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SOLAR SUN TRACKING SYSTEM: A MODEL FOR SUSTAINABLE ELECTRICITY SUPPLY FOR INDUSTRIAL AND ECONOMY DEVELOPMENT IN NIGERIA

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ABSTRACT

Inadequate access to electricity in the country has been a major cog in the wheel of progress to socio-economic and technological growth of the nation. Increasing erratic and power shortages in Nigeria has been identified as responsible for the dwindling development of small scale business down to industrial sectors. This paper has therefore sorts the need to analyze the important to improve on harnessing Photovoltaic (PV) energy. Solar sun tracking is used to have sun intensity perpendicular on solar cell from sunset to sunrise. The result shows that at least 60% energy can be tracked every hours of the day sustaining the efficiency of electricity as needed. Recommendations are made, that Government should be more pro-active in its drive in the provision of electricity to the nation. All the laudable plans over the years gearing towards electricity generation should be lifted from paper to execution. Sun tracking model should be emphasized on as a means for sustainable electricity, economic development, poverty alleviation measures, and module for teaching and learning in higher institutions.

Key words: Solar energy, Photovoltaic (PV), Poverty, Electricity, Sun tracking, Development

INTRODUCTION

The growth of any nation, for economy to thrive, industries to develop, small scale enterprise to be sustained, hospitals to function properly, to facilitate domestic activities, for adequate mineral extraction, for profit maximization by manufacturing industries, effective transportation system, for optimal output by production companies, to enhance agricultural production and educational sector to advance in scientific work, they all need constant electricity power supplies. Electricity is the life wire, the foundation stone of all human endeavors, in fact the lubricant of sustainable economic national development. Electrification is a means of poverty reduction. World Bank (2000) define poverty as the deprivation in wellbeing, and comprising low incomes and the inability to acquire the basic goods and services necessary for survival with dignity. It also encompasses low levels of health and education, poor access to clean water and sanitation, inadequate physical security, lack of voice and insufficient capacity and opportunity to better ones life [1]. Poverty is any deficiency of elements or resources that are needed or desired, of unemployment which is due to the non-acquisition of relevant saleable skills an individual needs in order to fit into the job market [2].

In developing country like Nigeria this is greatly affected especially in technological development because of inadequate provision of constant, reliable and desire voltages of electricity for saleable skills to be attained so as to reduce prevailing poverty in the country. According to the Transmission Company of Nigeria (TCN); there was a drop in the nation's power generation capacity from 3,959 megawatts on January 4 to 2,662 megawatts on January 22, 2017[3].

This is a clear prove that the industrial sector will experience sluggish growth further worsened by electricity crisis such as electricity blackouts and the use of electricity generating devices. The same way it will affect other national developments down to small scale enterprises. Electricity generation has the tendency of improving the industrial sector as well as other sectors in the economy if revenues are sincerely directed to the development of electricity generation [4].

Over the years, in Nigeria, fossil fuel power generating plants had been used as the major source to the supply of electricity. These have tremendously provided leverage to the country. It is worthy of note that electric power system is undergoing changes as recent statistics shows increase constant power demand as against corresponding supplies.[5] This eventually affects power quality output to loads, number of hours provided, running cost of businesses, sustainability of industries, and the general standard of living of the citizenry drops. A part from its shortage and irregularity in supply, the method also have negative effect on the environment, as it causes depletion on Ozone layers, global warming due to emission of greenhouse gases and environmental pollution. It is acceptable believe around the world that access to modern energy (Electricity supply) is a necessary requirement for sustainable development. This belief is based on three basic arguments as regard energy for development:

