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SOLAR NOW: A MODULE FOR INCREASED USE OF SOLAR ENERGY IN SCHOOLS

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ABSTRACT

One of the advantages of renewable energy use is its non-polluting effect on the environment. Nigeria's prime location in the tropics places it at a vantage position to effectively utilize the ever-abundant energy from the sun. Depending on the energy from the over-subscribed national grid, as is the case presently, is not a sustainable approach to the near energy-crisis we experience in most of the urban and rural areas. In this paper, some ways of meeting the energy needs of schools through the use of solar energy have been presented. The use of photovoltaic arrays will improve the electrical energy need in schools. Distilled water needed in the laboratories can be obtained from the solar distillation kit. The construction and characterization of a solar distillation kit are discussed and some practical ways of harnessing solar electricity for use in schools using photovoltaic modules are suggested. Spending part of the school's lean financial resources to purchase distilled water is wasteful since the solar distillation kit offers a cheaper option. Being unable to operate electrical appliances in the schools due to unstable energy supply will be ameliorated when there is an increased use of solar electricity.

KEY WORDS: solar energy, distillation kit, and photovoltaic module

1. INTRODUCTION

Solar energy's unique attributes of needing no fuel, high durability and reliability and being able to operate for prolonged periods without maintenance, make it economical and sustainable for all types of remote applications. It serves as a backup energy even in urban areas, even if the traditional energy supply is stable most of the times. Of course, it is well known and agreed that the national grid supply of electricity in Nigeria by the Power Holding Company of Nigeria (PHCN) is inadequate and unreliable in our mega cities where energy is needed for domestic, office and industrial use. Presently, most of our rural areas, where over 70 percent of the nation's 120 million inhabitants dwell, are not yet linked to the national grid electricity. No one can say for sure when our electricity supply will improve.

Solar energy falls into three main categories: solar photovoltaic electricity, passive solar and solar thermal energy. All of them produce energy without releasing pollution particles or chemicals into the air. Photovoltaic cells are often called PVs for short. They absorb sunlight and turn it into electricity without using any moving parts. Instead, they use a photovoltaic effect to produce electrical energy. Passive solar uses the sun for lighting and heating, also without moving parts. There are different kinds of passive solar devices. Some absorb sunlight and then slowly release it, even after the sun sets. Others simply bring as much light as possible into a room. A window can be a passive solar device. Solar thermal systems also collect the sun's energy, but they use mechanical devices to move water or air across surfaces that have absorbed sunlight to heat them.

A very important characteristic of photovoltaic power generation, especially the decentralized solar home systems, is that it does not require a large-scale installation to operate compared to conventional power generation stations. Power generators can be installed in a distributed fashion, on each house or business or school, using area that is already developed, and allowing individual users to generate their own power quietly and safely. Rooftop power can be added as more homes or businesses are added to the community, thereby allowing power generation to keep in step with growing needs without having to overbuild generation capacity as is often the case with conventional large scale power systems. Compared to the other renewable energy sources like wind, waterpower and even solar thermal, photovoltaic power has some clear advantages. First, wind and waterpower rely on turbines to turn generators to produce electricity. Turbines and generators have moving parts that can break down, that require maintenance and are noisy. Photovoltaic (PV) systems on the other hand, have no moving parts, require virtually no maintenance and have cells that last for at least ten years (Siemens, 1998).

2. SOLAR ENERGY SYSTEMS

The solar home kit, for example Figure 1, is a complete solar energy system that powers electric lights and can power 12-volt electrical appliances like black and white television. The kit can include one or more solar panels depending on the needed application. In addition, it can incorporate a charge regulator, two 30cm fluorescent light tubes, one nightlight; all needed cables and other installation materials. The end-user only has to add a battery. Solar systems for generating electricity begin with the solar module (Van der Plas et al., 1998). The module gathers solar energy in the form of sunlight and converts it into direct current (DC) electricity. Some photovoltaic systems are used to power a load directly like in water pumping or in utility grid connection.

In such a case, no storage using batteries may be needed. It should be noted that the more the amount of sunlight or number of solar modules (panels), the more the electricity produced. Components such as charge regulators, batteries and inverters regulate, store, condition and deliver the electricity. Other elements connect the different components of the system.

