Expert Opinion on Environmental Biology

Research Article

A SCITECHNOL JOURNAL

Photovoltaic SolarEnergy: A Mean to Reduce Energy Shortfall in Africa

Bebga Nguidjoi Thomas Gaël

***Corresponding author:** Bebga Nguidjoi Thomas Gaël, Energy Economist graduated from IFP School (France) PhD Student in Economics /University of Dschang- Cameroon, E-mail: bthomasgael@yahoo.fr

Received Date: 22 December, 2021; Manuscript No. EOEB-20-13125
Editorassigned date: 24December,2021,PreQC No. EOEB-20-13125(PQ);
Reviewed date: 14 January, 2022, QC No. EOEB-20-13125;
Revised date: 24 January, 2021, Manuscript No. EOEB-20-13125;
Published Date: 31 January, 2022;DOI:10.37532/2325-655.22.11(1).101

Abstract

Access to energy is a strategic priority in all regions of the world. Today, nearly 1.6 billion people, either 20% of the world's population, lack access to modern energy and 3 billion people, either 40% of the world's population depends on traditional biomass and coal as the main source of fuel. In Africa, issue of energy accessibility has always been at the heart of the debates because of the relentless shedding of power that is undermining the lives of many Africans. Outside of some countries in North Africa (Algeria, Libya, Tunisia, Egypt) which are doing well with an electrification rate above 90%, followed from South Africa to the south of the Sahara with an electrification rate of around 70%, the situation remains quite worrying in the middle of the continent with sub-Saharan Africa where this rate is below 50%. Africa's renewable energy production potential is far greater than the continent's current and estimated electricity consumption. Particularly for renewable energy, Africa has an outstanding solar energy potential of 10,000 GW. The objective of this work consist of exposing solar energy technology, the situation of energy shortfall in Africa and outlook of development of this sector. The variables used for multidimensional descriptive analysis are respectively the rate of access to electricity, rate of growth of GDP, rate of electricity produced from photovoltaic solar energy, the rate of population growth and the level of solar potential in the countries that constitute our field of study. The factorial map shows that countries with average solar potential and those with high solar potential. Also, it emerged that the countries with a high rate of access to electricity are mainly those of North Africa (Libya, Algeria, Tunisia, Egypt), Mauritius, Cape Verde and the Seychelles. The rate of access to electricity is also high in South Africa, and there is a fraction of electricity that is produced from photovoltaic solar energy. Overall, results of econometric model indicate that Africa's solar potential is a key variable in improving people's access to electricity. In terms of the significance of the explanatory variables, the solar potential level variable would have a significant and positive influence on the rate of access to electricity.

Keywords : Renewable Energy, Energy Shortfall, Econometric Model.

Introduction

Access to energy is a strategic priority in all regions of the world. Today, nearly 1.6 billion people, either 20% of the world's population, lack access to modern energy and 3 billion people, either 40% of the world's population depends on traditional biomass and coal as the main source of fuel. Lack of access to clean, affordable and reliable energy hinders human and economic development and is a major obstacle to achieving the Millennium Development Goals. This situation remains difficult in developing countries, particularly in rural areas of Africa. In Africa, the issue of energy accessibility has always been at the heart of the debates because of the relentless shedding of power that is undermining the lives of many Africans. Outside of some countries in North Africa (Algeria, Libya, Tunisia, Egypt) which are doing well with an electrification rate above 90%, followed from South Africa to the south of the Sahara with an electrification rate of around 70%, the situation remains quite worrying in the middle of the continent with sub-Saharan Africa where this rate is below 50%1. However, this situation must be differentiated between countries and is a hindrance to development even though there is a real potential for the development of poorly exploited renewable energies. Africa's renewable energy production potential is far greater than the continent's current and estimated electricity consumption. Particularly for renewable energy, Africa has an outstanding solar energy potential of 10,000 GW2. Currently Africa is experiencing sustained growth and an increase in its population which was estimated at about 1.1 billion in 20123. According to the 2013 economic outlook, Africa's Gross Domestic Product increased by 4.2% in 2012 compared to a growth rate of 3.5% in 2011. On average it accelerated in 2013 and 2014 from 4.5% to 5.2%. These forecasts are based on a gradual recovery in world economic conditions4. In order to ensure this economic growth coupled with an increase in population and therefore an increasingly growing energy requirement, it is appropriate to find a way out of the energy crisis facing African countries. This state of affairs has led us to the following question: Can the enormous potential that Africa has in terms of solar energy could contribute to reduce energy shortfall in Africa? The objective of this work is twofold and will consist of exposing solar energy technology, the situation of the energy shortfall in Africa and the outlook of development of this sector. The work is divided into two main parts, each consisting of two chapters. The first part is devoted to solar photovoltaic energy and precariousness energy in Africa. We will discuss solar technology photovoltaics in Africa in the first chapter and in the second chapter the situation of energy insecurity on the African continent. The second part is intended to analyse the problem of under electrification and prospects for the development of the solar photovoltaic sector in Africa. The third one chapter will present the situation of under electrification in Africa through a data statistics analysis. Chapter 4 will outline the issues and perspectives of the development of the photovoltaic sector in Africa. Photovoltaic solar energy : A mean to reduce energy shortfall in Africa 6 Presented and written by BEBGA NGUIDJOI Thomas Gaël 2019