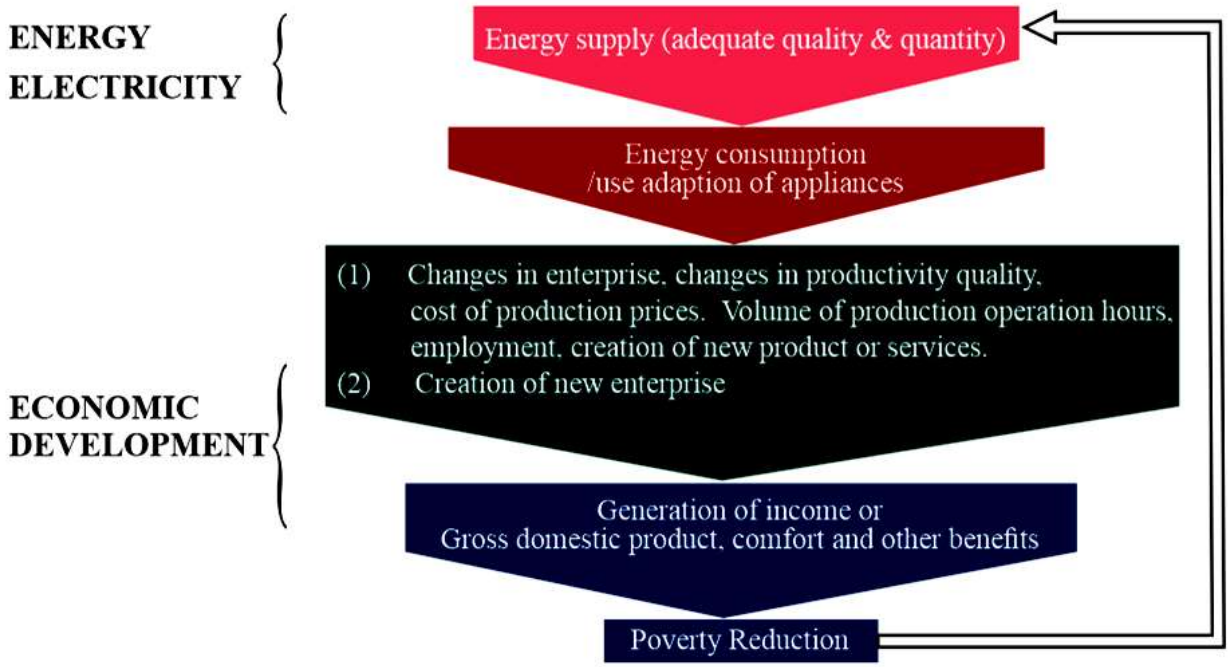
(i) modern energy may be a crucial input to achieving several of the Millennium Development Goals (MDGs)

(ii) modern energy use may enable the poor in developing countries to engage in improved or new income generating activities (often called 'productive use of energy', as opposed to 'consumptive use'), thereby eventually leading to an

improvement in their living conditions (Practical Action 2012, UNDP/WHO 2009, DFID 2002, UN 2002, UN Millennium Project 2005, Brew-Hammond and Kemausuor 2009) and

(iii) exclusion from modern energy might be a direct indicator of poverty based on definitions which refer to living standards – for instance, access to electricity is included in a recently published 'Multidimensional Poverty Index' by the UNDP (2010).[6]

Among all modern energy types, electricity access is included most frequently and as basic means of national development strategies. Taking electricity to be source of poverty reduction is the basic reasons why there is understanding of the links between electricity supply and poverty reduction through income generation. The relationship consists of several steps and many factors influence each of these steps. The first step towards all sectors benefiting from electricity supply is the actual provision of electricity and the industrialist decision to make use of it [7]. However the steps that follow, namely the actual use of electricity and the subsequent changes that the use of electricity brings in the life of people in relation to increased productivity, ultimately lead to impacts at business level, such as increased income leads to increase in standard of living. The chain from energy supply infrastructure to development outcomes can further be explained in the chart below.



Source: Figure.1 (adapted from Kooijman-van Dijk 2008).

