Solar Photovoltaic Technology Status, Prospective and Challenges in Zambia: A review

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Abstract:

Achieving sustainable development and use of solar energy have been regarded by the government of Zambia and the sub –Saharan African region as the best alternative to the current energy deficit as well as environmental concerns in the region. This review is a desk study of the on-going research on the sustainable energy and environmental policy analysis for Zambia. The country has had challenges with achieving the set targets of 10,000 new household connections by 2013 and ended up reducing the target to 2500 households of which 500 household of the target connected by 2015, which resulted in a CO2 reduction of 12,005 t CO2. In this paper, a review of the status and prospective of solar PV technologies in Zambia is carried. Furthermore, it highlights the programs of the solar PV technology in Zambia such as introduction of the solar PV mini-grid with the lowest tariff of US$0.0602/kWh. Finally, it discusses the Zambian government policies and initiatives to promote solar PV technology in the country and reduction of the green house gas emissions. The review on solar photovoltaic energy will help the decision makers and various stakeholders to understand the current PV status, barriers and challenges in Zambia.

Key words: Sustainable, Energy, Environment, Photovoltaic technology, Zambia

1. Introduction

In this time and age there is still one-third of humanity lacking access to electricity and associated services. Similarly around two billion people in the world still rely on firewood, animal grease or kerosene lamps for light despite all the advancement in energy technologies in the world [1]. Africa is the worst hit followed by Asian continent due to over reliance on carbon driven energy. In these continents, millions of people are still living on an average of 2USD per day. Despite not having alternative other forms of energy such as nuclear energy in developing countries, disposal would also be a challenge making it not a best option. As a result, lack of better energy alternatives in developing countries has caused many challenges such as environmental concerns, economic growth, basic medical services, and better opportunities. In the midst of all challenges, achieving clean universal access to electricity is one of the main goals set by the United Nations for the global energy sector [1] and as well as embracing the sustainanble development goal seven (ensure access to affordable, relaiable, sustainable and modern energy for all).

Southern Africa has embraced the set goals despite of late been hit with major energy crisis due to

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escalating demand growth and capacity addition projects that are lagging behind targeted schedules. The region needs to examine to a greater extent the interaction between energy and society in order to address the energy trilemma such as security, equity and environmental sustainability. In the past years,a call to up scale the renewable energy sector has since seen a rise. In 2012, Southern African Power Pool's (SAPP) total installed capacity was 57,182 Megawatts (MW) with an available capacity of 51,702 MW, against a peak demand of 53,833 MW [2]. Subsequently, at the regional level there is a peak deficit of about 2,131MW and a strong movement to embrace non-hydro renewable energy. Most of the countries in the SAPP have started to determine their grid capacity to accommodate renewable energy and policies to import renewable energy-based electricity, as can be seen in South Africa [2].Zambia has to priotized to address the energy crisis both locally and in the region. Zambia is a Southern Africa Development Community (SADC) member state with a population of nearly 16 million people, an average growth rate of 2.9% and a current urbanization rate of 3.2% [3] [4] [5]. Zambia plays a critical role in the SAPP, both as a supplier of hydropower from the Zambezi River Basin, and as an interconnector to the Congo River Basin [2].

This paper seeks to review the status, prospective and challenges of solar photovoltaic technology in Zambia. A study of the Zambian government policies and its initiatives to promote solar PV technology in the country has been conducted. Furthermore, the paper highlights the status of the solar energy and efforts the government of Zambia is trying to take in order to achieve the embarked on set targets to provide clean energy to 90 % and 50% of urban and rural electrification respectively by 2030. This review on solar photovoltaic technology will help the decision makers and various stakeholders to understand the status, barriers and challenges of solar PV technology in the country.

2. Materials and Method

This paper is based on the desk study of the on-going research on the policy analysis of Zambia. The study is highly dependent on literature review pertaining to renewable energy technologies and sources in Zambia and the world. More than 30 publications, reports and government websites resources on renewable energy and policies are reviewed. The literature has then been broken down to plot the number of authors against the recommendations as shown in figure 1 below. The plots show the action that the government of Zambia has to do in order to improve the rural electrification levels in the country. The actions were abbreviated as; integrated resource planning (IRP), renewable energy targets(RET), draft grid code(DGC), policies and regulations (R), purchase power agreement(PPA), business model(BM), capacity building (CB), institutional framework (IF) and finances (F). Challenges arose from the search of the relevant documents pertaining to the latest development of the RE sector in the country due to lack of updates information on the government websites (REA, MEWD, and ERB). This resulted in some information been sourced from reliable sources like the IEA, world bank as the major sources of the write up.