LEFT I : SOLAR PHOTOVOLTAIC ENERGY AND ENERGY SHORTFALL IN AFRICA

In this section, a description of the solar photovoltaic sector and a presentation of the energy shortfall in Africa will be presented.

CHAPTER I : SOLAR PHOTOVOLTAIC ENERGY IN AFRICA

This chapter will describe solar photovoltaic technology and present the situation of this sector on the African continent.
I) Photovoltaic solar technology: general description

Photovoltaic solar energy comes from the conversion of sunlight into electricity in semiconductor materials such as silicon or covered with a single metal layer. These photosensitive materials have the property of releasing their electrons under the influence of an external energy: this is the photovoltaic effect. The energy is provided by the photons (components of light) which strike the electrons and release them, inducing an electric current. The electricity produced is available as direct electricity or stored as a battery (decentralized electricity) or as electricity injected into the grid. A photovoltaic solar generator consists of photovoltaic modules. The performance of an installation depends on the orientation of the solar panels and the areas of sunshine in which you are in. Photovoltaic solar energy technology has evolved considerably. From first-generation solar photovoltaic technology to third-generation solar photovoltaic technology. First-generation solar photovoltaic technology dominates the market with low costs and better commercial efficiency. It is a mature technology with a wide range of manufacturer. Second-generation photovoltaic technology is also attractive due to material costs and manufacturing costs. It's a thin layer technology, less mature, with modest market share. However, it must address issues of material durability, availability and toxicity (cadmium). Third generation solar photovoltaic technology has the potential to have the highest level of efficiency. However, this technology is being demonstrated and is not yet widely commercialized.

Photovoltaic solar energy : A mean to reduce energy shortfall in Africa
Of course, Africa benefits from significant sunshine. Solar energy for electricity generation can be exploited in two ways:

- Solar thermal for generating electricity via steam;
- Solar photovoltaics.

The solar photovoltaic potential of Africa can be seen in the table below compared to other renewable energies:

African	*Wind energy*	*Solar energy*	*Biomass*	*Geothermal*	*Hydroelectric*
region	***TWH/year***	***TWH/year***	***EJ/year***	***TWH/year***	***TWH/year***
East	*2000 – 3000*	*30 000*	*24 - 74*	*1 – 16*	*578*
Central	*-*	*-*	*-*	*-*	*-*
North	*3000 – 4000*	*50 000 – 60 000*	*8 – 15*	*-*	*78*
South	*16*	*25 000 – 30 000*	*3 – 101*	*-*	*26*
Western	*0 – 7*	*50 000*	*2 – 96*	*-*	*105*
Total	*5000 – 7000*	*155 000-170 000*	*82 – 372*	*1 – 16*	*1844*

Source : IRENA

The solar potential of parts of Africa and North Africa in particular has led to a large-scale project (Desertec project) which consists of setting up installations in the Sahara that could eventually cover 10 to 15% of Europe's electricity needs.

