

SOLAR PHOTOVOLTAIC ENERGY PROGRESS IN ZAMBIA: A REVIEW

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Abstract: Regionally, Southern Africa is facing many challenges with regard to the level of access to energy. The situation is most compounded in the rural areas where poverty and lack of development are taking place at a snail pace. In order to achieve and promote sustainable development, the use of solar energy has been regarded by the government of Zambia and the sub-Saharan African region as the best alternative to the current energy deficit that the region is facing. To begin with, the government of Zambia, in the last decade, has supported solar photovoltaic energy research and development. However, the country has had challenges with achieving the set targets of connecting 10,000 new household by 2013 and ended up reducing the target to 2500 households of which 500 household of the proposed target was connected in 2015. This review is a desktop study of the on-going research on the solar energy and policy analysis of Zambia. It reviews the current solar photovoltaic and renewable energy trends in Zambia based on secondary data collected from various literatures, reports, and local contacts. The paper also highlights some of the solar energy achievements and failures in Zambia such as the 50MW solar mini-grid with the lowest tariff of US\$0.0602 unit per kilowatt-hour and as well as the efforts, the government of Zambia has made through the help of international donors and the World Bank to scale up initiatives. Finally, it has also discussed the Zambian government policies and initiatives to promote deployment of solar energy technologies in the country. The review of solar photovoltaic energy is vital, as it will help the decision makers and various stakeholders to understand the current renewable status, barriers and challenges in Zambia and find alternative ways to overcome these challenges and barriers.

Key words: Photovoltaic, Solar Energy, Zambia, sustainable development

1. INTRODUCTION

Zambia as a country has had many challenges concerning energy generation. The country as whole, since the onset of drought, had challenges in maintaining the load balance between the rural and urban areas. Of the two, the rural areas have faced a lot of energy driven challenges due to their insignificance in the economic and development growth of the country. In order to maintain this imbalance, and achieve sustainable development, the government has considered and put as a priority solar energy as an alternative to the dominant hydro power generation. 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 in the region as a whole. Generally, Africa is the worst hit in energy deficit followed by the 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 other alternative 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 economic growth, basic medical services, and better opportunities. In the midst of all challenges, achieving 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 sustainable development goal seven (ensure access to affordable, reliable, sustainable and modern energy for all). Southern Africa has embraced the set goals despite of late been hit with major energy crisis due to escalating demand growth and capacity addition projects that are lagging behind targeted schedules. The region needs to examine largely 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 scale up 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 generation 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 base power systems and policies to import renewable energy-based electricity, as can be seen in South Africa [2]. Zambia has to prioritised 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 currently with urbanisation rate of 3.2% [3] [4] [5]. Zambia plays a critical role in the SAPP, as an interconnector to the Congo River Basin [2].

The objective of this paper is to give a comprehensive review of solar energy progress in Zambia. First, a brief overview on the current energy status of Zambia is provided. Then, the progress status of solar energy development and potential is presented. We believe that this review on solar photovoltaic energy will help scholars and various stakeholders to understand the current solar energy status, barriers and challenges that the country is facing.

1.1. Energy Supply and Demand in Zambia

The supply capacity of electricity in Zambia has not seen any significant growth since the past decade. This deficit in the supply is due to the increasing demand for electricity for domestic, commercial, agricultural, industrial, and mining use [6]. In Zambia it was estimated that, the generation capacity would meet the peak demand before 2010 and from 2012 to 2017 a peak power demand of 2000 to 2500 MW would occur, which is beyond the current generation capacity as shown in figure 1 [7]. This deficit in energy supply has lead to demand side management DSM) or load curtailment as an intermediate solution to the problem [6] [4]. With such energy inadequacy the country has lined up programs to significantly tap energy from renewable energy resources, such as biomass, solar, wind and geothermal energy that can be exploited for both on-grid and mini grid systems than only from hydro. Though hydro has been the major source of electricity, its untapped potential, considering the abundance of water resources, remains to be high in the country. Hydropower resources are estimated to exceed 6,000 MW, of which only 1,760 MW has been developed [8], including approximately 24 MW of mini-hydro projects [3]. The current installed capacity is above 1,900 megawatts (MW) of which 3,000 MW could be harvested through planned solar projects [3] [4]. The main supplier of the tapped hydro is the vertically integrated national public utility, the Zambia Electricity Supply Corporation (ZESCO). It dominates the electricity supply industry with a significant share of about 94%, with two other operators providing a small share (6%) of generation and 86% and 14% of transmission capacity, respectively [6].

