Journal of Energy Research and Reviews

2(3): 1-5, 2019; Article no.JENRR.47687

Solar Energy as an Alternative for an All Year Round Production of Vegetables in Anambra, Nigeria

C. U. Ikeh[1*]

[1]Department of Physics/Ind. Physics, Nnamdi Azikiwe University, Awka, Anambra, Nigeria.

Author's contribution

The sole author designed, analysed, interpreted and prepared the manuscript.

Article Information

DOI: 10.9734/JENRR/2019/v2i330079
Editor(s):
(1) Dr. Bojan Durin, Assistant professor, Faculty of Geotechnical Engineering, University in Zagreb, Croatia.
Reviewers:
(1) Himanshu Dehra, India.
(2) H. M. Ali Uet, Pakistan.
(3) Hachimenum Amadi, Federal University of Technology, Nigeria.
Complete Peer review History: http://www.sdiarticle3.com/review-history/47687

Short Research Article

Received 21 December 2018
Accepted 07 March 2019
Published 23 March 2019

ABSTRACT

Epileptic power supply is a major problem in Nigeria and one of the ways Nigerians have solving this challenge is by using renewable energy as an alternative power supply in place fossil fuels. Among renewable energy sources, solar is the most important because it is available in this part of the world. This energy source is also used in various industries including agriculture and it can be used in irrigation and sprinklers in farmer's vegetable farm. This research was carried out through field visitations and extensive literature on the performance of photovoltaic modules. This paper outlines the use of solar water pump for irrigation in vegetable farms, the benefits and concludes with suggested recommendations which can help production of vegetables during dry season in Anambra State. It aims at contributing a better understanding of the potential impact of solar photovoltaic (PV) on sustainable production of vegetables with special attention to the effect of income generating activities in the State. It is known that during dry season, vegetables do not get enough water, sometimes these agricultural products are very scarce and expensive. Solar photovoltaic water pumping is found to be economically viable in comparison to electricity or diesel based systems for irrigation and sprinklers in the vegetable farm. Solar photovoltaic water pumping is therefore, an attractive alternative for irrigation and sprinklers in Nigerian vegetable farm due to the huge solar potential in the country.

**Corresponding author: E-mail: nelikechin@yahoo.com;*

Keywords: Solar water pumping; photovoltaic; irrigation; sprinklers; fossil fuels; dry season solar energy.

NOMENCLATURES

PV : Photovoltaic
TDH : Total Dynamic Head
P : Density
g : Gravitational Acceleration
E : Hydraulic Energy
V : Volume
W : Watt
CO_2 : Carbon Dioxide

1. INTRODUCTION

Anambra State is situated in the South-Eastern part of Nigeria, where it receives maximum solar energy radiation making it highly suitable for the use of solar energy for the production of electricity. Nigeria normally experiences two seasons a year namely: the dry and rainy seasons. During the dry season which spans through five months a year, i,e November – March, farmers experience hardship due to lack of water in their vegetable farms. Irrigation is the only solution for steady production of vegetables during dry season. Moreover, irrigation which requires energy to pump water, is one of the most energy-intensive operations in the farm. The main source of this irrigation is electricity. But the epileptic power supply from the national grid is a major problem in Nigeria and one of the ways Nigerians have been solving this challenge is by using alternative power sources. One of these alternative sources is the use of solar photovoltaic panels. Renewable energy is considered an alternative to fossil fuels and nowadays it attracts much attention. Among the renewable energy sources, solar is the most important because it is available in all parts of the world. Also this energy source is used in various industries including agriculture and its fuel does not cause pollution like the other fossil fuels. These fossil fuels, diesel and natural gas are very expensive for everyday use. Africa is endowed with a lot of solar energy and we need to tap such huge resource for the benefit of the rural poor. Farmers can hardly afford the conversional source of energy such as the use of fossil fuel or electricity for processing their farm produce. It is therefore paramount to consider the availability of the solar energy in agriculture to ensure food security and improve the lives of the rural poor, [1]. Hence, a resort for a better alternative, which is the renewable and sustainable power from the sun called the solar energy that will be used for the irrigation process by farmers in Anambra, Nigeria. Both the solar photovoltaic (PV) and solar thermal technologies can be utilized in farms. The former converts the sunlight directly into electricity and only operates when the sun is shining, the later concentrates sunlight by using mirrors, where the sunlight is either used directly as a source of heat or to power a generator to make electricity, [2]. Here in this paper we focus on the use of photovoltaic PV panels to pump water for irrigation.