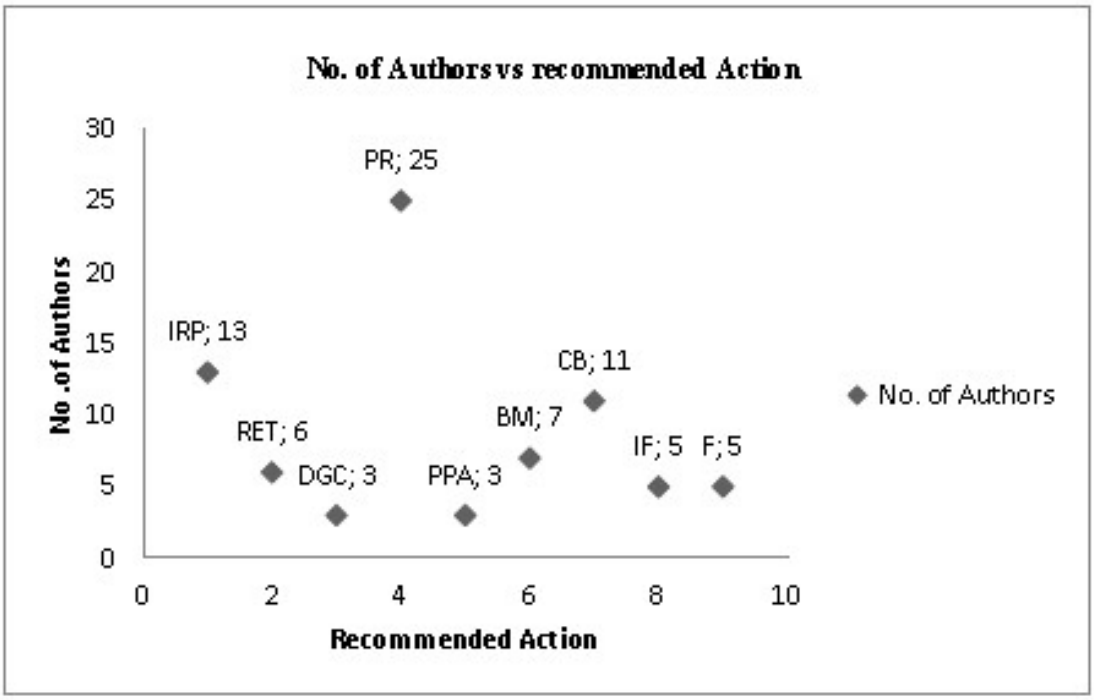

Figure 1: Authors vs Recommendation Compiled by Author

3. Status/Prospective and Challenge of Solar PV Technology in Zambia

3.1. Status and Prospective of Solar PV Technology

In 2008, the country wide renewable energy assessment by National Energy Policy (NEP) indicated that solar radiation levels are high in Zambia. The potential energy output per unit area is approximately 5.5kWh/m2/day with an total annual average solar energy falling in the ranges of 2100 – 25005 kWh/m2 [8]. The insolations levels are highly favorable for the country to tap into solar energy technologies as an alternative to the hydro[10]. The rural electrification authority (REA) has so far installed solar homes systems (SHS) for 250 schools, community center, chief's palaces and 500 households excluding individual privately installed SHS. Furthermore, there are 400 households installed under an Energy Service Company pilot project in 2004 which turned out to be unsuccessful and has since not been duplicated to the rest of the country [8]. In addition, REA has installed a 60 kW solar Off-mini grid PV project in Mpanta, Samfya district of Luapula Province, which is supplying about 50 households [9]. Despite the Solar radiation levels been considered to be high in the country much has not been done to harness this technology. Furthermore, a thorough assessment of the solar energy potential in terms of distribution and extractable potential for energy generation throughout the country has also not been done. An assessment can not only assist the stakeholders to plan and tailor RE solutions for specific areas but also address the financial and technological needs in the areas and population density in regions of the country. However, despite of its huge initial capital costs, solar photovoltaic technology has over the year evolved and has offered the best solution to provide electricity for both rural and urban areas. The technology does not only offer the best alternative to hydro, it also provides pollution free environment, fairly less to no disturbance to the landscape to which it is installed. Solar energy offers a mitigating factor towards addressing the energy supply deficit and as well as provide solution to the connectivity of off –grid areas

especially in the rural areas.

