POSSIBILITIES AND LIMITATIONS OF SOLAR ENERGY AS A SUSTAINABLE AND RENEWABLE POWER SOURCE TO HELP END THE CURRENT POWER DEFICIT IN ZAMBIA

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Abstract

Background and Objective: The study investigates the possibilities and limitations of solar energy as a sustainable and renewable power source to help end the current power deficit in Zambia. The study's main objective is to investigate the possibilities and limitations of utilizing sunlight as a continuous inexhaustible power supply to supplement existing power generation to end the deficit.

Study Design/Materials and Methods: The basic design is the mixed methods research (MMR) design, a combination of quantitative and qualitative research methods that provide solutions to research query(s) correctly and ethically. The MMR comprises data gathering using questionnaires and interviews, evaluating, translating, and providing both quantitative and qualitative information in one study. The study generates a generic hypothesis that if solar energy is fully explored, developed, and continuous systems implemented, the current power deficit will come to an end, boosting economic growth and national development.

Results: Once fully exploited and developed, solar power is likely to offer solutions to global and Zambian power challenges in particular.

Practical Implications: The current condition in the world concerns power challenges that need urgent solutions. The study results indicate that globally only industrialized nations have taken up the challenge seriously, whereas in Africa, where the energy problem is acute, very little is being done.

Conclusions and Summary: The governments of the world, Zambian included, must formulate a solar energy framework and make considerable investments in sunlight harvesting.

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DOI: 10.19253/reme.2022.01.004

Keywords: solar energy, inexhaustible, mixed methods, quantitative method, qualitative method

JEL classification: (Q40, Q42)

Paper type: Literature Review

1. Introduction

A stable and fail-safe electric power supply forms the main factor for the economic development of any country globally (Sumathi, Kumar, and Surekha (2015). The book entitled "Solar Energy: Fundamentals, Technology and Systems" by Jäger, Isabella, Smets, Swaaij, and Zeman (2014) states that energy or power exists in different forms and is needed for various fundamental utilizations. This makes power an imperative commodity that human beings need all the time for their various activities (Yahyaoui, 2018; Jager et al., 2014; Sumathi et al., 2015).

According to Yahyaoui (2018) and Kalogirou (2014), the sun is the main source of power. This is why studies on harnessing solar power are of significant value. Furthermore, citing Sumathi et al. (2015), sunlight will be the main power generating source for both growing and advanced nations in the coming years.

Of late, solar power production and related technological equipment have become cheap and achievable globally (Hansen, Nygaard, and Pedersen, 2017). The (solar) technology provides an unpolluted power supply and enhances huge yearly savings (Li and Shi, 2015). The transformation of solar power directly into electricity using apparatuses built of semiconductor materials is called photovoltaics (PV) (Jager et al., 2014; Yahyaoui, 2015; Sumathi et al., 2015).

Electrical energy deficiency in Zambia has been a significant challenge to the country's economic development for a long time (Sumathi et al., 2015). Existing hydroelectric power plants in Zambia have failed to meet the ever-increasing population and industrial power demands due to failing old hydroelectric generating plants, lack of investment and prohibiting cost of constructing new hydroelectric plants, and prolonged droughts since the 2014/2015 rainy season (Kesselring, n.d.; Sinyolo, 2020; Falchettaa et al., 2019; Emetere, Agubo, and Chikwendu, 2021; Mwitwa, 2018). This has seriously affected the country's general economic growth and development due to the power deficit. This is the reason why alternative power sources must be explored.

Unfortunately, instead of power deficit being a motivation, affected nations, especially in Africa, have done very little or nothing (Mwanza and Ulgen, 2021) to diversify from water power production and look at the sunlight as a continuous inexhaustible alternative power source. Firstly, the gap is mainly due to a lack of visionary leadership concerning looking for alternative sources like sunlight. Secondly, institutions of higher learning need to include solar power studies in their curricula.

Thirdly, governments must pay more attention to exploiting the sun as a reliable and dependable alternative power source (Emetere et al., 2021).

The research question, "To what extent does solar power exploration, development, and new solar power technological system implementation impact current power deficit, economic growth, and development?" must be given the attention it deserves. This research question will provide several pertinent issues pertaining to solar power that, once resolved, may present the solution to current power crises in the country. To be able to achieve this, three major study methodologies have been employed, including the quantitative (organized) method, qualitative (semi- or unorganized) method, and mixed methods investigation (Mohajan, 2018; Bouchrika, 2020).

Mixed methods research makes the research problem easier to comprehend than either numerical or non-numerical method alone (Boru, 2018; Dawadi, Shrestha, and Giri, 2021; Harrison, Reilly, and Creswell, 2020) as it integrates the benefits of both methods. This means that mixed methods investigation is the one to utilize in a situation where neither numerical nor non-numerical analysis can fully provide answers to the study query.

The study hypothesis is that "If solar power is fully explored, developed, and a continuous system implemented, the current power deficit will come to an end, boosting economic growth and national development." To achieve the foregoing, a more reliable and continuous inexhaustible power supply source must be identified. It is against this problem that the study attempts to look at the possibilities and limitations of solar energy as an alternative reliable and dependable power source to hydroelectric power generation with a view and hope that the possibilities outweigh the limitations. For instance, according to Kabir et al. (2018) and Yahyaoui (2018), solar energy exhibits the highest global power potential compared to other renewable energy sources like biomass and thermal energy.