The benefits that comes from constant use of electricity are endless as seen in fig 1, at poverty reduction in the chart, the arrow takes you back to the base where needs are met with the use of electricity. According to data from the Nigeria's National Population Commission, we have about 178.5 million people in the country. Electricity supply of 5,000 MW is grossly not enough to supply such a large population in Nigerians. Despite the availability of electricity to an estimated 55 percent of consumers, load-shedding for rationing electricity is generally practiced all over the country [8]. Much more than 5,000 MW of electricity is required for the socio-economic growth of the nation. With the use of modern energy modeling tools, Energy planning experts estimated that for the Nigerian economy to develop at a rate of 10 percent the country's electricity requirement by 2020 will rise of 30,000 MW, and by 2030 it will be 78,000 MW. The current energy mix for electricity supply requires addition of more sources such as: solar, wind, coal biomass/biofuels and nuclear [9]. This

will improve security of electricity supply and serves as the best plans for national development.

The above master plans confirms that the nation is actually suffering from poor supply of electricity which would have helped in the reduction of poverty, improve technological growth and fast track national development. This paper has therefore seen the exigency to improve on the existing solar energy source of electricity. Many of the empirical research on photovoltaic (PV) have not really emphasized on the importance how this source of power should be sustained. The solar energy requires constant direct sun light that should be perpendicular to the panel, and anything short of that usually affects its efficiencies, as such sustainable power supplies are not realized.

Solar Energy

Nigeria lies within a high sunshine belt and, within the country solar radiation is fairly well distributed. Annually, the average of estimated total solar radiation varies from about 12.6 MJ/m2-day (3.5 kWh/ m2-day) in the coastal latitudes to about 25.2 MJ/ m2-day (7.0kWh/ m2-day) far north. With an average annual solar energy intensity of 1934.5 kWh/m2-yr; thus, over a whole year, an average of 6,372,613 PJ/year (≈1,770 Thousand TWh/year) of solar energy falls on the entire land area of Nigeria. This is about 120 thousand times the total annual average electrical energy generated by the NEPA. With a 10% conservative conversion efficiency, the existing solar energy resources is almost 23 times the Energy Commission of Nigeria's (ECN) projection of total final energy demand by Nigerians in the year 2030, and just under 200 times of the demand by the year 2010 for the High Growth Scenario. For the Low-Growth Scenario, the available resource

is about 12 times demand by the year 2030 and just under 100 times demand by the year 2010[10].

Objectives of the study

The sustainability of power supplies in a given environment, or business raises the per capita income and standard of living in that area. This simply means, electricity serves as life-wire to any sustainable development. Therefore, the objective of this study specifically assesses provision of:

- A Non-pollutant and reducing environmental degrading source of electricity supply
- Sensitizations on access to source of electricity supply and poverty reduction
- A noiseless source of electricity supply with 10% conservative conversion efficiency.
- A simple source of electricity supply to stimulate economic growth and development
- An efficient and effective solar energy that will be capable to track sunlight that will be perpendicular to the panel from all direction at any time of the day making it possible to have constant electricity power supplies.
- Photovoltaic source of energy as a module for teaching in higher institution

METHODOLOGY

Methodology can be defined as the systematic means of data collection, approach, techniques, experimental, research/ development, and correlated/regression analyses. By this definition, the research work adopted correlated/regression analyses that compare quantitative

strength relationship between two or more variables with the aim of providing new knowledge that can be used in creating new technology, provision of constant electricity power supplies, and a model for teaching in any higher institutions.

These alternative energy sources include; solar, nuclear and wind, but in this research our focus is on solar energy. Solar energy can contribute to saving exhaustible energy sources, is the cleanest source of energy that is generated by harnessing the power of the solar radiation, through the conversion of the sun's radiation to electricity using Photovoltaic panel. There are three parameters upon which the amount of power available from a photovoltaic panel is determined, this includes;

1. The intensity of the sunlight
2. The type and area of material
3. The wavelength of the sun rays

In resent time progress in solar panel technology has taking care of the type and area of material; the type and area of material used for solar panel are well standardized. As this system "solar tracker" ensures the intensity of sun rays hits the surface of the panel from sunrise to sunset [11]. The solar panel is to tracks the sun's direction to produce the maximum possible power. This is obtained through the designed and implementation of a two-axis tracker system, that maintains the panel orthogonal position with the light source. The system is integrated with an inverter and deep cycle rechargeable batteries.