3.1.1. Programs to Scale up Solar PV Technology

In the past, issues of energy policies have mostly been politicized ,leaving nothing much documented nor published by reliable sources on the internet, hence leaving no basis for referencing in this paper. Solar photovoltaic programs (SPV) in Zambia is promoted through the rural electrification authority(REA), Energy Regulation Board (ERB) and private sector projects since the development of the national energy policy in 2008 and enactment of REA. The program and projects failures have mostly been attributed to financial constraints, delayed implementation and lack of expertise .The government of Zambia in 2015 through ERB introduced the rural electrification feed in tariff (REFit) as one of the ways to scale up the deployment of the technology in the country as well as attract independent power producers (IPP) [6]. Various officers from REA and ERB underwent training from south Africa [4]. All stakeholders in the sector consider the dissemination of SHSs and the setting up of decentralized renewable energy mini-grids as solution to scaling up the technology. This prompted the setting up of office for promoting private power investment (OPPPI) for power project developers greater than 10 MW under the ministry of energy and water development. OPPI deals with acquisition of water rights, licenses, permits facilitation and technical support in environmental impact assessments (EIAs) [11] [3]. However, in order to encourage small scale IPPs the the following are some of the recommendations:

a) Support should be extended to decentralized renewable energy mini-grids of less than 10 MW and off-grids which is currently lacking in the OPPPI.
b) The capacity of local private operators and financial institutions must be built up, so that they can develop and appraise bankable renewable energy project proposals and provide micro- finance.
c) There is need for creating a level playing field for local private sector involvement. one of the initiatives implemented is the World Bank scale -up initiative that aims at easing the documentation process for independent power producers. The country is participating in this program and more has to be done to achieve a sustainable approach to increasing and implementing of RE projects.

In 2015, the World Bank through the scale up initiative shortlisted two companies to construct the proposed two mini grid plant in Luapula and Central province respectively. From proposed the set- up 100MW mini grid , Zambia has set the lowest price of USD 6 cents /kWh as compared to Dubai's USD 3 cents /kWh and the rest of the world as this price will remain static for the next 25years

3.1.2. Initiatives to Promote Solar PV Technology

Through the government initiatives to promote renewable energy, REA was formulated with the responsibility of implementing the REMP by facilitating the creation and monitoring the

operation of rural electrification organisations or companies. These included entrepreneurs, community-based organization and other to fulfill their obligations and perform in accordance with standards and appropriate tariff structures (jointly set up with the ERB), keeping a balance between the need for affordability with sustainability of electricity delivery systems. The Rural Electrification Fund (REF) is sourced by monies approved by the parliament, electricity levies, loans, grants and donations from any sources in Zambia. Any funding from sources outside the country are approved by the minister under the ministry of energy and water development. Recently the country has intensified the roll out of off- grid electrification by engaging independent private partner participation. This is been made possible by introduction of the OPPPI under the MWED to allow easy of tendering and facilitate financing for the projects. The government has also priotised to addressing the energy crisis in its new constitution.

3.1.3. Financing and Investment of Solar PV Technology

The energy sector in Zambia traditionally is funded and implemented by the government through ZESCO and by independent power producers (IPPs) and independent power transmitters (IPTs) (CEC, Lunsemfwa Hydropower Company and Northwestern Energy Corporation). However, in recent years, the sector has attracted investment from private foreign investors as well as development partners and institutions. These include, the World Bank, China Africa Development Fund (CAD Fund), EXIM Bank of India, the African Development Bank, the European Investment Bank, the French Agency for Development and the Development Bank of Southern Africa. Although most of these investments have been for the mostly geared toward the development of large hydropower dams and transmission infrastructures, this renewed interest of financiers in the sector which is mainly due to the favorable investment framework that includes fiscal and non-fiscal incentives as well as investment subsidies. Furthermore, the World Bank through the scaling up campaign has looked into private sector participation by reduction of the tedious work that go into the tendering process for renewable energy projects.