This project is paradoxical in that it consists of exporting electricity to Europe and not to the neighbouring countries of Africa which are cruelly lacking.

More specifically, the countries of Africa have invested in solar energy through projects on the capacities to be installed by 2015 because of the high sunshine. For example, in terms of solar photovoltaic capacity5, the following countries have set themselves as objectives : Algeria (5.1 MW), Benin (6 MW), Botswana (1 MW), Burkina Faso (20 MW), Cape Verde (7.5 MW), Chad (100 MW), Djibouti (50 MW), Egypt (100 MW), Mauritius (12 MW), Morocco (2,000 MW), Mozambique (6,000 MW), Namibia (400 MW), Nigeria (10 MW), South Africa (100 MW) and Tunisia (20 MW).

In the present state of technology, however, the exploitation of solar energy remains a very heavy alternative in terms of investment. In the following table we present the electricity generation costs of solar photovoltaic energy compared to other renewables:

Electricity production	***Global weighted – average Cost of Electricity (USD/KWH) 2018***	***Change in the cost of electricity 2017-2018***
Bioenergy	***0.062***	***-14%***
Geothermal	***0.072***	***-1%***
Hydro	***0.047***	***-11%***
Solar photovoltaics	***0.085***	***-13%***
Concentrating solar power	***0.185***	***-26%***
Offshore wind	***0.127***	***-1%***
Onshore wind	***0.056***	***-13%***

Source : Renewable power generation costs in 2018, IRENA.

In most parts of the world today, renewables are the lowest-cost source of new power generation. As costs for solar and wind technologies continue falling, this will become the case in even more countries. Very low, and falling, costs of electricity for solar PV and onshore wind, as well as cost reductions for CSP and offshore wind until 2020 and beyond, make renewable power the competitive backbone of the global energy sector transformation. Beside making the decarbonisation of the electricity sector economically attractive, these cost decreases unlock low-cost decarbonisation in the end-uses sectors of industry, transport and buildings as the costs of electric end-use technologies such as electric vehicles and heat pumps.

CHAPTER II : ENERGY SHORTFALL IN AFRICA

Energy shortfall6 is a symbolic dividing line, a dividing line between individuals or social groups who have access to energy and those who do not. In other words, it's a disparity of access to energy. This disparity is strongly marked on the one hand between countries, but also between urban and rural areas. Africa remains a land of energy fractures that are not conducive to its development. With 14% of the world's population, Africa consumes only 3% of the world's energy (BP Statistical Review 2013). These fractures are different in different countries and according to the environment of residence.

I) Fracture by country

There is a divide between a North Africa, a Middle Africa and a South

Africa. This situation shows that Africa's energy mix is changing from region to region. At both ends of Africa, North and South Africa account for 70% of the energy consumed by the entire continent. More specifically in the North (Morocco, Algeria, Tunisia, Libya, Egypt), abundant gas and oil are the main sources of development and the main energies consumed. In South Africa, consumption is mainly based on coal, products derived from liquefaction and petroleum products. The rest of Middle Africa, home to the ¾ of the continent's population, accounts for only one-third of continental consumption.

II) Fracture by residential setting

A real divide also separates the rural world from the urban world. Distribution infrastructure is almost non-existent in rural areas. Thus biomass and especially wood fire remains mainly the energy source.

III) Fracture between export of resources and local consumption

Africa is full of huge energy potential but uses little commercial energy; and therefore has huge significant energy saving potential. 6 www.wikipédia.org

LEFT II : ANALYSIS OF ELECTRIFICATION IN AFRICA AND PERSPECTIVES OF SOLAR PHOTOVOLTAIC DEVELOPMENT

CHAPTER III : STATISTICAL ANALYSIS OF UNDER ELECTRIFICATION IN AFRICA

I) Data analysis

In this section we performed a multidimensional descriptive analysis using SPAD software. The aim is to become better acquainted with the data set in order to establish the characteristics of the profiles of the countries in our sample. The variables used for this analysis are respectively the rate of access to electricity, the rate of growth of GDP, the rate of electricity produced from photovoltaic solar energy, the rate of population growth and the level of solar potential in the countries that constitute our field of study. The following factorial map shows that countries with average solar potential and those with high solar potential. Also, it emerged that the countries with a high rate of access to electricity are mainly those of North Africa (Libya, Algeria, Tunisia, Egypt), Mauritius, Cape Verde and the Seychelles. The rate of access to electricity is also high in South Africa, and there is a fraction of electricity that is produced from photovoltaic solar energy.