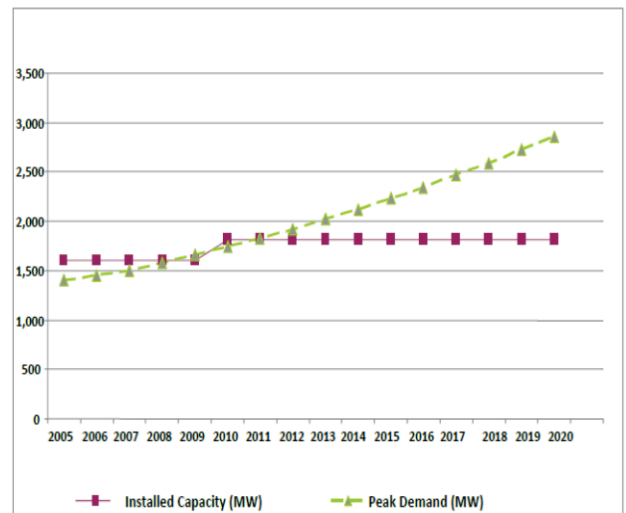


Figure 1: Projected Power Demand [7]

2. APPROACH AND FINDINGS

This paper is an extract of the on-going research on the energy and policy analysis in Zambia. A review of secondary data from the internet was conducted. Literatures' pertaining to Zambia from 1990s to 2016 was read in order to get the insight on the renewable energy progress in Zambia. Challenges arose when much of the information was not found from the official Zambian energy organizational websites as they were not up to date but had vital information concerning the status in the country. The literature on energy, policies and renewable energy in Zambia was considered for this write up.

3. STATUS OF SOLAR ENERGY AND PV TECHNOLOGY IN ZAMBIA

In the recent past rural electrification in the country has been achieved mainly through grid extension by ZESCO [9] [10], until 2006 when REA was fully established and put in charge of rural electrification. In 2008, the first approach of the REA was to provide rural access through grid extension and only completed 53 grid extension projects. The slow progress in grid extension encouraged the REA to rethink its rural electrification approach and include solar home systems and off-grid PV systems. According to renewable energy assessment carried out by National Energy Policy (NEP) in 2008, Zambia is endowed with high solar radiation levels as shown in figure 2[9]. The total annual solar energy that the country receives are estimated to be in between 2100 and 25005 kWh/m², with average annual daily solar radiation of about 5.5kWh/m²/day [11]. Such high solar radiations levels are good for both electricity generation and thermal energy systems which can be used in the energy mix with other renewable energy sources like hydro. To date the rural electrification authority (REA), Ministry of Energy and Water Development (MEWD), and Energy Service Company has installed solar PV systems in schools,

community center, chief's palaces and households across the country and a 60kW solar off-grid PV

System as summarized in table 1 [11] [12].

Table 1: Solar PV Technology Status in Zambia [8, 9, 10]

Description	PV Technology Status			
	MEWD (No. of Units)	REA (No. of Units)	ESC (No. of Units)	Capacity per unit
Schools	400	250	-	=>1kW
Households		500	199	>1kW
Community centers		50	264	=<1kW
Chief's Palaces		50	-	=>1kW
Off-Mini grid	-	1	-	60kW
Average Total Installed Capacity	=<2MW			

However, despite abundance of solar irradiation levels been considered to be high in the country, the

contribution of solar energy to energy mix has still remained low as can be noticed in Table 1.

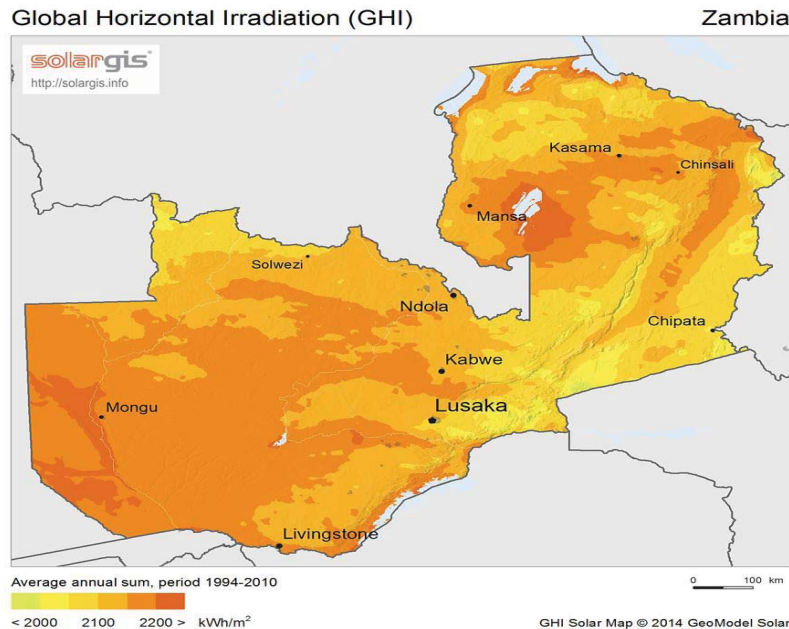


Figure 2: Solar Irradiation Distribution in Zambia [13]

3.1 Barriers and Challenges to wider deployment of solar PV Technologies in Zambia

Zambia has a huge solar energy potential, which is well distributed across the country as shown in figure 2 above, that can be tapped for electricity generation and other uses. However, the country faces various barriers and challenges in the distribution and utilization of this energy potential as an alternative for electricity generation. Different groups that want to invest in solar energy faces various barriers and challenges. The groups facing these barriers and challenges to invest in solar PV technology can be divided into three groups namely the public, the local investors, and the foreign investors.