According to Silimina (2020), in Zambia, solar power is abundant throughout the year averaging 2,000 to 3,000 hours of sunshine per year and average irradiation of 5.5 kilowatt-hours per square meter per day. Once explored, exploited, and developed, it will supplement the existing hydroelectric generation in the country. As a result, it will help reduce or altogether remove the power deficit, accelerate economic growth, and enhance the country's general development.

For solar installations in Zambia, the total prospective area is approximately 82,564.601 km^2 which is 10.97% of Zambia's aggregate land area. Interestingly this area can produce 10,240.73 TWh annual power, lessening CO_2 discharges and attaining the United Nations Sustainable Development Goals (SDGs) (Mwanza and Ulgen, 2021; The SDGs, 2022).

The mean power country availability is 31 percent, with 67 percent catering for the cities and towns and four percent for countryside dwellers. This has escalated the energy demand nationwide in recent years and has continued to grow year after

year. A statement from the Zambia Development Agency (ZDA) indicated that the need for power yearly increases at a mean rate of three percent (Energy Regulation, 2020).

The total production capacity of power in Zambia has increased from 2,800 MW to 3,030 MW of electrical energy, of which 85 percent is water produced (Zambia Power, 2019), which has been drastically affected in recent years by the effects of climate change. The country's major water energy production plants comprise the Kariba North Bank Power Station, Kafue Gorge Power Station, Victoria Falls Power Station, Lunsemfwa Hydro Power Company (LHPC), and the Itezhi Tezhi Hydropower Station. Additionally, the country has had a fossil fuel plant at Maamba Collieries since 2016 that produces 300 MW of electrical energy for ZESCO. ZESCO is the biggest state-owned power company responsible for energy plants' power grids and delivery grids. It is the sole buyer of electrical energy from independent power producers (IPPs) (Energy Regulation, 2020; Maamba Colliries, 2021; Zambia, 2020).

In terms of solar power harnessing in Zambia, the Industrial Development Corporation (IDC), the Ministry of Energy, and other cooperating partners initiated the first solar energy production undertaking. This was done in 2019 by a collaboration of French (Neoen) and American conglomerates, constructing a 47.5 MW production yard feeding straight into ZESCO's country network. This was followed by an Italian company Enel producing 26 MW of solar energy in May 2020 and feeding into the country's network (Energy, 2020).

For a long time, Zambia has relied on hydroelectric power generation. However, today hydroelectric power generation has experienced multiple deterrents due to weather effects rendering the system unreliable and unsustainable. The two main obstacles that hampered power production in those plants include total reliance on rainfall and the cost of improving the existing plants' know-how (Gorkaltseva and Sinkala, 2017).

A significant deterrent to Zambia's full dependence on hydroelectric power generation has been the effects of weather variations, specifically the persistent lack of sufficient rainfall. In agreement with Silimina (2020), the continuing rain deficiency has negatively affected power generation at gigantic weirs. For this reason, the author of this paper believes the nation must look at other fail-safe clean energy prospects other than hydroelectric power generation supplies, and renewable energy resources must be considered the best option.

Hydroelectric power generation is a clean, sustainable power supply but is no longer the most preferred option due to a persistent lack of rain over prolonged periods. The other deterrents include a lack of serious investment in hydroelectric power generation and an ever-increasing demand for power in the country by farmers, miners, and production industries. As a result, other sustainable power supplies are being sought (Silimina, 2020).

1.1. Study Significance

Electrical energy deficiency in Zambia forms a basis for undertaking research to examine the possibilities and limitations of uninterrupted power supplies. The whole essence of the study is to identify a power source that would provide a fail-safe continuous inexhaustible alternative energy to supplement hydroelectric power and consequently avail all citizens' entry to using electrical energy. Zambia as a nation requires a dependable and sustainable power supply for economic growth and development. In this study, the sustainable power source that forms the basis of the study is sunlight. Once explored and exploited, solar power would provide the greatest resource of sustainable and inexhaustible energy (Mainza, 2020).

It is hoped that the research results will help come up with tangible solutions and recommendations for the current electrical deficiency Zambia suffers and that all the possibilities identified will outweigh the limitations.

1.2. Objectives

General Objective

The general objective of the study on sunlight as an alternative power source is:

To investigate the possibilities and limitations in utilizing sunlight as a continuous inexhaustible power supply to supplement existing hydroelectric power generation to end the deficit.

Specific Objectives

The specific objectives of the study include the following:

— To explore the possibility of solar energy as a renewable power supply.
— To examine the sustainability of solar energy as a renewable power supply.
— To assess the development of solar energy continuous systems that are pollution-free.
— To assess limitations that are likely to impact the positive exploitation of solar energy as a sustainable renewable power source.
— To develop a framework that will contribute to policy formulation on solar energy as a sustainable renewable power source.

2. Literature Review

2.1. Introduction to the Literature Review

This literature review concern the topic of the paper entitled "Solar Energy: Potential and Future Prospects" by Kabir, Kumarb, Kumarc, Adelodund, and Kim

(2018). This topic entails that two aspects involved must be understood, namely the potential of solar power and its possibilities in years to come. These two form the foundation of this literature review.

2.2. Solar Energy

According to Kabir et al. (2018), Tian, Zhang, Yuan, Che, and Zafetti (2020), Yahyaoui (2018), Sumathi et al. (2015), Jager et al., 2014, and Kalogirou, 2014), solar energy radiates from the sun and is a significant source of inexhaustible free power called solar energy for planet Earth. Since the sun is a considerable source of unlimited free power (Hoffman, 2019), it is imperative to explore the possibilities of solar energy as a continuous inexhaustible power supply for the benefit of humanity. This in itself forms the foundation of the study.