The design is made up of three major parts;

1. Mechanical
2. Electrical
3. Software (control program)

- **Mechanical:** The mechanical part includes; the moving mechanism that enable rotation of the solar panel, metal casing to hose the circuitry and other metal fabrication and frame work for supports.
- **Electrical:** The electrical part consist of; solar panel movement control circuit, charge control circuit, sensors, inverter and protection circuits.
- **Software:** These are set of computer instructions known as program, written in C^{+} programming language using Arduino integrated devotement environment. The **figure 2** shows the sun's path within a year. With the single axis systems sited in the northern hemisphere, the panel is faced southward with an appropriate angle and so as shown in **figure 2,** cannot always stay perpendicular to the direction of the sun radiation. Therefore, the double axis trackers are used for maximizing the reception of the sun radiation.

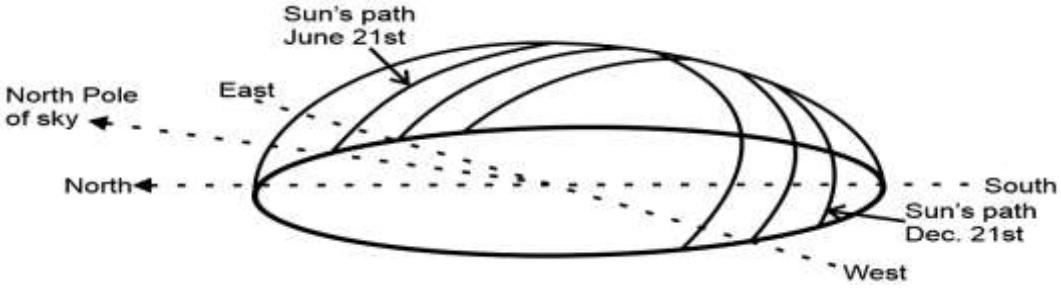


Figure 2. The path of sun during the different seasons

Source: *International Symposium on Power Electronics, Electrical Drives, Automation and Motion*

The sun status is determined based on the angles of zenith and azimuth. The zenith angle is the angle between the sun's direction and

the axis perpendicular to the desired area and upward. The azimuth angle is the between the North Pole and the direction of the sun's projection on the earth in the clockwise direction. The **figure3** shows these angles. In this figure, there is another angle that is complementary to the zenith angle and is called the elevation angle "h".

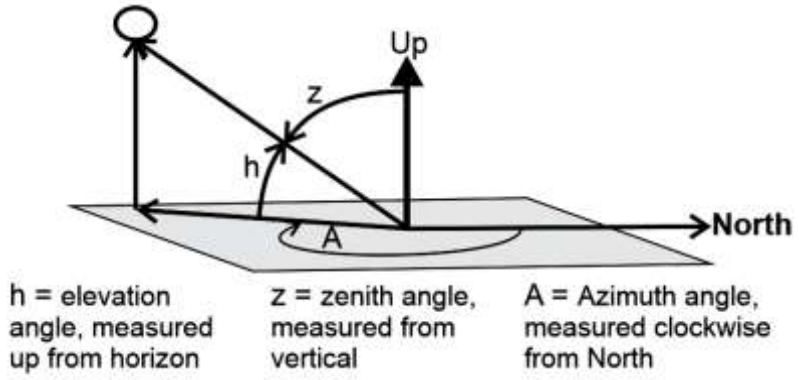


Figure 3. Sun position in the sky

Source: *International Symposium on Power Electronics, Electrical Drives, Automation and Motion*

Hardware

The main components are: Solar panel, Sensors (LDRs), Actuator, Power jack, and Microcontroller (Arduino UNO)

Solar panel: Solar panels are devices that covert light into electricity. The word solar is used as they derive energy for operation from the sun. They are sometimes called photovoltaic which means "light-electricity" solar cells or PV cell [12].