The Public: The public faces various challenges to participate in the use and deployment of solar PV technologies such as [3] [2]:

- Lack of availability of information on the use of solar PV technologies,
- Lack of awareness and community participation in the solar energy project,
- High initial cost than normal due to huge interest solar technology distribution companies charge to capitalize on the ignorance of the citizens,
- Lack of expertise to encourage the public to invest in solar PV technologies educate and offer trainings to communities in order for

- them to participate and use affordable RET to satisfy their basic energy needs for consumption.

The Local Investors: At the same time, the local investor usually faces a huge drawback to invest in the renewable energy technologies such as solar PV technologies due to the following challenges and barriers [14].

- Technical and financial constraints such as lack of technical expertise to develop bankable renewable energy based power plants project proposal
- Insufficient working capital due to difficult to access the loans in the country
- High interest rates offered by banks due to high risk perceptions
- Lack of expertise from local financial institutions to give appraise to renewable energy based off-grid or grid connected project proposals

The Foreign Investors: The current situation in the energy sector in Zambia does not provide attraction to the international investors due to some of the following barriers and challenges particularly in electricity business [1]:

- Low tariffs making investment into electricity sector unattractive
- Absent of regulatory frameworks which stunt investment and growth of the energy sector
- Lack grid code for renewable energy technology and infrastructure hurdles like lack quality testing
- Relatively low market for off-grid due to low income of end users in rural areas hinders foreign investors to virtue into off-grid PV systems.

However, despite its huge initial capital costs, solar photovoltaic technology has evolved over the years. The solar energy technology offers a number of opportunities to the country such as employment creation for both rural and urban, access to reliable and affordable clean energy, energy security, access to clean and safe water such as in solar PV water pumping system and lastly but not the least sustainability. Sustainability is very important for the progress of the society and economic development for the national. In addition, solar energy can be used to mitigate the energy deficit the country is currently facing since it is during the day when the demand is above the generation and during this time the country receives huge amount of solar energy.

3.2 Scaling up programs for Solar PV technologies in Zambia

In Zambia most of solar PV technology based programs are handled by the Rural Electrification Authority (REA), Energy Regulation Board (ERB), and private sector projects. However, despite of a number of program that were/or have been launched by either government or international nongovernmental organization most of the programs and projects failures have mostly been attributed to financial constraints, delayed implementation and lack of expertise. Hence, to overcome these failures the government has setup a number of programs such as:

Training of ERB and REA officers and equip them with the knowledge needed for the effective performance of the organizations [4].

Create an office for promoting private power investment in order to help developers of more than 10MW power plants in Zambia in terms of paper work and environmental impact assessments [3, 11].

REA through the help of Swedish government has formulated a number of the solar home system projects in Eastern province of Zambia [14, 15, 7].

The World bank have initialed a solar energy source mapping program across the country in order to guide new entrants [17].

3.1 Government initiatives to promote use of Solar Energy technologies in Zambia

The government of Zambia in its National Energy Plan has set a number of goals and objectives to achieve by 2030. In order to include solar energy in the energy mix, the government is intending to deploy about 500,000 solar home systems across the country and establish solar PV farms producing at least 100MW. Therefore, in order to encourage private sector participation in the energy sector the government of Zambia through REA and ERB have initialized a number of financial incentives to promote deployment and investment in renewable energy technologies. These incentives can be divided into two main groups i.e investment and production incentives. For example the minister of energy announced in parliament that the “government of zambia is evaluating bids for development of 300 MW solar power plants across the country”. Furthermore, the government has since started the tender process of procuring 600 MW of solar power through the Industrial Development Corporation (IDC). Two plants of 50MW each constitute Round 1 of the 600 MW program. This will cost approximately USD1.2 billion - and all of this will be primarily financed by the private sector with IDC funding a minority shareholding on behalf of Zambians [15].

Investment incentives: In order to overcome the huge initial investment cost barriers that comes with renewable energy technologies, the government of Zambia has introduced tax waivers on all imported

renewable energy technologies such as solar energy technologies.

