswana has one of the highest solar radiation levels in the world, with a mean annual solar insulation of 21MJ per square meter per day (Department of Energy, n.d.: 3). This high level of solar radiation automatically suggests that Botswana should be one of the foremost countries on solar energy production. Currently Botswana is trying to generate power through the coal project, but as argued by Boidus (2014), if Botswana goes the route of solar, it will have many benefits for the nation, including no pollution and the fact that solar is renewable.

Why solar energy?

World Bank (2012: 31, 47) sums up the need for Botswana to quickly compare and contrast available energy sources and take action this way,

"*It is important for Botswana to not entirely rely on coal in future as it has a high carbon footprint. The country further needs to develop the potential of renewable energy sources, in particular solar power. Energy accounting could assist with predicting future electricity shortages, optimising energy use mixes and encouraging energy efficiency and fuller exploitation of under-utilised energy resources."*

Among sources of energy for Botswana, solar keeps being repeated. Advantages and disadvantages of solar energy follow: cleanness of solar energy, it is light and easily accessible. However, the disadvantages of solar energy are maily that it can be expensive to gather equipment at first (AfDB, 2009).

Conceptual Model

Authors of this paper propose the following conceptual model to give an idea to policy makers and other stakeholders on how planning and implementation of solar projects could be done in Botswana. The conceptual model is illustrated in Figure 1.

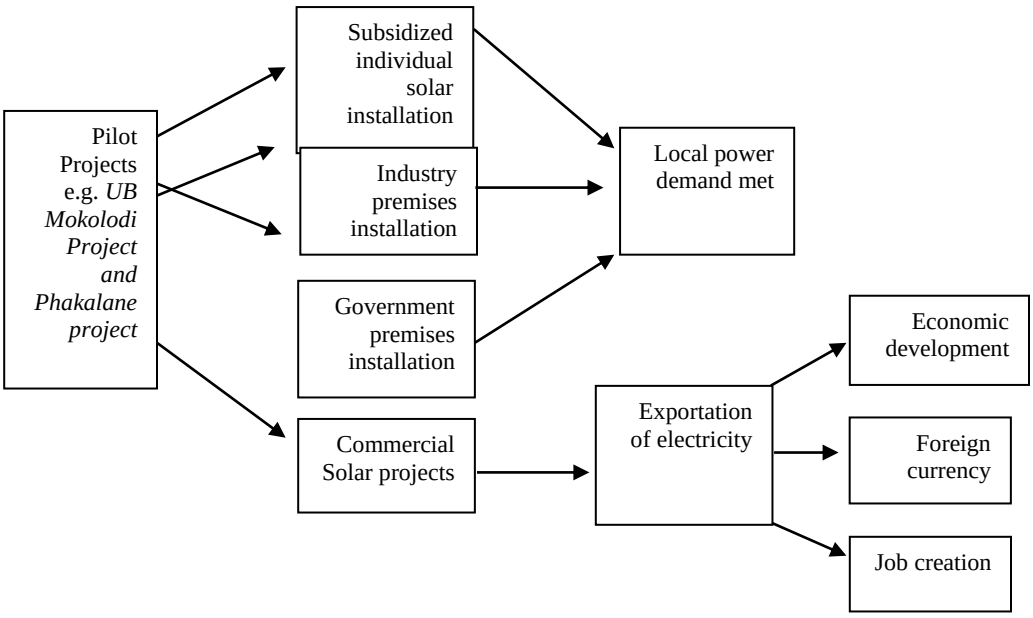

Figure 1: Conceptual Model for Solar Energy in Botswana

(Authors' own compilation, 2016)

As shown in Figure 1, the conceptual model adopts some of its concepts from literature. According to literature, there are already a few pilot solar energy projects such as University of Botswana – Mokolodi Solar Project and Phakalane Solar Project. Authors of this current study suggest that a few more pilot projects are needed in Botswana to supplement current projects. After that the country could possibly pursue four main solar generation avenues: 1) subsidized individual solar installation (whereby government subsidizes home solar installation); 2) industry premises installation (where industries are encouraged to install and use solar energy); 3) government premises installation (where government installs and uses solar power in their premises) and 4) commercial solar projects (whereby government and private sector comes up with major solar power station(s) that generate power mainly for exportation).

