POSSIBILITY OF RURAL ELECTRIFICATION THROUGH SOLAR ENERGY IN NIGERIA

M.R. Adu[(1)] and B.O. Bolaji[(2)]

[(1)]Department of Electrical/Electronic Engineering, Federal University of Technology, Akure, Nigeria
[(2)]Department of Mechanical Engineering, Federal University of Technology, Akure, Nigeria.
E-mail: bobbolaji2007@yahoo.com

ABSTRACT

This paper presents the analysis of the possibility of employing solar energy for the supply of electricity to the rural communities in Nigeria. It describes various types of photovoltaic systems for rural electrification with more detailed discussion devoted to the domestic power supply, health care systems and lighting systems. It highlights the potentials of solar pumping systems in addressing the problems of lack of potable water and supply of water for irrigation in the rural areas.

INTRODUCTION

The sun has been worshipped as a life-giver to the planet since ancient times. The industrial ages gave the understanding of sunlight as an energy source. This discovery has never been more important than now as it is realized that the fossil energy sources are yielding energy with greater and greater reluctance and even the exploitation is affecting the planet's ambience (Thomas, 1998).

According to Adegoke and Bolaji (1999, 2000) and Bolaji (2003), the energy supply from the sun is abundant and inexhaustible. It is more evenly distributed over the earth's surface than fossil fuels and the amount of energy available for conversion is several orders of magnitude greater than the present world requirements. For instance, the earth receives annually, energy from the sun amounting to 1×10^{18} kWh. This is equivalent to more than 500,000 billion barrels of oil or about 1000 times the present annual consumption of energy of the whole world. This means that in less than one hour enough energy is supplied to the earth to satisfy the entire energy demand of the human population over the whole year (Garg, 1982).

The history of the direct conversion of solar energy into electricity is dated back to 1839, when Edmund Becquerel observed that electrical currents are generated from certain light-induced chemical reactions (Dostrovsky, 1988). A similar effect was observed in a solid (selenium) several decades later. A comprehensive understanding of these phenomena, however, had to await the progress of science in the field of quantum theory in the early parts of twentieth century. The development of the first solid-state devices in the late nineteen forties then paved the way to the announcement of a silicon solar cell with 6 % efficiency – the first usable solar cell (Chapin *et al*., 1954).

Much interest in solar electricity appeared particularly in the wake of the oil crisis in the early nineteen seventies. Today, the direct conversion of light into electricity, or photovoltaic, is becoming accepted as an important source of power generation. In U.S.A. over 50 megawatts of photovoltaic power modules were produced in 1991. The production rate has been increasing at almost 20 % annually over the last few years, and this trend is likely to continue. It has been estimated that the annual module production will reach hundreds of megawatts by the end of the 20th century and tens of gigawatts in the next 40-50 years (Thomas, 1998).

Direct conversion of solar energy to electricity is reliable, involves no moving parts, maintenance costs are very low. The operation of a photovoltaic system does not produce audible sound, and create no atmospheric pollution. Photovoltaic systems are modular and can be quickly installed. Power can be

generated where it is required without the need for transmission lines.

The provision of electricity to rural areas derives important social and economic benefits to remote communities throughout the world. Therefore, this paper deals with the possibility of power supply to remote houses or villages through photovoltaic systems

Needs for Rural Electrification

Most rural areas in Nigeria have no access to electricity, even areas where there is electricity the supply is erratic and unreliable. The electricity problem is potentially the most serious at it affects virtually every facet of lives in the rural area. The United Nation estimates that two million villages within 20^{o} North and South of the equator have neither grid electricity nor easy access to fossil fuel. It is also estimated that almost a half of all people worldwide do not have electricity, with a large number of these people living in climate ideally suited to photovoltaic applications (Hill, 1998). In Nigeria, millions of houses in the rural area do not have access to grid electricity.

Moreover, rural electricity supply through grid extension is of great disadvantage, in that the extension and subsequent maintenance of transmission lines over long distances and often over difficult terrain is expensive. But photovoltaic electricity exploits the following advantages over other alternative forms of rural electricity supply:

- There are no fuel costs or fuel supply problems,
- The equipment can usually operate unattended to over a considerable length of time, and
- It is very reliable and requires little maintenance.

Photovoltaic (PV) Systems for Domestic Power Supply

Application of domestic power supply through photovoltaic system is common in developing countries and remote locations in industrialized countries. This can also work successfully in Nigeria. The size range varies from 50 W to 5 kW depending on the existing standard of living. Typically large systems can be used in remote locations or island communities where household appliances including refrigerator, washing machine, television and lighting are used. In developing regions, large systems (5 kW) are typically installed for village supply, while small system (50 – 200 W) is used for lighting, radio and television in individual houses.