Several researchers had worked on the performance of photovoltaic system under different climates. Sanusi et al. [3] had investigated on the effect of temperature and irradiance on the three commercially available PV modules and found a linear behavior between output power and ambient temperature. Bashir et al. [4] reported experimental data for the three different PV modules for January and found monocrystalline module more efficient. Also the effect of dust deposition on the performance of PV modules in different cities were investigated by some researchers and the module efficiency showed significant degradation, [5] and [6]. Other researchers analyzed how water cooling and micro channel cooling will enhance the efficiency by absorbing the heat generated by the PV modules. The studies both by [7] and [8] showed that a significant performance improvement of the PV cells can be achieved through the proposed cooling techniques.

Crop water requirement is highest during the dry season when the sun is at its peak. Solar energy also works best in lifting water for irrigation during such periods. The solution should ensure both a reliable supply of water to the vegetable farm and encourage sustainable economic activity in Anambra State. The aim of this paper is to contribute to a better understanding of the potential impact of solar photovoltaic PV on sustainable production of vegetables, with special attention to the effects on income generating activities in the State.

2. SOLAR PHOTOVOLTAIC

Solar energy is a clean and abundant renewable energy which is currently used in many types of photovoltaic designs. In the use of solar water pump we do not need the battery for storage rather we need an overhead tank installed in the

farm. During the day we pump water by the use of electricity generated from the PV panel and stored for use in the farm. Moreover, solar energy is a promising alternative compared to a non-renewable and fossil fuel energy sources. The sun is the most abundant and sustainable source of energy. About half of this energy reaches the earth's surface, and the rest is absorbed or reflected back into the outer space.

Here the earth receives its solar radiation from nuclear fusion reactions between hydrogen atom and helium atoms at the core of the sun, [9]. The rate at which solar energy reaches a unit area at the earth is called solar irradiance or solar insolation measured in Wm^{-2}. The integral over time of solar irradiance is called solar radiation or solar irradiation also measured in Jm^{-2}. Often solar irradiance is also referred to as solar radiation with the same units (Wm^{-2}) [10]. Peak radiation is observed during the dry season in Anambra State with the values of $22.470112Jm^{-2}day^{-1}$, $22.32187Jm^{-2}day^{-1}$ and $22.279368Jm^{-2}day^{-1}$ in February, March and April respectively, [11].

2.1 Photovoltaic Effect

The photovoltaic effect is a process that generates voltage or electric current in a photovoltaic cell when it is exposed to sunlight. It is this effect that makes solar panels useful as it is how the cells within the panel converts sunlight to electrical energy.

If the photon is observed by a valence electron, its energy is increased by the energy of the photon and if this energy exceeds the band gap, the electron will jump into the conduction band, where it can move freely. The electron can then be moved by the electric field across the p-n junction, resulting in the flow of electrons which will continue as long as the solar cell is illuminated, [12]. It is affirmed that in order to produce electricity, PV cells require a p-n junction across a semiconductor. At present silicon still remains the major source for the PV cells in industries. On the other hand when light energy strikes the cell, electrons are released from the material atoms. Electrical conductors attached to the positive and negative sides of the material allow the electrons to be captured in the form of a direct current, [13]. This electricity can then be used to power a load, such as a water pump, or it can be stored in a battery. It is a simple fact that PV modules produce electricity only when the sun is shining, so some form of energy storage is necessary to operate systems at night. One can store the energy as water by pumping it into a tank while the sun shining and distributing it by gravity when it is needed after dark.