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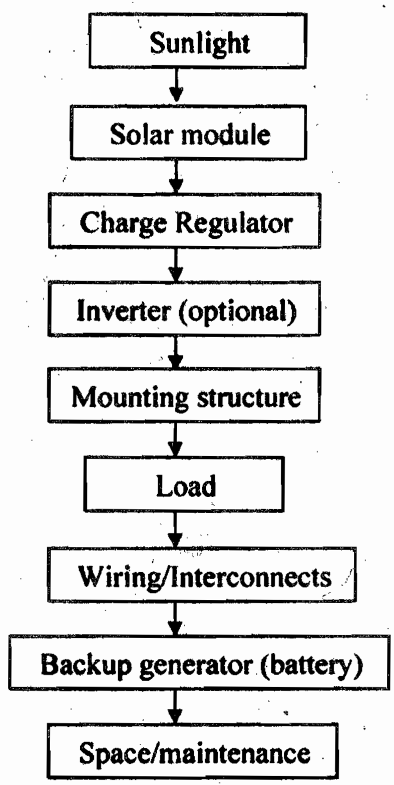

Fig 1: Elements of a solar electric power system

3. SOLAR ENERGY MODULE FOR SCHOOLS

Two solar energy systems are proposed to be promoted and introduced in schools. These will help to reduce the financial cost of running the schools, protect the environment and lessen the dependence on the unreliable and over-subscribed conventional electric power supply in most of the urban schools. For schools in the rural areas not linked to the national grid, the module being proposed is the viable alternative to their near energy crisis. The present situation of teachers refusing posting to schools in the rural areas or the principals operating from far away urban areas will be flagged since life will be better in such remote areas. There will be internet facilities and constant electricity courtesy of the SOLAR NOW programme.

PHOTOVOLTAIC (PV) SOLAR SYSTEMS FOR SUPPLY OF SOLAR ELECTRICITY

One key way of saving money in the schools is by using solar energy to charge batteries used in the laboratories and illuminate the school surroundings and reading rooms at night using energy efficient fluorescent lamps. If this is done, there will be no need to pollute the fragile environment using kerosene lanterns and likely cause health problems to the students. The 12-watt and 24-watt solar modules can be used for this purpose. During the day, the solar energy will be used to charge the batteries for use at night. The television in the common rooms can be powered using solar energy. Obviously, one surest and effective method of demonstrating the beauty of alternative sources of energy is through introducing the photovoltaic module as one of the energy suppliers in the schools such as for the following cases.

- Reading rooms illuminated by solar energy,
- Street lamps for nighttime illumination,
- Solar Energy supplementing the energy supply in the laboratories,
- Charging batteries for local automotive electricians, powering refrigerators, powering the common room television and radio sets using solar energy,
- Internet café with two or three computers located in the school library for teaching and research only,
- Charging mobile phone batteries with solar energy at a nominal fee.
- etc.

SOLAR DISTILLATION KIT

Distilled water is needed in the various Chemistry and Biology laboratories for experiments. Using part of the lean financial resources of the school or institution to purchase this commodity is wasteful especially since there is a viable alternative that can be supplied using the solar distillation kit. In this section are presented some details about a solar distillation kit constructed and characterized in the Physics laboratory of Imo State University, Owerri by Obidike (1998). The constructed solar distillation kit has the following dimensions: the rectangular flywood box has a length of 1.22m and width of 0.56m. The galvanized pan box has a length of 1.17m and width of 0.51m making a surface area of 0.597 m^2. The 0.05m (1.22-1.17 m) difference in both lengths and widths of the two boxes were meant for insulation that was achieved using sawdust. The overhead prism fitted in the galvanized pan box has the dimensions: length=1.17m, width=0.51m, height=0.5m. The materials used for constructing the solar distillation kit (all are locally available and cheap) include plywood (1.5cm thick), galvanized pan, insulating material (saw dust), rubber hose and plain rubber, transparent (PVC) glass, long woods (2 inch x 2 inch) and inlet tap (½ inch). Other details about the mounted solar distillation kit are listed in Obidike (1998). The total cost of construction of the solar distillation kit was five thousand Naira (about 62.5 US dollars) at the exchange rate of eighty Naira to one US dollar in 1998. That is the same like that constructed at Anambra State University of Technology Uli by Ozuomba (2007).

PERFORMANCE EVALUATION OF THE DISTILLATION KIT

After construction, the distillation kit was mounted in an open space where there is no obstacle to incident solar radiation impinging on the transparent glass of the setup. Experiments were carried out to determine its performance and efficiency for a period of 28 days (16 June – 14 July) between the hours of 7am – 5pm. For each set of readings in a day, the inner temperature of the distillation kit was taken. At the end of the day, 5pm, the amount of distillate was measured using a measuring cylinder graduated in cm^3. Before starting experiment the next day at 7am, the amount of distillate for the period, 5pm – 7am was measured. The total amount of distillate any day is what is needed. We also measured the temperature inside the solar distillation kit every two hours between 7am – 5pm each day.