3.3.1. Support Towards Solar PV Technology

The Government, supplemented by external assistance, has tried several programs to overcome the deficit in the energy supply. Until recently, this has always been a failure for the government as the projects tend to be politically driven. But in the last few years, projects have been driven by dedication and rigorous policy implementation, REA has tried to stand and formulate strategic decisions that will insure the availability of electricity in the rural areas of Zambia. Of these strategic decisions the REMP and vison 2030 were formed as initiatives to promote electricity in rural areas. The REMP and Vision 2030 have set a goal of 50% access to electricity in rural areas by the year 2030 and 15% by the year 2015 from the current less than 4%. This has seen the REA roll out various campaigns in the media in order to sensitize the masses about the initiative. In order to achieve these goals, REA has also included the installation of solar home systems to every individual as opposed to initial policy direction of installing the off-grid solar home system in the community centers and chiefdoms only. The approach of solar home systems

has the potential to foster electrification of houses especially in the Zambian rural areas where electrification levels are very low [14].

Despite of the challenges, the rural electrification approach should also cater for the commercially oriented sustainable-electricity service delivery, by providing performance and matching grants as well as technical assistance to private sector-led project proposals. However, affordability of electricity is a key issue in rural Zambia. This could be mitigated by providing options to facilitate end-user access to electricity service, including targeted subsidies and deferred payments schemes that could be pre-financed, either directly by service providers or through a micro-finance institution. There is need for a sound business model to be developed for both SHS and stand-alone mini-grids in order to increase the viability and sustainability of decentralized renewable energy projects and improve access to electricity services in rural Zambia. Such a programme would include capacity building for all stakeholders – namely policy makers, financial institutions, suppliers, installer's networks, often implemented by the national utilities, and the use of small-scale distributed generation, often implemented through Rural Electrification Agencies (REAs) funds.

Other development partners such as the Swedish Development Agency (SIDA) and the Dutch International Cooperation Agency (DGIS) also provided financial assistance for similar activities. However, this approach in Zambia has evidently a poor implementation track record, as the sector relies on donor-driven distribution of free or highly subsidized solar PV systems. Although solar PV systems are a practical option for meeting part of the electricity needs of populations in remote areas, they often face major maintenance issues throughout their lifecycle due to the lack of local skills and ownership from the beneficiaries. For a more sustainable and successful solar PV programme, the REA should aim for a long-term delivery approach on a commercial basis by involving the private sector, especially entrepreneurs, throughout the supply chain, as well as micro-finance institutions, to provide end-user finance for the uptake of these systems. Price discovery by REA through a mechanism of aggregating the demand, coupled with strong technical evaluation of the equipment and capacity of the vendors, could facilitate this process by reducing costs of the systems and allow for the commercial viability of standalone PV systems. Although many potential mini-hydro sites exist in Zambia, only three sites (Mujila Falls Lower, Upper Zambezi, and West Lunga in North-Western Province) were financially feasible.

Table1: Summary of the Policies and National plans compiled by Author.

Policies, strategies and national plans	Priority Areas	Overall goal	Areas of intervention	Key output
Vision 2030	• Macro-economy • Water and sanitation • Infrastructure • Energy • Science and technology	To achieve a Prosperous Middle Income Nation by 2030	Macro and micro economy policy levels	To attain annual average real GDP growth of at least 10% through-out the Period of implementation.
Fifth National Development Plan (FNDP), 2006 - 2010	•Rural electrification •Bio-fuel development •Energy efficiency and conservation •Renewable and alternative energy development and promotion	To achieve a broad based wealth and job creation through citizenry participation and technological advancement	Agricultural development, complemented by: • Infrastructure • Tourism • Manufacturing • Mining • Energy	Reduction of poverty and improvement of health, wealth and wellbeing of citizens through well coordinated and interlinked sectoral strategic plans.
Sixth National Development Plan (SNDP), 2011 - 2015	• Environment • Electricity • Renewable energy, alternative energy and biomass • Energy efficiency and management • Mining • Forestry Management	Sustained economic growth and poverty reduction	Infrastructure development • Economic growth and diversification • Rural investment and poverty reduction • Enhance human development	Improve high poverty levels in rural areas and promote rural development through stimulating agriculture productivity and promotion of agribusinesses, improving the provision of water and sanitation, health, education and skills development
National Energy Policy	• Renewable energy, alternative energy and biomass • Energy efficiency and management • Mining • Forestry Management	To provide well developed, managed, reliable and sustainable energy services for the improvement of the quality of life of all Zambians	Biomass, renewable energy, hydroelectricity and energy management	Ensure access to energy by general public as well as industry at the same time ensuring the conservation of energy and making the energy available for all economic development