Solar power is harvested from the sun using newly developed technology such as photovoltaic (PV) cells (Shaikh, Waghmare, Labade, Fuke, Tekale, 2018; Sumathi et al., 2015; Yahyaoui, 2018). The methods used in solar energy harvesting have been proven and are used globally as inexhaustible power alternatives to water-generated energy (Kabir et al., 2018). Moreover, increasingly PV approaches surface as a sustainable and cost-effective resource of green power (Altas and Sharaf, 2014; Sumathi et al., 2015), making its future utilization potential very high.

For time immemorial, water has been used as the main source of inexhaustible electrical power (IRENA and AfDB, 2022; Tian et al., 2020). Until recently, solar energy was considered a costly and uneconomical electrical energy source (Hagumimana, Zheng, Asemota, Niyonteze, Nsengiyumva, Nduwamungu, Bimenyimana, 2021) compared to hydroelectric power produced (Wei, Jiheng, Junhong, Zhe, Lingbo and Baodeng, 2020) globally by over 150 nations (Saw and Qing, 2019). According to Kalitsi (n.d.), only 10 percent of the African population receive hydropower. It is not equally spread, with North Africa receiving 23 percent, West Africa 25 percent, and South, Central, and Eastern Africa a combined 51 percent.

On this basis, the study concerning assessing the possibilities of using sunlight as a continuous inexhaustible power source, especially in Africa, must be considered as power forms the economic foundation of many a country globally (Sumathi et al., 2015; Atebaa, Prinsloob, and Gawlik, 2019). Moreover, several deterrents affect hydropower generation in Africa, especially insufficient rain making hydropower plants ineffective (Falchettaa, Gernaatc, Huntd, Sterl, 2019; Mwitwa, 2018). Falchettaa et al. (2019) and Emetere, Agubo, and Chikwendu (2021) listed Kenya, Tanzania, Ghana, Zimbabwe, Zambia, and Malawi as countries seriously hit by lack of enough or no rain at all, making their power-producing facilities ineffective since 2015.

Unfortunately, despite this development, nations affected have done very little or nothing to diversify from hydropower production and look into the sunlight as a continuous inexhaustible power source (Mwanza and Ulgen, 2021). The gap

is mainly due to a lack of visionary leadership and little attention given to issues concerning power. The power deficit should have been a motivation to digress from hydropower plants to more robust photovoltaic systems.

Africa needs leaders who can 'think outside the box" and steer the continent in the right direction. This study aims to bring to light the means and measures necessary to move away from hydropower to a more reliable and dependable power source such as sunlight. These data fortify the study in that, indeed, there is a need to investigate possibilities, especially of using sunlight as a dependable global power source providing unlimited free power (Tian et al., 2020). The solution lies in power diversification and mixes that are hardly affected by weather shifts.

2.3. Potential and Future Prospects of Solar Energy

Power can be classified as either inexhaustible or exhaustible (Kadhim, 2018). Three distinct power sources include natural fuels such as coal or gas, nuclear sources, and inexhaustible sources (Qazi, Fayaz, Rahim, Hardeker, Alghazzawi, Shaban, Haruna, 2019; Sumathi et al., 2015; Yahyaoui, 2018). This study focuses on continuous inexhaustible sunlight as an abundant alternate power source. This is in line with the second specific objective of the study to explore the sustainability of solar energy as a renewable power supply.

The future of solar power is very promising and immense, and photovoltaic (PV) approaches have attained higher utilization levels as the costs of PV systems have dropped by 50% over the last five years. Solar energy is continuous, safe (Kalogirou, 2014), inexhaustible, and available to all freely. Current fuels like oil, coal, gas, and nuclear materials used in power production emit toxic discharges, impact the environment negatively, and are expected to be depleted soon (Sumathi et al., 2015; Hoffman, 2019). This makes solar power advantageous with significant future potential as it is cheaper, continuous, safe, and inexhaustible (IRENA, 2019; Mwanza and Ulgen, 2021; Kalogirou, 2014; Altas and Sharaf, 2014).

Sunlight as a continuous inexhaustible power source is the focus of this study. The sun emits 100,000 TW of solar energy received by planet Earth (Kadhim, 2018; Yahyaoui, 2018). According to Qazi et al. (2019), power needs have escalated hugely, and sunlight is a source that can help to end the crisis. Emetere et al. (2021) stated that three types of power sources are employed from Nigeria in West Africa to South Africa: water, natural gas, and coal. Unfortunately, natural gas and coal are exhaustible, pollute the environment, deplete the ozone layer, add to global warming, and hydropower depends on precipitation and thus cannot be relied on for continuity (Martins, Felgueiras Smitkova and Caetano, 2019).

The enormous amount of sunlight reaching earth can be changed into electrical and thermal power using PV cells which can spur economic growth and development (Kadhim, 2018; Rumman, Khdair, and Khdair, 2020; Martins, Felgueiras

Smitkova, Caetano, 2019; Yahyaoui, 2018; Jager et al., 2014; Sumathi et al., 2015; Kalogirou, 2014). This power source can be depended on now and for future use, as it is sustainable, renewable, and inexhaustible (The Future, 2015). The available literature on solar energy potential and future prospects (Gielen, Boshell, Saygin, Bazilian, Wagner, and Gorini, 2019; Rumman, 2020) supports sunlight sustainability.

From now on, solar power must not be considered from a negative perspective as being costly. Instead, researchers and manufacturers must collaborate to develop accessible and cheaper technology for solar power harvesting equipment. This would make power to all a reality. Unfortunately, existing technology is costly (Veal, 2014), thereby prohibiting wider usability leading to shunning solar energy in most cases.