4. DISCUSSION

During the first week of experiment (June 16-22, 1998), the temperature inside the solar distillation kit rose from 24°C at 7am to its highest value of 50°C at 3pm (Fig 2a). The total amount of distillate (Fig. 2b) recorded by the solar distillation kit varies from day to day depending on the weather condition. On cloudy days, a smaller amount of distillate was recorded from the kit. This is due to less amount of incident solar radiation on the transparent glass cover of the kit. In all, the solar distillation kit constructed at the Imo State University Physics laboratory performed satisfactorily judging from the total amount of distillate recorded (Fig. 2a and b). The results are encouraging although the experiment duration was short (28 days) and performed at the peak of the wet season (16 June – 14 July 1998). Nigeria receives abundant solar energy that can be usefully harnessed (Ojosu, 1990). For example, the mean solar power potential over Owerri per day for 1985-1997 was reported by Chineke (2002) as in the range of 4.57 kWh^{-2}. This is obvious from the results listed for Owerri in Figure 3.

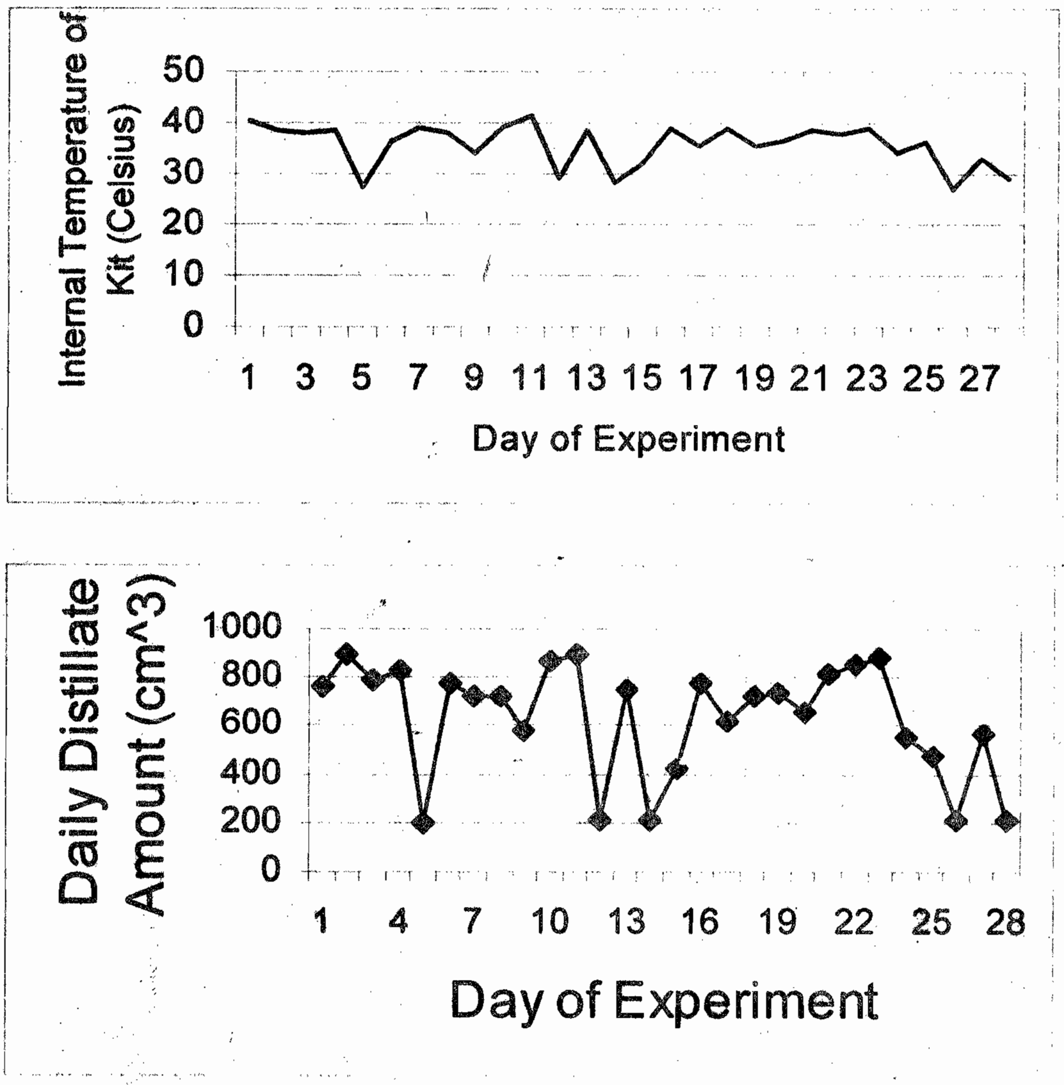

Fig 2: (a) Internal temperature in °C and (b) the total amount of distillate in cm^3 measured with the solar distillation kit for the experiment period (June 16 – 14 July 1998).

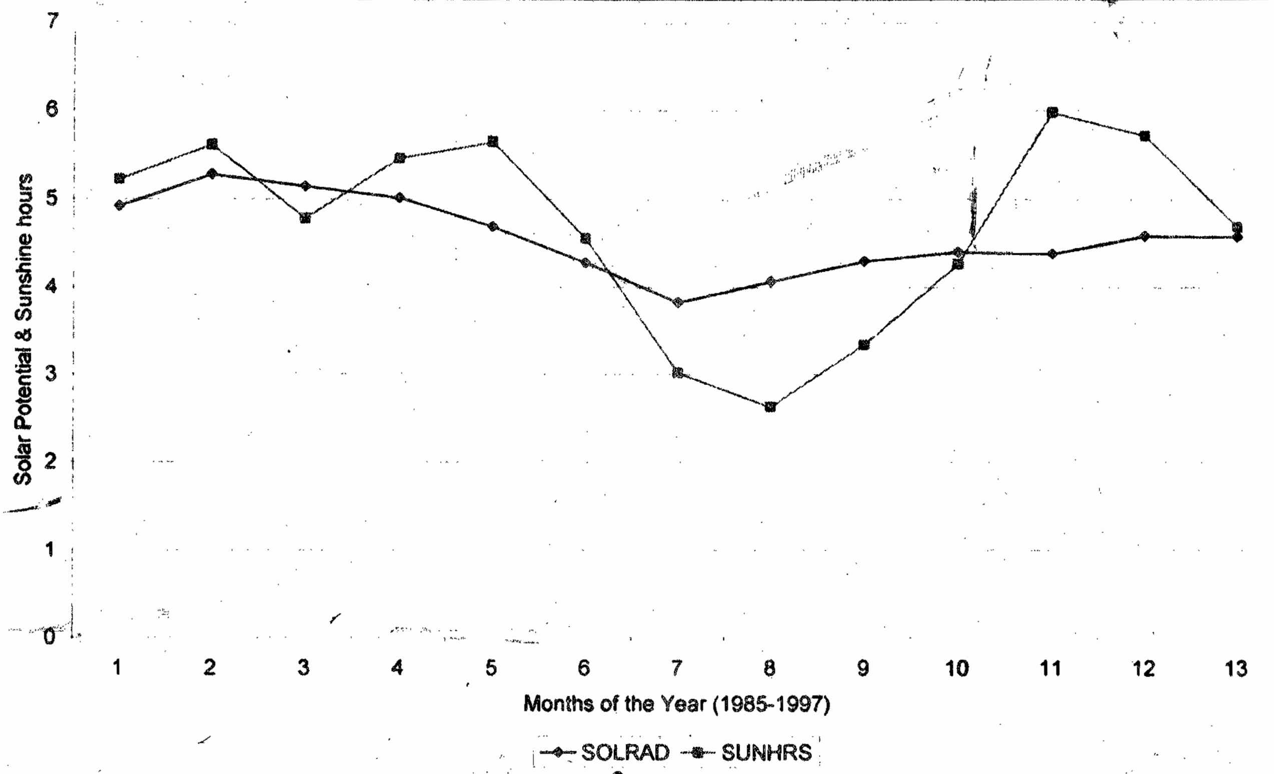

Fig 3: Long-term mean solar power potential (kWh^{-2} per day) and sunshine hours for 1985-1997 at Owerri.