The first three ways of solar generation in the conceptual model are hoped to meet local solar power demand; while commercial solar power station(s) aim at generating solar energy to supply some local entities, but mainly for exportation. Exportation will help create jobs, empower local entrepreneurs, earn foreign currency and increase gross domestic product.

3. Methodology

Botswana's consistent importation of electricity and recent frequent power cuts has been counter-productive to the country. Thus, power cuts have negatively affected productivity in both private and public sector. A literature search has been done to find out ideas on how other countries have implemented solar projects and how Botswana could harness its sunshine into solar energy. A conceptual model has been proposed by the authors of this paper to solve power challenges in Botswana.

Research approach

While lessons have been drawn from other African countries on solar energy, particular attention has been put on Australia which shares a similar climate to Botswana.

Research process

Data was gathered from peer-reviewed journal articles, private and public sector reports, official country websites, books, conference papers, published and unpublished technical papers, official blogs and other related sources.

Data Analysis

Thematic content analysis was used for data analysis looking at various concepts pertaining to renewable energy sources.

Methodological limitations

The methodology of research literature review adopted in this study is limited in that it lacks field study which could possibly give results on the ground. It only looks at studies that have already been published in the past (secondary data). Another limitation of research literature review is that it considers various researches which had different research designs and approaches which may not be easy to compare in terms of specificity and coherence.

However, although literature review has its weaknesses, the researchers take this literature study as a foundation for future studies.

4. Finding

Empirical evidence internationally and globally

[5] Australia is similar to Botswana in that a vast part of the country is a desert, just like Botswana. This means that both countries receive lots of solar radiation almost all-year round. Australia's successful implementation of renewable energy, especially solar projects, in recent years could give Botswana insights on the way forward. Australia's success in this regard is demonstrated by the following statement, *"More than 1.4 million solar power systems had been installed in Australia at the end of 2014, along with more than 900,000 solar hot water systems"* (Clean Energy Council, 2014: 10).

[6]

Clean Energy Council (2014: 3) states that in Australia, household solar fared better than the large-scale sector in 2013. Increased consumer engagement and awareness about electricity prices and the benefits of solar technology meant more than 230,000 households and businesses installed either solar power or solar hot water. In terms of business, *"More than 15,000 businesses have now installed a solar power system, collectively saving more than $64 (Australlian) million on their power bills every year"* (Clean Energy Council, 2014: 4). This means that businesses in Australia are taking advantage of renewable energy sources to run their operations. Botswana enterprises that have suffered from power cuts could follow suit.

The Australian Renewable Energy Agency (ARENA) plays a major role in supporting renewable energy projects (Wright & Hearps, 2011). In 2014 alone, Australian household and commercial solar <100 kW stood at 4834GWh, powering an equivalent of 680,900 households during the

year 2014; while large-scale solar was at 118GWh, powering an equivalent of 16,700 households during the year 2014 (Clean Energy Council, 2014: 7; Wright & Hearps, 2011).

While the Australian government's actions are commendable, however, Wood & Blowers (2015: 4) argue on the contrary, *"About 1.4 million Australian homes have installed solar panels on their roofs since 2001. It is the largest take-up of photovoltaic (PV) solar systems of any country. These home owners wanted to save money, depend less on the electricity grid, and play their part in tackling climate change. But lavish government subsidies plus the structure of electricity network tariffs means that the cost of solar PV take-up has outweighed the benefits by almost $10 billion."* Therefore, it follows that, while the Australian government had a good initiative; they spoiled the plan by over-subsidizing the renewable energy projects. This serves as a warning to other countries such as Botswana so that when they implement such projects, they should let most of the costs to be borne by the consumers rather than by government.