The population in Africa and globally has increased over the years, and as such, the power demand has equally escalated (Emetere et al., 2021; Jager et al., 2014; Kalogirou, 2014). Unfortunately, little attention is given to power issues in Africa, as opposed to developed and advanced nations (Emetere et al., 2021). The biggest gap has been a lack of knowledge. Institutions of higher learning need to include solar energy studies into their curricula to stimulate further research on how best sunlight can be harvested and distributed for domestic and industrial purposes.

Ellabban, Abu-Rub, and Blaabjerg (2014) stated that the currently widely utilized power generated from such sources as oil, petroleum, and natural gas proved reliable drivers of economies. This hypothesis is supported by Mahfoudh and Amar (2014) and Atebaa (2019), who emphasized the importance of electrical power to the expansion of a country. Sadly these sources have grave environmental concerns (Kalogirou, 2014) and the use of renewable energy as another source is highly encouraged (Ellabban et al., 2014).

In this study, the preferred continuous inexhaustible power source is sunlight. Of course, other renewable energy sources may be considered, but more attention must be paid to solar power as a single dependable source due to its sufficiency. Furthermore, the available literature needs to emphasize that, once tapped and distributed, solar energy will ensure power continuity, consequently leading to sustainable economic growth and development.

This means that sunlight provides a sustainable power supply (Kalogirou, 2014) that cannot run out (Kabir et al., 2018). This also indicates that solar power source has greater potential and high possibilities for current and future utilization. Ellabban et al. (2014) and Darwin (2015) stated that power generation globally from renewable energy sources is anticipated to rise 2.7 times between 2010 and 2035. What is more, the solar power source is unlikely to run out in the near future.

From the foregoing perspective, it is imperative to investigate the possibilities and limitations of using solar energy as a continuous inexhaustible power source. The essence is to understand potentials as opposed to drawbacks in exploiting and harnessing sunlight, mainly based on available data. Therefore, this study aims to

examine the available literature on the topic and milestones attained to ensure further research on the topic is substantiated.

2.4. Inquiry Question for This Review

The research question relating to the study topic is, "What are the possibilities and limitations of solar energy as a sustainable and renewable power source to help end the current power deficit in Zambia and enhance economic growth and development?"

3. Literature

3.1. Introduction

This literature review is based on 13 journals giving information on solar energy. Five themes were identified based on the results concerning various journals to bring out what each journal highlighted in relation to solar power. Journals that stated almost the same theme were grouped together, and the findings were made available.

3.2. Assessing the Consumption of Alternative Energy Sources

Power as the most needed item (Kaunda, Morel, and Mtawali, 2013; Jager et al., 2014) globally requires proper continuous management. In Zambia, this calls for a strong National Energy Policy (NEP), which is a fundamental factor in harnessing and promoting entry to power amenities (National Energy Policy, 2019) and meets the critical needs of the human race (Owusu and Sarkodie, 2016). According to Silimina (2020), in Zambia, solar energy is abundant throughout the year averaging 2,000 to 3,000 hours of sunshine per year and average irradiation of 5.5 kilowatt-hours per square meter per day.

Once developed, it will supplement the existing hydroelectric generation in the country. As a result, it will help reduce or altogether remove the power deficit, accelerate economic growth, and enhance the country's general development (Sumathi et al., 2015). Rural areas will consequently gain a reliable fail-safe power supply.

Sadly, little effort by governments in Africa over the last years has been made toward harnessing solar energy as a reliable power source (Mwanza and Ulgen, 2021). To address this gap, the government in Zambia, for instance, has recently established solar power projects in various locations of the country for domestic use mostly (Milonova, 2021). However, these projects have been hindered by insufficient follow-ups to see how they are coming along and if they can be integrated into the industrial sector.

Recent studies have indicated that global power usage has "skyrocketed" from 8,588.9 million tonnes (Mtoe) in 1995 to 13,147.3 Mtoe in 2015 (Goswami, 2015; Jager et al., 2014; Ahmad and Zhang, 2020). Mardani, Jusoh, Zavadskas, Cavallaro, and Khalifah (2015) pointed out that continuity and inexhaustible are two words that have become crucial to humankind. Therefore, alternative continuous inexhaustible power sources (El-houari, Allouhi, Rehman, Buker, Kousksou, Jamil, and El Amrani, 2020) must be looked at to provide fail-safe power that will mitigate disasters due to weather shifts and meet the ever-rising power demand (Mardani et al., 2015; Abolhosseini, Heshmati, and Altmann, 2014). Globally, Africa leads in the power deficit, followed by Asia due to overdependence on carbon-generated energy (Bowa, Mwanza Sumbwanyambe, and Pretorius, 2017).

In Africa, for instance, the gap that I consider to have negatively impacted economic growth and development has been sovereign nations working in isolation. Africa, the biggest recipient of sunlight over long periods of hours per day, needed to formulate a continental policy or framework on renewable energy. Putting resources together, Africa can develop solar projects in strategic locations that would supply the entire continent with uninterrupted power.

However, Zambia was selected to join the International Renewable Energy Agency (IRENA) in 2013 as a contributing nation for the Renewable Readiness Assessment (RRA) Process. IRENA is a worldwide intergovernmental organization authorized to promote collaboration, provide data and encourage the assumption and justifiable utilization of inexhaustible power. In the RRA, development engagements were identified to assist in fortifying the nation's investment framework, generate a renewable-friendly institutional and monitoring structure, sustain techno-economic assessments of renewable energy methods, and develop a biofuel framework. The ultimate objective was to aid Zambia with enacting the Draft Renewable Energy Strategy (IRENA, 2013).