The secondary schools, while using the money that would have been used to purchase distilled water to purchase more important books and equipment can in addition sell the distilled water to generate more revenue for the school or institution. The solar distillation kit has the prime advantage that is can be cheaply constructed from available local materials and also easily installed in the school by the technicians available in such institutions. The solar distillation kit requires almost no maintenance except ensuring that the dust on the transparent glass cover is cleaned from time to time for maximum performance. This id due to the fact that, dust can reflect/absorb part of the incoming solar radiation incident on the glass of the distillation kit. If adopted, the solar distillation kit will prove especially invaluable for Chemistry and Biology laboratories in Nigerian schools.

The photovoltaic modules can be introduced to supply clean electricity in the institutions of learning. Although the initial cost of installation may seem high, the solar system will last longer and pay back its worth within some years especially since it requires near zero maintenance. More importantly, the photovoltaic module for generating extra electricity especially in rural areas, will help to improve the living standards of students in such rural schools. Even in schools located in the urban areas, the photovoltaic systems can be used to power simple DC appliances in the laboratories, provide street lighting, illuminate reading rooms at night and powering television sets in the common rooms. Another advantage of supplying part of the electrical energy in the schools through photovoltaic energy is the obvious cushioning of the effects of poverty. This will be through a diversion of the funds that would have been used to "buy" such energy to other more needy areas in the school budget like equipping the library, running costs, etc. A one kilowatt PV system for example (Siemens, 1998)

- prevents150 lbs. of coal from being mined
- prevents 300 lbs. of CO_2 from entering the atmosphere
- keeps 105 gallons of water from being consumed
- keeps NO and SO_2 from being released into the environment.

THE EXAMPLE FROM SENEGAL

The 15-million-CFA (around 25,000-U.S.-dollar) project, which will provide electricity to a dozen educational institutions in rural areas, is funded by the UN Educational, Scientific and Cultural Organisation (UNESCO). Its main objective is to "strengthen education in rural areas through solar energy". According to the Senegalese Minister of National Education, Moustapha Sourang, "quality education cannot occur without electricity". It is the first school project between Senegal and UNESCO in renewable energy. The failure by the government to privatise the National Electricity Company of Senegal (SENELEC) has caused shortage of electricity in the country. But since July 2002, the project has bridged the energy gap, with the Manantali Dam providing an infusion of 60 megawatts of electricity per hour (MW/h). SENELEC produces, on average, 300 MW/h for an estimated energy demand of 270 MW/h. http://www.ips.org/

But because of frequent power outages during high-demand seasons, SENELEC had difficulty satisfying local demand. Thus, schools, as all other sectors of the national economy, suffered from lack of power. For example, every time there was a power outage, people using computers were automatically cut off from the Internet. But with solar power, as soon as the power gets cut-off, the solar panel kicks in and the computers are hardly affected. Also, the solar energy reduces electricity bill. Computers connected to solar energy will not need surge protectors because they will be hooked up to batteries, each of which lasts for four hours, and each of which acts as surge protector. In Senegal, where fewer than 25 percent of rural people have electricity, renewable solar energy can be a viable alternative. With nearly 3,000 hours of sunshine per year, Senegal can use solar energy in its educational system.

COMPARISON OF SOLAR DISTILLED WATER, PHOTOVOLTAIC ELECTRICITY WITH DIESEL/PETROL AND GRID CONNECTED ELECTRICITY

The distillation kit that was constructed at Imo State University Owerri cost five thousand Naira (₦ 5,000) and produced 11.2 liters of distilled water per month like the one constructed by Ozuomba (2007). This is equivalent to one thousand, six hundred and eighty Naira (₦ 1,680), with the implication that within three months, it can pay back its production cost. As compared with grid electricity or diesel/petrol generator for the purpose of producing distilled water, the cost of maintaining the solar distillation kit is minimal. With the hike in the tariffs by the Power Holding Company of Nigeria (PHCN) and that of petroleum products, officially, petrol at 75 Naira a litre and diesel 85 Naira, the SOLAR NOW option is the most viable alternative at providing affordable energy for the schools, especially in the rural areas. In the secondary schools, the solar distillation kit can be made smaller to cost say three thousand Naira which can be accommodated by most school budgets. The beauty of using the solar distillation kit in secondary schools is exposing staff and students to the practical aspects of energy generation and use, making them understand the practical principles of Physics and Chemistry.