Karekezi & Kithyoma (2001) carried out a study of rural energy sources in Sub-Saharan Africa. They reviewed emerging trends in the rural energy sector of sub-Saharan Africa, and discussed the limitations of over-reliance on solar PV. They suggested possible options that could have greater impact on rural clean energy development. Their findings were that the majority of rural households in the region, would likely keep using biomass fuels as the dominant fuel of choice. Solar thermal, wind pumps, micro/pico hydropower and cleaner fuels such as kerosene and LPG, have not received adequate attention from policy makers. These alternative energy options could significantly improve the performance of rural small and micro enterprises. This article argues that rural energy policies that emphasize a broader range of renewable energy sources that target income-generating activities are likely to yield greater benefits to the rural poor than the current policies that rely on the solar PV option.

Empirical evidence in Botswana

Ofetotse & Essah (2012) carried out a study to establish how Botswana could explore its energy concept. They employed literature review, questionnaire survey and empirical study. Findings showed an increased output from 100MW to 2595MW plus, thus assuming 85% plant capacity. They argued that while BPC and the government predicted positive assertions such as finishing the second phase of the Morupule B. Project by 2013, that was too ambitious. They suggested that predictions should be more realistic. Ofetotse & Essah (2012)'s findings are similar to suggestions by BIDPA (2012) that Botswana should not just wish well on coal revenue; but rather systems and policies must be put in place urgently. What this helps all stakeholders to do is to be realistic and minimize predictions which are not based on facts.

On the other hand Colman (2010) carried out a study in which he wanted to discover the network of actors in the Botswana's power generation. The paper made use of literature review and 34 interviews focusing on clean energy transitions in Botswana and the roles of International and Southern African actors and decision makers and key stakeholder groups and individuals within Botswana. Colman (2010)'s main argument was that, while Botswana should learn from other countries; care should be taken to compare like with like. This is because Botswana could run the danger of comparing their energy sector with that of developed countries; yet developed

countries have privatized power companies and in Botswana, the government still owns and runs the power corporation. The level of efficiency and conceptualization differ. Hence, such comparison may not give accurate information for decision-making.

Therefore, success of solar projects depends on the particular country under consideration and its strengths. Botswana's greatest strengths are that solar radiation is one of the highest in the world for almost all-year-round. Thus, solar energy solutions tailor-made for Botswana need to be implemented.

5. Discussion & Conclusion

This study sought to find out ways in which other countries have implemented solar projects. The empirical evidence has shown that solar energy is one of the best ways for Botswana to provide clean energy to the nation. However, there are challenges that come with solar energy implementation. For instance, it is expensive at first to implement the projects. But once the projects start running, in the long-run; Botswana will benefit by stopping importation of electricity, stopping power cuts and possibly exporting the solar power; thus, empowering local enterprises, earning foreign currency and boosting economic development. As the Botswana government leads the solar project, caution should be taken to avoid extravagant subsidies that could 'sink' the country's money.

Recommendations

It is recommended that Botswana government should put together policies, regulations and frameworks that support use of solar energy as a major power generation strategy for the country. The conceptual model proposed by the authors of this paper as shown in Figure 1 could be helpful to decision-makers.

There is also need to benchmark with other countries such as Australia and USA that have experience in solar projects. However, for ultimate success, government should first of all privatize the Botswana Power Corporation to increase efficiency in project management.

Apart from domestic solar power, the government, with help of the private sector, should spear head a major commercial solar project(s) that can supply majority of the country's power needs and export power.

The Australian Renewable Energy Agency (ARENA) plays a major role in supporting renewable energy projects. Botswana should form a renewable energy agency that will spearhead the solar power agenda. Care should however be taken by government so that it will not repeat the Australian government error of over-subsidizing renewable energy projects thereby resulting in losses.

Study limitations and suggestions for further studies

Firstly, the study is limited by use of literature review methodology instead of field study. Secondly, there is acute shortage of literature on solar energy in Botswana. Therefore, the researcher had to rely more on international sources, of which there are few peer-reviewed journal articles on the subject.

It is suggested that a field study should be done in Botswana to find out two things. Firstly, how ready is the nation to use solar energy as an alternative to regular electric power? Secondly, how

ready is the government to come up with policies, regulations and frameworks that support a major solar generation project?

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