II) Econometric analysis

In developing the model, we considered the relevant variables in light of the empirical literature we had previously conducted. The problem is to explain the variability in the rate of access to electricity. In other words, it will be necessary to take into account the relevant variables that could affect the rate of access to electricity in Africa. As an explanatory variable, the rate of access to electricity and as an explanatory variable, the rate of growth of GDP, the rate of electricity produced from solar photovoltaic energy and the level of solar potential in the various countries. The data sources come respectively in the order of the variables mentioned above from the World Bank Group, the International Energy Agency and the International Renewable Energy Agency (IRENA).

a) Presentation of the econometric model

(taux_acces_elec)i =(tcroispib)i + (elec_pv)i + (pot_solaire)i + εi

Where :

taux_acces_elec : rate of access to electricity

tcroispib : rate of growth of GDP

elec_pv : rate of electricity produced from solar photovoltaic energy

pot_solaire : level of solar potential in the various countries

ε : error term which takes into account the variability of the rate of access to electricity not

b) Estimating model parameters, validating assumptions and interpreting results

We have estimated the model and the results are recorded in the following table:

Before proceeding with the interpretation of the above results it is imperative to first validate the assumptions underlying this model.

Normality test

At the 5% threshold, the assumption of normality of the model residues is accepted as the Jarque-Bera probability value (3.79) is greater than 0.05.

Homoscedasticity Test

Heteroskedasticity Test: Breusch-Pagan-Godfrey

In the above table it is noted that for the White heteroscadasticity test, both probabilities are greater than 5%, the hypothesis of homoscedasticity of errors is accepted.

There are 52 observations available. The number of explanatory variables is K=3. On the Durbin & Watson table, one reads at the threshold of 5% : dinf= 1,34 et dsup=1,72. Durbin Watson statistic of final model (II) is DW=1,96. 4-dinf=2,66 et 4-dsup=2,78. We obtained dsup < DW < 4 - dsup, it can therefore be assumed that the errors are not autocorrelated. The coefficient of determination is 16.68% indicates that 16.68% of the fluctuations in the rate of access to electricity are explained by the model. The model is globally significant because the value of Prob (F-statistic) is less than 5%. In terms of the significance of the explanatory variables, the solar potential level variable would have a significant and positive influence on the rate of access to electricity. This result is consistent with the situation that African countries would have a comparative advantage in exploiting their solar potential to improve access to electrification among populations. The rate of electricity from photovoltaic solar has no influence on the rate of access to electricity. This result reflects the low level of installed capacity of photovoltaics in Africa. Photovoltaic solar energy : A mean to reduce energy shortfall in Africa

CHAPTER IV : OBSTACLES AND PERSPECTIVES OF THE DEVELOPMENT OF SOLAR PHOTOVOLTAIC ENERGY

I) Obstacles to the diffusion of renewable energy in Africa: case of solar photovoltaics Several obstacles explain the weakness of sustainable exploitation of solar potential in Africa. These are mainly institutional and financial.

a) Institutional barriers

There are no specific regulatory frameworks. In other words, the inadequacy of the regulatory framework despite the progress made by some countries to allow self-generation and free access to the electricity grid for the sale of electricity from renewable energy sources. There is little use of international mechanisms. The CDM (Clean Development Mechanism) established in 1997 under the Kyoto

Protocol, has the particularity of involving developing countries. It is a market mechanism focused on the execution of projects that aim to reduce gases and therefore include projects to deploy new energies.

b) Financial barriers

There is a weakness in renewable energy financing and subsidies compared to conventional fossil fuels. States have introduced these subsidies for the protection of poor social strata. Banks are still limited in the financing of renewable energy investment due to a range of technical and financial obstacles. National regulatory frameworks are not always adapted, so the lack of local expertise to support the feasibility of the investment (choice of technologies, feasibility study, audits). There is also limited capacity within banks to analyse these projects and the associated risks. Nevertheless, some banks are becoming aware of the business opportunities they can draw from financing renewable energy investments.