The RRA two-day workshop mainly focused on three main areas for the RRA in Zambia: on-grid electricity, off-grid electricity, and biofuels. The off-grid electricity, among many other types of renewable energy, also catered for sunlight power (IRENA, 2013). Such and many other similar collaborations regionally and globally would put Zambia and other developing nations in a position to develop a common solution to power challenges encountered.

Additionally, Zambia is also a member state of SADC, and one of the objectives of this regional grouping is access to satisfactory and consistent power services for the entire SADC. The member states recognized the importance of power as a promoter of regional development at a rate of seven percent and lessening poverty on a justifiable basis (IRENA, 2013). Such regional and international collaborations would certainly assist in harnessing solar power and ending the current power deficit.

As the situation stands, humanity faces a disaster by using up inadequate natural energy supplies before coming up with continuous and substitute energy sources

(Hoffman, 2019; Jager et al., 2014; Oludaisi, Kayode, and Ayodeji, 2017). This calls for assessing the development of continuous inexhaustible solar power as an alternative pollution-free source, which is the third specific objective of the study. The author of this paper believes that all nations of the globe must be involved in finding a common solution to the global power deficit.

Bildirici (2013) and Bowa et al. (2017) indicated that usage of power in Africa, especially Sub-Saharan Africa, is very minimal in comparison to global utilization (Blimpo and Davies, 2019). High power utilization is a key factor in any nation's economic growth or expansion, leading to improved livelihood (Orhan, İnce, and Açık, 2020). Some studies have indicated that power usage is directly related to the commercial expansion of a nation (Blimpo and Davies, 2019; Bildirici, 2013). Owoeye, Olanipekun, Ogunsola, and Kutu (2020) and Blimpo and Davies (2019) pointed out that factors that determine electricity utilization include but are not limited to costs, revenue, and population growth.

As a researcher, my position on this matter is that Africa must now take a risk by investing in solar power generation to benefit posterity. All political differences need to be put aside to team up and strategically make considerable investments in harvesting solar energy. Taking of solar power limitations is not needed now; instead, we should focus on how to use this energy source well.

Certain countries need to set up universities solely for training and research into the best sunlight harvesting methods. This would assist a lot in understanding, developing, and designing locally produced equipment that would be cheaper than imported.

According to Chipoya, Muya, and Sichilalu (2019), Zambia encountered an unprecedented power deficiency from 2015 to 2017. The deficit reached a record of 1,000MW in 2015 (Ahmed, Baddeley, Coffman, Meikle, Oseni, and Sianjase, 2019). This made it possible to start looking at alternative continuous inexhaustible power sources like solar energy to provide alternate sources to existing hydroelectric power. Generally, power consumption in Africa and Zambia, in particular, has been very low, especially in rural areas (Blimpo and Davies, 2019). This means there is a need to explore and exploit sunlight as another power source to cater to countryside populations.

Unfortunately, despite the unprecedented lack of rain from 2015 to 2017 and beyond (Chipoya et al., 2019), Zambia, for instance, saw more investment in the construction and expansion of new water-generated power plants such as the 750MW Kafue Gorge Lower (KGL) hydropower plant on the Kafue River. My position is that funding must be instead directed toward exploring and exploiting solar power. This is because the reduced precipitation between 2015 and 2017 was not the last but continued even after 2017, rendering the hydropower facilities less effective.

3.3. Assessment of Solar Energy Source Distribution and Potential

Globally sunlight utilization using photovoltaic know-how has seen a tremendous upswing year in and year out. Citing Goswami (2015), solar power has had a mean annual growth rate estimated at 50 percent. As a result, photovoltaic technology (PV) has increased considerably yearly. For instance, in 2015, 227.1 GW of PV power was generated worldwide. This is an approximate figure as installations less than GW, and those countries with figures above GW but unverified were not considered (Taba, Mwanza, Celtin, and Ulgen, 2017).

Bowa et al. (2017) detailed that Zambia has faced many difficulties in ensuring power balance between towns and countryside areas. The persistent lack of adequate rain over prolonged periods has made the situation worse. This has affected hydropower production.

Currently, Zambia is generating 3,030 MW of electrical power, of which 85 percent is hydropower. Countrywide power utilization is a mean of 31 percent. Towns and cities receive 67 percent, and 4 percent goes to countryside areas. The government of the Republic of Zambia (GRZ) aims to ensure all citizenry get power by 2030 (Zambia Power, 2019). The examination of the possibilities and limitations of solar energy as a continuous inexhaustible power source cannot come at a better time than now, hence this study.

My understanding is that the challenge in Zambia, like most other developing nations, has been the exclusion of most countryside areas as potential economic areas. This, however, is a misnomer that requires to be revisited. It is a fact that extending power grids to countryside areas would be a gargantuan task and a costly undertaking. But governments should instead consider this an opportunity to have stand-alone solar power plants installed in such areas. This would change the uneconomical locations into economically viable zones contributing to the overall economic development of nations.

To provide continuous growth, the government has given attention to solar energy as a substitute for the existing major hydropower production. Zambia and the rest of the Sub-Saharan region have considered sunlight the best substitute for low hydropower production (Bowa et al., 2017). However, for most growing nations like Zambia, the challenge has been a lack of data on sunlight as a power source as very few meteorological posts countrywide provide such information.

As an investigator, I think that the (Zambian) government must ensure that modern meteorological monitoring posts are located in all districts and fitted with modern, up-to-date equipment. Additionally, personnel training in meteorological issues is cardinal to make the whole process possible. The lack of meteorological monitoring posts has been a serious gap in data collection and analysis.