3.2. Challenges and Opportunities Towards Solar PV Technology in Zambia

There is an urgent need to address the demand and supply gap in Zambia. Electricity shortage has strained the country since 2010 and further worsened in 2015. The projects which were intended to address the shortage are behind schedule and are failing to meet the deadline due to lack of funding. Zambia has low tariffs making investment into the electricity sector unattractive. The country also experiences poor project preparation and entry and this has led to most projects been dropped at implementation stage. There are also issues with power purchase agreements (PPA), absent regulatory frameworks stunt investment and growth in the energy sector. Additionally, the infrastructure hurdles such as grid connections, manufacturing, and quality testing impede development of the Zambia's renewable energy potential [1]. The relatively small size of the off-grid market and low income of perceived end-users do not make it substantially attractive to foreign investors, which is why the sector has mainly involved local private operators with the support of donors and development partners. Although the support of local private operators is a good step towards local empowerment, the following are some of the challenges faced by local private investors and operators [16]:

a) Technical and financial constraints, which include lack of technical expertise to develop bankable proposals
b) Insufficient working capital due to difficult access to loans
c) High interest rates due to high risk perception,
d) Lack of expertise from local financial institutions in appraising off-grid renewable energy proposals

However, despite of such constraints and challenges, Zambia agreed to be part of the Renewable Readiness Assessment (RRA) roll-out project supported by the International Renewable Energy Agency (IRENA) to enhance the deployment of renewable energy in Africa and globally [9]. The RRA consultations have given Zambia the chance to more carefully consider how to exploit its extensive renewable energy resources and it will require technical, policy, regulatory and capacity readiness with specific regard to developing renewable energy [3]. A renewable energy readiness assessment conducted by IRENA recommended eight action plans that Zambia needs to take in order to expand the rural off-grid electricity services. These are;

a) Develop integrated resource planning for all renewable sources.
b) Revise approach to settling renewable energy targets.
c) Revise and adopt the draft grid code, including renewable power provisions.
d) Develop policies and regulation for private sector involvement in decentralized renewable technologies.
e) Develop utility scale renewable power project with bankable purchase agreement.
f) Establish business model for private-sector off grid renewable energy

g) Build capacity for renewable energy deployment.
h) Develop the framework and sustainability criteria for feedstock, optimization and biofuel production.

The future prospects remain a challenge where access to modern energy services for all is concern. The Power Sector Development Plan for Zambia projected that the base case, energy demand of 8.1 terawatt hours (TWh) in fiscal 2007 would increase to 16.6 TWh by fiscal 2020 and 21.6 TWh in fiscal 2030. The figures indicate an average growth rate of 5.7 per cent per annum up to 2020 and 4.4 per cent up to 2030. The increases clearly show the need for Zambia to venture more into renewable energies [17]. Plans should include meeting the growing energy demand in a sustainable way and still meet the current deficits. The renewable energy strategy includes long-term renewable energy targets for specific applications. The government should consider setting tangible target for the RE sector. There is need to conduct research in the proposed developmental sites to avoid projects to be dropped and considered unattainable in future. Much has to be done to bring all solar technologies in the country to address the current shortages of electricity both in rural and urban area.

Conclusions

In this paper, a review of the current status of the solar energy technologies in the country and regional renewable as well as provincial wise renewable energy status has been presented. Zambia‘s energy consumption has been increasing at a relatively fast rate due to economic development. The economic growth rate has been projected at 3–5% per annum. With such a growth results a rapid urbanization and improving standards of living for millions of Zambian households hence the demand is likely to grow significantly in the near future. Zambia needs to realize the vast potential of renewable energy and need to step up effort for attaining the set goals for 2030 i.e. to electrify rural areas by 50% from the current less than 4%. This paper has discussed the present status and future perspectives’ of the solar photovoltaic technology in Zambia. It has further highlighted the major achievements in solar mini grid development, industrial applications and policies and initiatives that can affect the ambitious missions taken up by the government through rural electrification authority and the ministry of energy and water development. Thorough research on the proposed projects need to be carried out to avoid projects from being dropped and deemed unattainable after years of implementation delays. Further, there are lots of issues emerging out of the discussions in the future, which require immediate attention on the policy and implementation framework that can support in mitigating the potential barriers and challenges and provide impetus to solar initiatives in Zambia.

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