Production Incentives: The electricity supply sector i.e generation, transmission, and distribution in Zambia is mainly dominated by the Zesco limited which is vertically integrated utility fully owned by the government of Zambia. Thus, in order to open the sector for other companies to contribute to the energy sector and encourage energy production from renewable energy technologies such as solar PV technologies, the government of Zambia through Department of Energy in the Ministry of Mines, Energy and Water Development has introduced a feed-in-tariff for all energy generated from renewable energies [6]. Furthermore, in order to stimulate private sector participation, the government through Energy Regulation Board has increased the energy tariff by 25%. In addition, to encourage development of off-grid mini grid in rural areas far away from main electric grid, recently the government of Zambia has set up the lowest price of 0.06 USD /kWh for energy generated from mini grid plants based on renewable energy, which will be constant for next 25years. The set price is higher compared to Dubai's which is 0.03 USD /kWh, Mexico with 0.045 USD /kWh and Peru with 0.048 USD /kWh as shown in Figure 3 below.

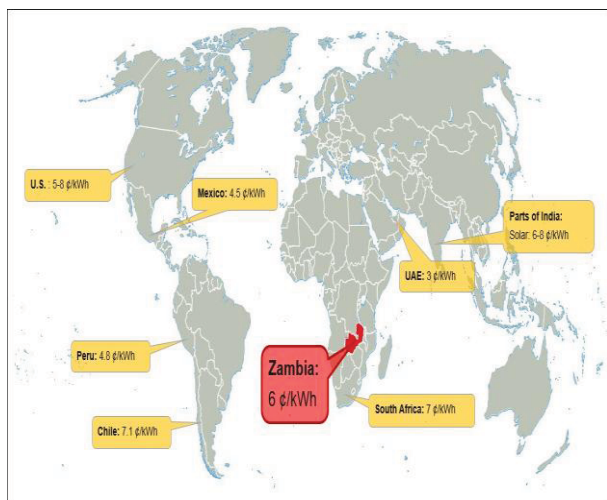


Figure 3: Price of Solar Energy Generated by Mini-Grid across the Globe [16]

4. FUTURE PROSPECTS OF SOLAR ENERGY TECHNOLOGIES IN ZAMBIA

The future prospects of solar PV technologies in Zambia looks pride with the government initiatives, set goals, and objectives in the National Energy Policy. The government of Zambia has dedicated itself to increase current energy access levels from the current 4% for rural areas to 50% and also increase the levels for urban areas to 90% by 2030. In order to overcome the ever increasing energy demand which is expected to increase from 8.1TWh in fiscal year 2007 to 16.6TWh in 2020 and 21.6TWh in fiscal year 2030 at a

growth rate of 5.7% per year up to 2020 and 4.4% per year up to 2030, the government have included in its plan to diversify energy mix by including solar energy based technologies such as utility scale PV systems and solar home systems[16, 17]. Therefore, in the next 14years the government of Zambia is planning to distribute about 500,000 solar home systems and install utility scale PV system of at least 100MW across the country [19,20]. Furthermore, in few years to come the government through build-own-operate model intends to install a total of 30MW in three provinces of Zambia, 10MW in Eastern, 10MW in Luapula and another 10MW in Northwestern Provinces of Zambia. In addition, in order to attract both local and foreign investors, the government of Zambia through Energy Regulation Board (ERB) has introduced feed-in-tariff and has set the energy price for mini off grid renewable energy based power system at USD 6cents/kWh for the next 25years. At the same time the government has introduced investment incentives in order to reduce the huge initial capital investment cost that are associated with renewable energy based technologies.

5. LESSONS LEARNT AND RECOMMENDATIONS

The increase in energy demand clearly shows the need for Zambia to venture more into renewable energies in the future energy mix[16]. Plans should include meeting the growing energy demand in a sustainable way and still meet the current deficits. The renewable energy strategy should 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. 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. Even though the support of local private operators is a good step towards local empowerment, the local private operators face technical and financial constraints, which may sometimes include lack of technical expertise to

develop bankable proposals, insufficient working capital due to difficult access to loans, high interest rates due to high risk perception, and lack of expertise from local financial institutions in appraising off-grid renewable energy proposals [14]. Even under 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 [12]. The RRA consultations have given Zambia the chance to more carefully consider how to exploit its extensive renewable energy resources. It will require technical, policy, regulatory and capacity readiness with specific regard to developing renewable energy [3].

6. CONCLUSIONS

The paper has presented the overview of the status of solar energy source distribution and present status, barriers and challenges, and government initiatives to promote solar PV technology in Zambia. It has further presented some lessons learnt and highlighted some recommendation for further consideration on the matter at hand. Zambia has a huge solar potential to tap in for electricity generation and other uses, with the current energy demand growth solar PV technology offers a best alternative for future sustainable energy mix. 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. Therefore, Zambia needs to realize the vast solar energy potential and step up efforts if it is to attaining the sustainable development goals set up by United Nation and also if the country is to achieve the new set goals of increasing access to modern energy service for all by 2030.

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