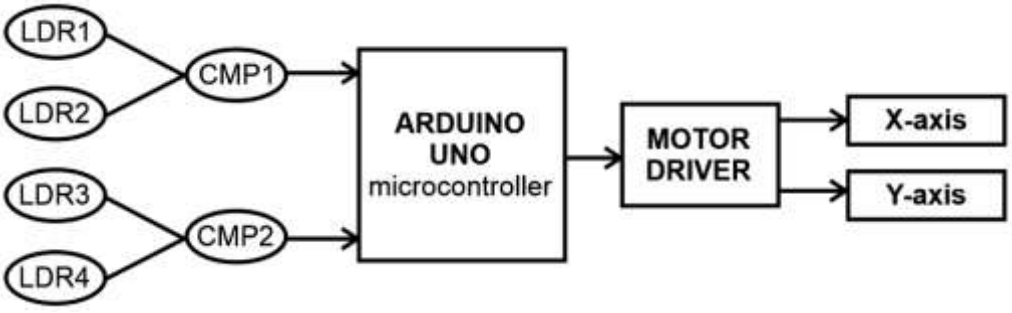
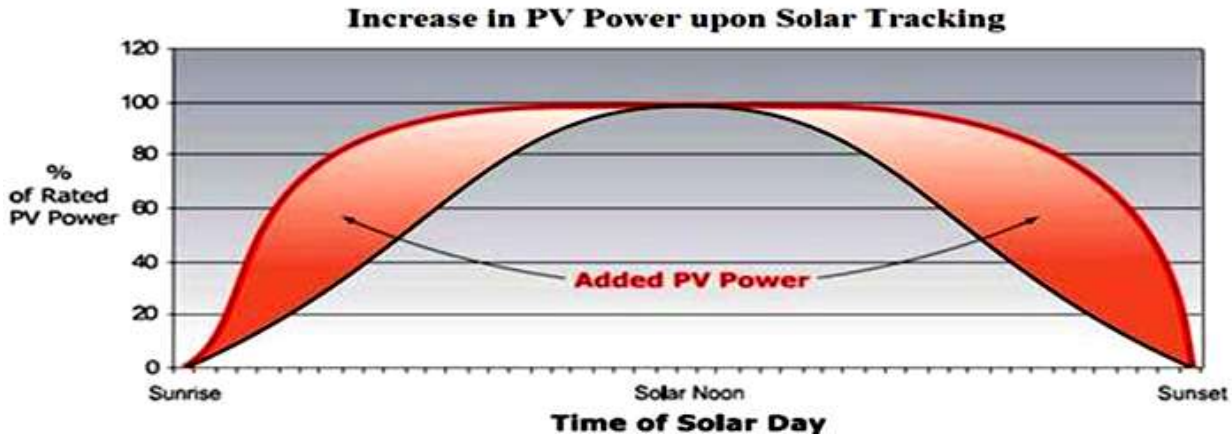


Figure 4.Block diagram of solar tracking system using LDR, actuator power jack and microcontroller [12]