3. SOLAR PHOTOVOLTAIC WATER PUMPING

Solar photovoltaic, PV, water pumping becomes the best alternative in Anambra State where the power from national grid is not steady. It is very advantageous in the sense that solar PV water pumps operate directly when the sun is shining which is very available during dry season when they are very much needed. The need for water pumping facilities in our farms cannot be over emphasized especially in our farms during the dry season. The unstable grid and unstable grid voltages force farmers to use expensive means of energy production to run their water pumps. Solar photovoltaic, PV, system for water pumping is a standalone system in which only solar energy is used as primary source and the system will only operate during the day which will be beneficial to our farmers.

Previous researchers had observed that increasing the farmers agricultural irrigation efficiency by only 100% could result in energy savings of more than 90million kWh annually. There are methods known to reduce irrigation energy use which include: maintaining existing pumps, servicing pumps regularly retrofitting pumps to increase efficiency installing new pumps with variable speed and properly sizing pumps, [14]. Solar photovoltaic, PV, water pumping had been recognized as suitable for grid-isolated rural locations in poor countries where there are high level of solar radiation. It is affirmed that solar PV water pumping systems can provide water for irrigation without the need for any kind of fuel or the extensive maintenance required by diesel pump. Photovoltaic powered water pumping systems have become attractive for agricultural applications in remote locations with limited access to conventional electricity, [15]. The performance of the photovoltaic, PV, water pump depends on the water flow rate which is influenced by the conditions of weather at the location, especially solar irradiance and air temperature variations. This also depends on water requirement, size of water storage tank, head (m) by which water has to be lifted, volume of water to be pumped (m^3), PV array virtual energy (kWh), pump and system efficiencies, [16]. Generally, photovoltaic is a renewable

which is a CO_2 neutral replacement for fossil fuels. Also there is a greater recognition of the importance of renewable energy particularly the modern solar photovoltaic, PV, water pump at the policy and planning levels. The technology is similar to any other conventional water pumping system except that the power source is solar energy. PV water pumping is gaining importance in recent years due to non-availability of electricity and increase in diesel prices. The flow rate of pumped water is dependent on incident solar radiation and size of PV array. Hence, for social benefits the renewable energy technology in agriculture should be promoted to mitigate climate change, to reduce fossil fuel consumption for agriculture and to protect the environment. Thus, renewable energy technologies play important role all over the world and their promotion should be manifold in the coming years to approach sustainable development in the country.

3.1 Sizing of the Motor Pump System

This can be estimated on the basis of instantaneous water flow and the Total Dynamic Head (TDH) which is the sum of static head of water in the well. Discharge head, drawdown head, discharge pressure and friction losses in pipeline. The formula used for sizing the water pump system is given as equation 3.1;

$$E = \frac{\rho g H V}{3.6 \times 10^6} \quad (3.1)$$

Where;

E - hydraulic energy required ($kWhday^{-1}$)
P - density of water ($1000kgm^3$)
g - gravitational acceleration ($9.8ms^{-2}$)
H - total hydraulic head (m)
V - volume of water required (m^3day^{-1})

On substituting all the values, equation 3.1 reduces to;

$$E = 0.002725HV\ (kWhday^{-1}) \quad (3.2)$$

Another important aspect of the site assessment is the orientation of the PV array. Usually the PV array is positioned in such a way that the sunlight is utilized to its maximum. The ideal orientation for panels is South as they will be exposed to the sun for the maximum length of time during daylight hours, [17]. The PV faces the South at a tilt angle equivalent to the latitude of the location. Since the latitude of Awka is $6^o\ 02^|N$, therefore, the photovoltaic, PV, array would be tilted at this angle.

