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

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 paper investigates the impact of solar energy on the 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.

Keywords: Solar water pumping, Photovoltaic, Irrigation, Sprinklers, fossil fuels, Dry season Solar energy.

1. INTRODUCTION

Anambra State is situated in the South-Eestern 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 thus 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 ite fuel does not cause pollution like the other fossil fuels. These fossil fuels, diesel and natural gas are very expensive for everyday use. 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. Here in this paper we focus on the use of photovoltaiv PV panels to pump water for irrigation. The solution should ensure both a reliable supply of water to the farm and encourage sustainable economic activity in Anambra 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. 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}) Camacho *et al.* (2012). 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, Ike (2014).

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, Kalogirou, (2009). 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. 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, Naranjo, (2013). 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, Foster and Cota, (2014). 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. 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;

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

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. The PV faces the South at a tilt angle equivalent to the latitude of the location. Since the latitude of Awka is $6^{o}02^{l}$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 issues which have recently gained attention include; renewable as a carbondioxed CO_2 neutral replacement for fossil fuel and greater recognition of the importance of renewable energy, particularly the modern solar PV water pump at the policy and planning levels. Our country, Nigeria would 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 can be easily achieved by the promotion of renewable energy technologies for various activities. The key factors to reducing and controlling CO_2 which is the major contributor to global warming are the use of alternative approaches such as renewable systems for energy generation of how these alternatives are used today and may be used in the future as green energy sources. These benefits would be dispersed in remote rural areas where they are greatly needed and can serve as linkages for further rural economic development.

References

Ans, F., (2017), System Design and Analysis of Solar Powered System in Residential, Commercial and Agricultural Sector; Unpublished M. Sc Thesis, Islamabad.

ArsalamRaza, Y. Q. Z., (2015), Solar powered Water Pump Lifting Agriculture Mechanics and Materials, *Renewable Energy* (787) 1993 – 1999.

Camacho, E. F., Berenguel, M., Rabio, F. R. and Martinei, D., (2012), Solar Powered Water Pumping System, *Renewable Energy;* 87, 609 -615.

Chel, A. and Tiwari, G. N (2010). 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;* 51, 393 – 409.

Foster, R. and Cota, A., (2014), Solar Water Pumping Advances and Comperative Economics, *Energy Procedia*; 57, 1431 – 6.

Ike, C. U., (2014) Global Solar Radiation in Awka, South East Nigeria Using Weather Station, *ARPN Journal of Science & Technology*; 4(11), ISSN2225-7217.

Kalogirou, S. A., (2009), Solar Energy Engineering: Process and Systems. Academic Press Control of Solar Energy Springer.

Naranjo, R. D. *et al.* (2013), Colorado Agricultural Energy Phase 2 Market Research Report, Colorado Energy Office (CEO Report), 7 & 8.

Omer, A. M., (2008), Green Energies and The Environment*, Renewable Sustainable Energy Rev.,* 12, 1789 – 1821.