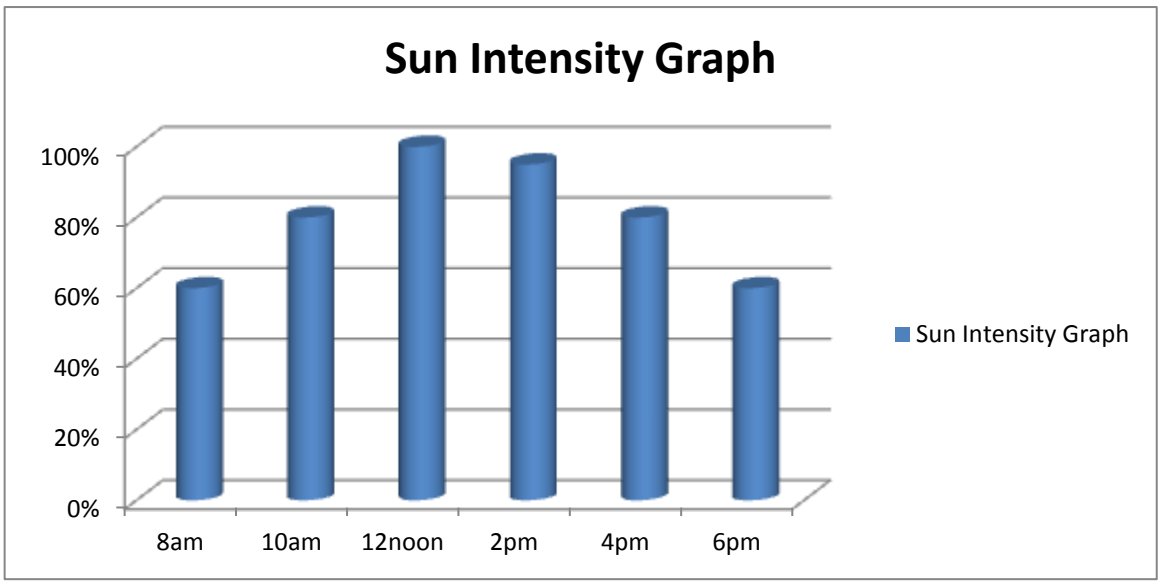
Analyses and Presentation

The increase in Photovoltaic (PV) power is realized through tracking. Considering the graph below, solar efficiency is felt when sun is perpendicular on cell mostly at noon hours, but irrespective hours of the day, energy are sustained providing electricity power as required through sunrise and sunset tracking method.[13]



Source: *International Symposium on Power Electronics, Electrical Drives, Automation and Motion.*

% PV = ∂Ax, this is arc area between 95 & 20% on Y-axis with corresponding increase on X-axis which can be represented thus (X+∂x, Y+∂y). ∂Ax/∂x = increase percentage PV power. The first lower arc is the normal Photovoltaic solar energy when it is not yet tracked, while the second upper arc is when the sun is tracked to be more perpendicular to the solar panel cell.



Source: Author, fig. 6. Hourly solar energy intensity tracking

Increase sunlight on solar cell is further explained through bar chart in spite of the hour of the day such that at least 1160.7kWh/m^2 solar energy intensity can be harnessed constantly out of 1934.5kWh/m^2 available in Nigeria yearly. This has actually proved that national development can be enhanced through solar sun tracking system. Practical demonstrations of this in higher institutions constitute a useful module for teaching and learning which inadvertently will be translated into national development.

CONCLUSION

Standard of living of any nation can be measured through some strategy adopted for the industrial and economic development of that country. It is not farfetched that dwindling economic development of Nigeria is not unconnected with constant erratic and unreliable power supply in the country. This research has actually x-rayed the possibility of tracking solar energy for the provision sustainable electricity as the hallmark that drives economic growth of a nation.

Using solar sun tracking model in addition with hydro power, thermal power, gas power biomass energy, and other sources of power generating plant available to the nation will surely reduce poverty that has strangulated the nation and crippled economy up this day.

RECOMMENDATION

Having seen electricity to play a vital role in the socio-economic and technological development of every nation, also seen the increase in population growth of the nation, more pressure and demand of electricity increases every day. Recognizing many decades discovery of electricity in the country, yet it is faced with acute electricity problems, hindering its development despite the availability of vast natural resources in the country. It is therefore recommended that the Government should be more pro-active in its drive in the provision of electricity to the nation. All the laudable plans over the years gearing towards electricity generation should be lifted from paper to execution. Industries should be encouraged to gear their resources to tap natural resources available in the country to generate electricity. Photovoltaic (PV) energy should not just be seen as a source of energy, but proper means of harnessing it should be employed. Sun tracking model should be emphasized on as a means for sustainable electricity, economic development, poverty alleviation measures, and module for teaching and learning in higher institutions.

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