Oparaku (2003) had shown that centralized PV systems are not cost effective taking into account the price of diesel, petrol and grid extension materials. However, solar home systems with power rating up to 300 Watts were determined to be cost effective (Oparaku, 2003). Strategies for the dissemination of solar home systems need to be explored so that electric power for lighting, television and radio entertainment can be made available to more than 50 million Nigerians that reside in the rural communities. This is especially attractive considering the modular nature of photovoltaic applications, its environmental benefits and the present government's commitment at alleviating the quality of life of the rural dwellers, most of whom are poor. Going for the diesel, petrol generator option or grid extension in order to provide energy in the schools is not cost effective. The life cycle cost (LCC) of the petrol generator option is 93 percent of its PV counterpart of 300 Watt capacity. Although grid extension option is in the range of 5-8.2 percent of their PV counterparts, in the short run, it needs to be pointed out the decentralized solar home systems for electricity generation are more cost-effective in the long-run (Oparaku, 2003). Chineke et al (2002) had presented a scenario that portrays a bright future for the SOLARNOW programme.

5. CONCLUSIONS

The much orchestrated 'electricity for all by the year 2000' has not been achieved even in the mega cities! Ensuring that most of the schools in the rural areas are linked to the national electricity grid may even remain elusive by the year 2025! The solar energy option for providing of laboratory distilled water and powering electrical appliances in the schools and illuminating reading rooms will help not only to protect our fragile environment but conserve the lean financial resources of the institution. Solar energy is a viable alternative to improving the energy supply in the school system. Its decentralized nature makes it even more attractive.

The solar distillation kit constructed in the Physics Laboratory of Imo State University Owerri performed creditably well when it was mounted and characterized in the peak of the wet season when cloudy days are common place. From Figure 3, we notice that temperatures of as high as 54°C were recorded with total distillate of up to 900cm^3 per day in some cases. The many clear advantages of supplying part of the electrical energy needs in institutions using Photovoltaic (PV) solar energy systems have been stressed. The obvious is that enough solar energy is available in many parts of Nigeria, which can be harnessed for use in the schools. It is advocated that school authorities, as a matter of urgency and financial prudence, immediately procure solar modules and associated accessories for immediate installation. This done, the present deplorable energy supply situation in the schools will be improved, especially in the rural areas where access to electrical energy supply is still a mirage.

The installation of solar panels could provide schools with new uses, such as nightly adult literacy classes and other educational, or sports, activities. Solar panels can also be hooked up to the Internet to break the isolation of remote villages, putting teachers in touch with the rest of the world. Often, " bush teachers" refuse to take up postings in rural areas, for lack of electricity. If less-endowed countries in Africa like Senegal are moving forward in the SOLAR NOW programme, Nigeria can do even much better. It is further recommended that school laboratories across the country go on immediately to construct and install of the cheap solar distillation kits for producing distilled water, which can be sold to local automotive electricians.

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REFERENCES

Agbaka, A. C., 1996. Solar Power and Applications. Cel-Bez Publishers, Owerri.

Chineke, T. C., 2002. A robust method of evaluating the solar energy potential of a data sparse site, The Physical Scientist, 1: 59-69.

Chineke, T. C., Achunine R.N. and Nwofor, O.K. 2002. The use of Solar Energy Options for cooking, food processing and house lighting. Webs-Media Communications, Owerri.

Malik, M. A. S., Tiwari G. N. and Sodha, M. S., 1982. Solar Distillation. Pergamon Press, Oxford.

Obidike, S. C., 1998. Solar Energy in two dimensions: thermal and photovoltaic system. BS Project, Imo State University, Owerri.

Ojosu, J. O., 1990. Data Bank; the Iso-radiation Map for Nigeria. *Solar and Wind Technology*, 7: 563-575.

Oparaku, O. U., 2002. Assessment of the cost-effectiveness of photovoltaic systems for telecommunications in Nigeria. Int. Jour. Solar Energy. 22 (3-4): 123-129.

Oparaku, O. U., 2003. Rural area power supply in Nigeria: A cost comparison of the photovoltaic, diesel/gasoline generator and grid utility options. Renewable Energy 28: 2089 - 2098.

Ozuomba J., 2007. Personal Communication

Sambo, A. S. and Bello, M., 1990. An experimental evaluation of collector units for thermosiphonic solar water heater. Nig Jour. Solar Energy 9: 223 - 238.

SIEMENS, Photovoltaics worldwide: Siemens Solar Products catalogue http://www.siemensolar.com

SIEMENS, Siemens Earthsafe Residential. http://www.siemensolar.com/Earthsafe/residential_systems

Van der Plas, R. J. and Hankins, M., 1998. Solar Electricity in Africa: a reality. Energy Policy 26: 295 -305.