Mwanza, Chachak, Çetin, and Ülgen (2017) explained that despite being blessed with an assortment of power sources, Zambia has not fully harnessed them. Nevertheless, the total power availability has increased to 3,030 MW, of which hy-

dropower is 2,393 MW, coal is 333 MW, thermal/diesel is 122 MW, thermal/HFO is 91 MW, and solar power is 91 MW (Zambia Power, 2019). However, several factors have inhibited the exploration and exploitation of solar energy. They include a lack of solar power data, equipment, and limited knowledge.

This gap requires attention as less data on sunlight prevents the implementation of solar power plants anywhere in the country. According to Guangal and Chala (2019), solar energy is one of the best options as it is a clean, renewable energy source found abundantly in most places. According to Goswami (2015), it is expected that solar energy will continue to be an imperative inexhaustible power source in the coming years. According to Goswami (2015) and Mwanza and Ulgen (2021), this is mainly due to decreasing cost of PV know-how.

The solar power reaching the earth in one hour and thirty minutes is adequate to meet the global power demand for one full year. Moreover, due to a number of advantages of solar energy, many countries and organizations have started to invest colossal amounts of money into sunlight harnessing. Consequently, the technologies are advancing, and the cost of generating solar energy decreases from time to time (Guangal and Chala, 2019; Jager et al., 2014; Goswami, 2015; Mwanza and Ulgen, 2021).

There are greater possibilities and potential for investing in solar power, and systems can stand alone in various locations without being integrated into the existing grid, thereby reducing installation costs. This is one of the advantages of solar energy as the plant can be independent of the national power network and operate in areas where power is required, especially in the countryside.

3.4. Renewable Energy Ensuring Sustainability through Community Acceptability

Antwi and Ley (2021) indicated that 840 million individuals do not have access to power, and over 2.7 billion globally do not use unpolluted energy in their households. Most of these persons reside in underdeveloped countries. Prohibiting factors to access and affordability of energy are numerous, with the critical being the prohibitive cost of power, especially in Africa, requiring urgent attention (IRENA and AfDB, 2022).

In Africa, over 573 million habitants do not receive power covering 80 percent of Africa's total population. The lack of safe, unpolluted energy has adversely affected the continent's progress and economic expansion, escalating deforestation and other environmental risks (Antwi and Ley, 2021). Unfortunately for Zambia and four other nations, as reported by IRENA and AfDB (2022), gender is surprisingly one of the factors that inhibit women's accessibility to energy.

In such areas as Africa, it would be unfortunate for governments to fail to supply electricity to all rural areas, given the abundant sunlight throughout the year. As a continent experiencing long periods of sunlight, Africa should be the least to

complain about the power deficit. The amount of solar energy that reaches planet Earth unceasingly is 1.05 × 105 TW. If one percent of that power is transformed into electricity with 10% efficiency, 105 TW of power would be provided, which significantly exceeds the total global power needs projected for 2050, at 25–30 TW (Goswami, 2015).

My proposal is that governments must shift from investing more in hydropower production to more in sunlight exploration and exploitation, which will quickly and adequately help end the power challenges. The resultant effect will be providing electricity to all countryside dwellers, leading to an economic boom and development. Solar power is the way to go committedly, leaving no one behind (Goswami, 2015).

From that perspective, the community must play a more prominent role in ensuring the success of inexhaustible power projects. Most people globally do not have electricity. If they were involved, they would welcome the idea and support all efforts to have the inexhaustible power plants installed in their localities and offer protection. Furthermore, embracing inexhaustible power know-how by the community is paramount to meeting all society's energy requirements (Antwi and Ley, 2021).

The main reasons why society may not be in support of inexhaustible power supply plants in their neighborhood include disturbance to quietness, presence of an increased number of vehicles and other equipment, toxic waste, and an influx of people in search of employment impeding safety (Cohen, Reich, and Schmidthaler, n.d.). Therefore, every effort must be made to address all factors that would increase opposition from members of the public. In other words, for the successful undertaking of inexhaustible power installations to ensure continuity, the community must be involved and accept the project.

In my view, for the projects to be successful, the community members must also be employed in them apart from involving them in such activities as meetings only. This calls for proper management of community members and would promote ownership, consequently culminating in project success. Most available literature considers the community's involvement ending with meetings for consultation on project permission and land issues. However, the community members must also form part of the workforce to ensure success.

González, Sandoval, Acosta, and Henao (2016) explained that effective know-how and greener power generation and utilization procedures have led to a transition from conventional power generation to inexhaustible methods. Furthermore, an ever-increasing need for power globally (Jager et al., 2014) has led to the utilization of other inexhaustible energy sources like sunlight departing from the conventional ones and consequently mitigating weather shifts and averts deficits globally. This study aims to help understand that renewable energy sources (RES) are a way to provide power to countryside locations where the majority are underprivileged, improving living standards in the communities (González et al., 2016; IRENA, 2019).

The author of this paper understands that this literature is important as it brings out issues that concern the community, which are too important to be ignored. Without community participation, renewable power project implementation possibilities may not yield the desired outcomes. One important factor is understanding paybacks associated with photovoltaics (PV), including cost reduction, data availability to the public, and assurance of know-how used (Rai, Ribinson, 2013).

It must also be noted that in all continuous inexhaustible power undertakings, especially in countryside areas, training of the locals is paramount but has been lacking. The training must aim to enlighten the communities on the benefits and how to install the equipment to make it easier for the community to use it properly. The author of this article believes that governments must emphasize long-term benefits to the communities compared to short-term benefits to ensure full community participation and workability of the projects.