A typical configuration of these systems is shown in Fig. 1. The inverter can be omitted in the systems where AC power is not required. Photovoltaic system can be mounted on the roof of buildings to serve the double purpose of heat absorbers and electrical generators. The electric energy from the roof could be stored in 120-volt lead-acid storage batteries and this energy will provide the electrical needs of the building (Fig. 2). A large number of PV systems were installed in Germany within the government sponsored "Rural Electricity Programme" (Bloss *et al*., 1991).

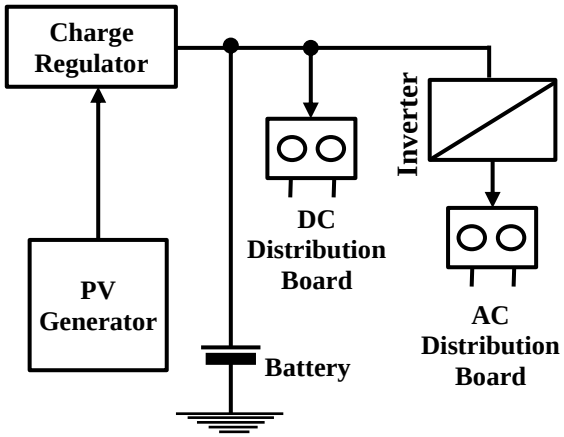

Fig. 1. Configuration of a residential PV system.

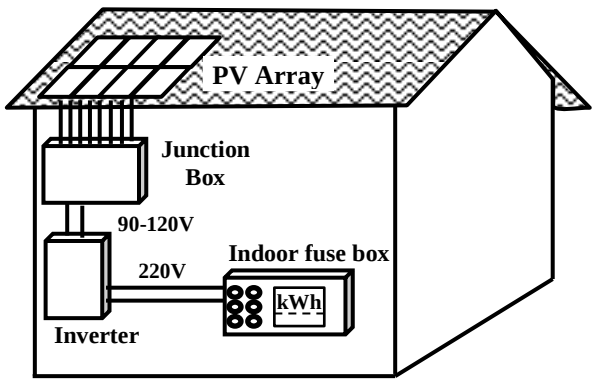

Fig. 2. Roof-top PV installation in buildings

Solar Photovoltaic Refrigerators for Health Care Systems

Extensive vaccination programmes are in progress throughout the developing world in the fight against common diseases. In order to be effective, these programmes must provide immunization services to rural areas. All vaccines have to be kept within a strict temperature range throughout transportation and storage period. The provision of refrigeration for this purpose is known as the vaccine cold chain.

Vaccine refrigerators are required to maintain vaccine between 0 ^{o}C and 8 ^{o}C at all times. In addition, a separate freezing compartment is usually needed to freeze ice packs which are used for transporting vaccines in cold boxes. Since most rural health centres in Nigeria have no access to electricity and diesel generator often suffer from mechanical breakdowns and fuel supply problems, solar photovoltaic refrigerators will be more reliable and more appropriate to provide a more sustainable vaccine for immunization services to rural areas.

Solar PV for Lighting Systems in Rural Areas

Lighting is taken for granted in the industrial countries and in most of the urban area of the developing countries. But in rural areas where there is no access to grid electricity, lighting is restricted to candles, kerosene lamps or torch lights powered by expensive throw-away batteries.

In terms of the number of installations in USA, lighting is at present the biggest application of photovoltaic systems (Bloss *et al*., 1991). In Nigeria, photovoltaic systems can be used to provide lighting for domestic and community buildings in rural areas. This application can also be used for street and security lightings.

Problems of Lack of Potable Water in the Rural Area

More often, untreated waste disposed into water bodies which serves as natural water supply for communities downstream have negative impact on consumers' health. In addition, improper refuse dumps release leachate that migrates into water sources. Leachate derived from waste dumps has been shown to contain more than 40 organic contaminants and a host of other pollutants including heavy metals. These pollutants besides degrading water resources have toxic effect on human when consumed (Oguntoke and Ogunwede, 2003).

The results of the research carried out by Oguntoke and Ogunwede (2003), showed that, most stream water in Nigeria are highly polluted. Their analysis of samples of some stream water showed that turbidity, dissolved solids, chloride, iron levels, coliform count and total bacteria count in these stream water are outstandingly higher than the recommended levels for human consumption. For instance, in China, higher mortality rates for stomach and liver cancers have been associated with high level of pollutants in stream water. Other health problems associated with drinking polluted water include diarrhea, cholera, intestinal worm infection and typhoid fever.

Water supply through solar pumps is more suitable for drinking purpose than stream water, because this water is pumped from treated boreholes and wells into an overhead tank where it will finally be treated to WHO required standard before circulation. In India, more than 500 solar pumping systems have been installed for village water supplies. The report of research carried out in these villages after the installation of solar pumps, shows drastic drop in the occurrence of water related health problems such as typhoid, diarrhoea, dysentery, and cholera (Thomas, 1998).

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