4. CONCLUSION

The study of solar energy as an alternative for an all year round production of vegetables in Anambra, Nigeria has been presented. The use of solar PV water pump for irrigation will help:

- The use of renewable as a carbon dioxide, CO_2, neutral replacement for fossil fuel.
- Our country Nigeria benefit from pollution reduction, climatic mitigation and the increase in trading opportunities that arise from new income sources.
- Fossil fuel use reduction in the agricultural sector in Nigeria which can be easily achieved by the promotion of renewable energy technologies for various activities.
- In reducing and controlling CO_2 which is the major contributor to global warming.
- To dispersed these benefits in remote rural areas where they are greatly needed and can serve as linkages for further rural economic development.
- All year round production of vegetables and steady income generation in Anambra, Nigeria.

COMPETING INTERESTS

Author has declared that no competing interests exist.

REFERENCES

1. Amankwah E. Solar energy: A potential source of energy for agricultural & rural development in Ghana. Journal of Agriculture & Ecology Research International. 2015;3(4):131–140.
2. Ans F. System design and analysis of solar powered system in residential, Commercial and Agricultural Sector; Unpublished M. Sc Thesis, Islamabad; 2017.
3. Sanusi YK, Fajinmi GR, Babatunde EB. Effects of ambient temperature on the performance of a photovoltaic solar system in a tropical area. The Pacific Journal of Science & Technology. 2011;12(2):176–180.
4. Bashir MA, Ali HM, Ali M. An experimental investigation of performance of photovoltaic modules in Pakistan. J. Thermal Science. 2015;19(2S):525-534.

5. Ali HM, Zafar MA, Bashir MA, Nasir MA, Ali M, Saddiqui AM. Effect of dust deposition on the performance of PV modules in Taxila Pakistan. J. Thermal Science. 2017;21(2):915–923.
6. Catelani M, Ciani L, Cristaldi L, Faifer, M, Lazzaroni M, Rossi M. Characterization of photovoltaic panels. "The Effect of Dust" in Proceedings of the 2nd IEEE Energycon Conference & Exhibition Advances in Energy Conversion Symposium; 2012.
7. Ali M, Ali HM, Moazzam W, Saeed BM. Performance enhancement of PV cells through micro channel cooling. AIMS Energy. 2015;3(4):699–710.
8. Bashir MA, Ali HM, Amber KP, Bashir MW, Ali M, Imran S, Kamran MS. Performance investigation of photovoltaic modules by back surface water cooling. J. Thermal Science. 2018;22(6A):2401–2411.
9. Chel A, Tiwari GN. Standalone Photovoltaic (PV) integrated with Earth to air Heat Exchanger (EAHE) for space heating/cooling of adobe house in New Delhi (India). Energy Covers Manage. 2010;51:393–409.
10. Camacho EF, Berenguel M, Rabio FR, Martinei D. Solar powered water pumping system. Renewable Energy. 2012;87:609-615.
11. Ike CU. Global solar radiation in Awka, South East Nigeria Using Weather Station. ARPN Journal of Science & Technology. 2014;4(11).
ISSN: 2225-7217.
12. Kalogirou SA. Solar energy engineering: Process and systems. Academic Press Control of Solar Energy Springer; 2009.
13. Ali HM, Mahmood M, Bashir MA, Ali M, Siddiqui AM. Outdoor testing of photovoltaic modules during summer in Taxila Pakistan. J. Thermal Science. 2016;20(1):165–175.
14. Naranjo RD, et al. Colorado agricultural energy phase 2 market research report. Colorado Energy Office (CEO Report). 2013;7-8.
15. Cota A, Foster R. Solar water pumping advances and comperative economics. Energy Procedia. 2014;57:1431–6.
16. Bashir MA, Ali HM, Khalil S, Ali M, Siddiqui AM. Comparison of performance measurement of photovoltaic modules during winter months in Taxila Pakistan. International Journal of Photoenergy. 2014;8. Article ID 898414.
17. ArsalamRaza YQZ. Solar powered water pump lifting agriculture mechanics and materials. Renewable Energy. 2015;787: 1993–1999.

Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sdiarticle3.com/review-history/47687