3.5. Renewable Energy Challenges and Way Forward in Africa

Globally, nations desire to implement and utilize continuous, never-ending power sources that are pollutant-free, but this has been marred with a lot of obstacles, as stated by Bishoge, Kombe, and Mvile (2020), Emetere et al. (2021) and IRENA (2019). The main challenges include a lack of commitment by most African countries, the initial cost of equipment (Goswami, 2015), and harnessing this source. In contrast, European governments have developed a lot of renewable solar power plants.

In most African nations, electricity deficit is combined with poor infrastructure, leading to the costly, not dependable power supply, negatively impacting economic growth and expansion. Consequently, most of the Sub-Saharan African population depends on utilizing mainly wood, charcoal, agricultural residues, and animal waste as the main source of power for cooking (The Renewable Energy, n.d.; Rahman, Al-Mahmud, Rahman, Hussain, Ali, 2013). This type of power utilization has adverse effects on the environment, contributes to greenhouse effects, and takes longer to replace, making it unsuitable as a practical energy source (Rahman et al., 2013).

Africa's power supply is mainly concentrated in towns or cities, excluding the vast rural masses that use other means of power sources apart from water. The way forward in line with the study is to assess the possibilities of harnessing solar energy as another sustainable power source that would be off-grid (stand-alone systems) covering the rural areas (The Renewable Energy, n.d.). Once tapped and exploited, solar power would ensure electricity availability to all countryside areas.

In all literature available, no single literature talked about defiance to alteration or modification. According to Jain, Asrani, and Jain (2018), human beings, like organizations, usually do not want to embrace adjustment. People are more comfortable with the status quo. From this understanding, it is necessary to address the challenges of adjustment in solving the problems of energy deficit.

It is crucial to train people to embrace change when its time has come. One of the major challenges of renewable energy has been opposition to the shift from water-generated electricity to solar power concepts, which must be addressed urgently and adequately. This applies particularly to political leaders who are satisfied with the status quo.

Opposition to modification or adjustment ranges from practices, tools, land, and total rejection or denial, among many others. Therefore, research needs to adequately address these hindrances by recommending training concerning opposition to changes. Furthermore, political leaders need to consider the power deficit seriously and help solar power generation development.

3.6. Solar Energy Generation Potential

Hafner, Tagliapietra, and Strasser (2018) explained that the possibility of solar energy is massive on the continent of Africa and indeed globally (IRENA, 2019). African nations are exposed to extended hours of sunlight, and irradiation is well spread. The implication is that the solar power know-how can be used to ensure power is catered for all rural areas. This does not concern Africa alone. There is the capacity to set up solar power systems that can help end the global electricity challenges.

In agreement with Hafner et al. (2018), many impediments exist to implementing solar power harvesting in Africa. These range from lack of policy direction (Mudenda, Makashini, Malama, and Abanda, 2018), staff training, comprehension of technology, and incentives for local and overseas project financing. These challenges are still a considerable gap that requires attention for sunlight harnessing to be a reality, particularly in Africa and Zambia.

The author of this paper believes that looking at the problem from a national perspective would be very difficult and costly and should be considered through regions, especially in Zambia, where pilot projects are underway in the Eastern Province (Zambia: Solar PV, n.d.). Only after studying and understanding all the complexities involved can there be an extension to other regions until all rural areas are covered. Consequently, further research is required on how these obstacles can be addressed before full exploration and exploitation of solar can proceed.

Bogdanov, Farfan, Sadovskaia, Aghahosseini, Child, Gulgi, Ovewo, Barbosa, and Breyer (2019) stated that inexhaustible power sources, such as sunlight, are not easily affected by shifts in climate and are attainable. Globally all nations have agreed to move away from power sources like coal, biomass, and oil to more environmentally friendly sources like sunlight which is a perfect source. A number of factors have been identified as promoters of inexhaustible power sources. These include speedy cost reduction in inexhaustible power; clean air environment; lessened carbon releases; enhanced energy safety that is inexpensive and available to all resulting in significantly improved living standards (Bogdanov et al., 2019).

Despite all the benefits of solar energy as a continuous inexhaustible power source, the biggest challenge has been non-committal by decision-makers and those in authority in Africa. It is imperative that governments come up with a position on solar power and start including its development in their national budgets. The budget would be for further personnel training, research purposes, and undertaking pilot projects to understand and possibly come up with even cheaper means of providing sunlight-generated power to all.

Guangal and Chala (2019), Kabir et al. (2018), and Sharma and Harinarayana (2013) all brought out the advantages and as such benefits that solar energy can offer humanity. The author of this article thinks more benefits can be obtained from sunlight as a source of continuous inexhaustible power compared to, for instance, water. Therefore, it is imperative that decision-makers and those in authority take advantage of all the benefits indicated by different investigators and start looking at the sunlight as the solution to all power challenges globally, in Africa and Zambia in particular.

4. Research Methodology

In this proposal, the research was based on 13 different journals relating to the topic "Solar Energy: Potential and Future Prospects." Search tools like Google Scholar, ScienceDirect, and other internet search tools were used to obtain various works of literature on sunlight as a continuous inexhaustible energy source. From the 13 different journals, data were gathered based on the findings of each journal and put into five different themes.

5. Analysis

All 13 journals relating to the topic, "Solar Energy: Potential and Future Prospects," were evaluated by reading to arrive at suitable themes relating to the study. The journals whose findings related to and discussed the same results were put together under one theme.