II) Prospects for the development of solar photovoltaics in Africa

Prospects for solar photovoltaic energy in Africa will be promising in several areas.

Socio-culturally

The development of photovoltaics will help to reduce the gap between rural and urban dwellers, and will help to combat rural exodus. Electrification of rural areas away from the electricity grid will allow people to access lighting at night, as well as information (television) and communication (telephone) services.

In economic terms

With the soaring prices of certain commodities such as oil on world markets, solar photovoltaics will help reduce the dependence on fossil fuels. Together, it will be a real vector of economic development, through real opportunities for employment and local development. The exploitation of solar energy will also increase agriculture, and thus increase the production capacity of rural populations.

Environmentally

The exploitation of solar photovoltaics is a means of preserving forests. This will contribute to the fight against deforestation and the reduction of greenhouse gases.

Energetically

The development of solar photovoltaics will make it possible to take into account the aspects of sustainable development, namely the fight against poverty, the preservation of natural resources and the environment. The design of a sustainable energy development i.e. more environmentally friendly and concerned with the needs of future generations, help reduce inequality by ensuring better access to energy for all populations.

At the technical level :

Extension of solar equipment will encourage the training of human capacities and the creation or strengthening of enterprises in the dissemination and maintenance of equipment.

CONCLUSION

The main objective of the study was to understand the factors that could influence the rate of access to electricity. Two main points were addressed to explain this concern. First, a description of solar photovoltaic technology and the situation on the energy divide facing the continent. Second we carried out a descriptive analysis and an econometric analysis. Overall, the results indicate that Africa's solar potential is a key variable in improving people's access to electricity. Although the capacity currently installed has a negligible impact on access to electricity; It is necessary for policies to opt for this alternative energy source to strengthen the country's energy security and enable it to free itself from costly imports of fossil fuels. The main areas of intervention of States must be directed towards sanitation and the establishment of a coherent regulatory framework to facilitate thedevelopment of the photovoltaic sector.

References

1. Anderson RM, Heesterbeek H, Klinkenberg D, et al. How will country-based mitigation measures influence the course of the COVID-19 epidemic?. The Lancet. 2020;395(1028):931-34.
2. Chen B, Liang H, Yuan X, et al. Roles of meteorological conditions in COVID-19 transmission on a worldwide scale. Med Rxiv. 2020.
3. Guo XJ, Zhang H, Zeng YP. Transmissibility of COVID-19 in 11 major cities in China and its association with temperature and humidity. Infectious Diseases of Poverty. 2020; 9:87.
4. Kuldeep S, Aryan A. Impact of weather indicator on the COVID-19 outbreak: A multi-state study in India. Med Rix. 2020.
5. Poole L. Seasonal Influences on the Spread of SARS-Cov-2 (COVID19), Causality, and Forecastabililty (3-15-2020). SSRN. 2020.
6. Bull GM. The weather and deaths from pneumonia. The Lancet. 1980;315:1405-08.
7. Shi P, Dong Y, Yan H, et al. The Impact of Temperature and Absolute Humidity on the Coronavirus Disease 2019 (COVID- 19) Outbreak-Evidence from China. Med Rxiv. 2020.
8. Tan J, Mu L, Huang J, et al. An initial investigation of the association between the SARS outbreak and weather: with the view of the environmental temperature and its variation. J Epidemiol Community Health. 2005;59(3):186-192.
9. Yuan J, Yun H, Lan W, et al. A climatologic investigation of the SARS-Cov outbreak in Beijing, China. Am J Infect Control. 2006;34(4):234-36.
10. Ma Y, Zhao Y, Liu J, et al. Effects of Temperature Variation and Humidity on the Mortality of COVID-19 in Wuhan. Med Rxiv. 2020.