6. Results

A total of five themes were arrived at out of the 13 journals studied in terms of "Solar Energy: Potential and Future Prospects." The developed five themes became sub-titles in the literature review. The themes were formulated based on the findings of each journal on a specific subject.

All the journals related to the research subject were put under one theme, and accompanying descriptions followed. The descriptions under these themes, in turn, provided answers to the research inquiry, "How would full solar energy exploration,

development, and new solar power technological system implementation impact the current power deficit?"

7. Lessons Learned and Recommendations

The high global electricity demand in Africa and Zambia calls for serious investment in the continuous development of the solar power industry in the coming years. There is a need for governments of the world to take this matter seriously and ensure continuous inexhaustible power availability to all. The undertakings must embrace community participation to allay fears arising from misconceptions concerning the operation of such power plants in the communities.

There must be a deliberate policy to provide data on the gains associated with sunlight power systems and the photovoltaic (PV) equipment cost reduction. The governments, especially in Africa, where serious issues in terms of power supply to the inhabitants exist, must encourage would-be investors to enter rural areas and start installations of PV systems independent of national power grids. All countries, in Africa especially, must start including in their annual budgets substantial amounts of money to cater for research, exploration, and exploitation of sunlight. Africa, which is more exposed to long hours of sunshine, must take up this challenge and invest heavily in solar power harvesting culminating in economic growth and expansion as a solution to its main economic woes.

The continuous inexhaustible solar power capacities must be developed to meet the current energy demand and overcome existing deficits. The electrification sector must set realistic goals in rural areas to ensure all rural areas not receiving power do so by using stand-alone PV plants. To avoid abandoning undertakings and labeling them impossible, detailed investigations and data collection must be done in recommended areas before project implementation.

8. Conclusions

Sunlight provides the main resource of power to earth that is continuous and does not run out. Because of it, every effort is being made to develop, produce and utilize this power using reliable equipment. One of the major motivations to invest in and develop solar power systems is the fact that the energy thus generated or produced is safe, eco-friendly, and poses no known significant danger to the environment, nor does it have a negative impact on the planet.

Solar energy has a lot of benefits, such as lessening and reducing negative factors relating to power safety, weather shifts, and labor redundancies, to mention a few. Even though there are other types of renewable energy sources, it must be categorically stated here that sunlight is the best source with undoubted capacity as it

is not likely to run out. Therefore, solar power has the potential to meet and continue to provide energy as a significant source for the entire globe.

The available literature on sunlight as the main energy source indicates that Africa experiences prolonged periods of receiving sunlight than any other continent. This means that Africa must not experience power blackouts but instead harness this free power source and ensure that all peoples of Africa have access to electricity in one way or another. Solar energy can be utilized in a number of ways, including but not limited to the following: solar pumps, lighting, cooking, cooling, drying, and water heaters.

Solar power can be one of the major contributors to economic growth and national development. However, there are several deterrents associated with sunlight, such as the lack of proper technology and the high cost of photovoltaic (PV) systems. Sunlight as an energy source can provide fail-safe power now and in years to come. To that effect, new and efficient know-how is being developed to fulfill this goal and ensure continuous power availability at a realistic cost, reasonable and affordable to all.

Last but not least, sunlight as a source of continuous and inexhaustible power is the way to go for the global, regional, and local development of nations. This calls for substantial investment in terms of training, developing cheap and affordable PV systems, and generic policy formation as a guideline. Universities of the world must include solar energy studies in their curricula to train and equip engineers with the knowledge to make solar power harvesting on a global scale a reality. Global governments, Zambia included, must formulate a solar energy framework and invest in solar power harvesting.

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Streszczenie

Cel: Badanie analizuje możliwości i ograniczenia wykorzystania energii słonecznej jako zrównoważonej i odnawialnej energii w celu zlikwidowania deficytu energii elektrycznej w Zambii. Głównym celem badania jest zbadanie możliwości i ograniczeń wykorzystania światła słonecznego jako ciągłego, niewyczerpanego źródła energii w celu uzupełnienia istniejącej produkcji energii elektrycznej w celu wyeliminowania deficytu.

Materiały i metody badawcze: Podstawową konstrukcją jest projektowanie metod mieszanych (MMR) – połączenie ilościowych i jakościowych metod badawczych, które prawidłowo i etycznie odpowiadają na zapytania badawcze. MMR obejmuje zbieranie danych za pomocą kwestionariuszy i wywiadów, ocenę, tłumaczenie oraz dostarczanie informacji ilościowych i jakościowych w ramach badania. W ramach prowadzonych badań zaproponowano następującą hipotezę: obecny deficyt energii elektrycznej zostanie przezwyciężony, jeśli rozwiązania

dotyczące zastosowania energii słonecznej zostaną w pełni zbadane, rozwinięte i wdrożone w formie systemu ciągłego.

Wyniki: Po pełnym wykorzystaniu i rozwinięciu energii słonecznej powinna ona stanowić rozwiązanie globalnych, a w szczególności zambijskich problemów energetycznych.

Wnioski praktyczne: Obecna sytuacja na świecie dotyczy problemów związanych z władzą, które wymagają pilnego rozwiązania. Wyniki badań pokazują, że tylko kraje uprzemysłowione potraktowały to wyzwanie poważnie, podczas gdy w Afryce, gdzie problem energetyczny jest poważny, robi się bardzo niewiele.

Wnioski i podsumowanie: Rządy świata, w tym Zambii, muszą opracować ramy dla energii słonecznej i poczynić znaczne inwestycje w promieniowanie słoneczne.

Słowa kluczowe: energia słoneczna, niewyczerpana, metody mieszane, metoda ilościowa, metoda jakościowa