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USE OF SOLAR ENERGY FOR THE PROVISION OF COST-EFFECTIVE AND ENVIRONMENTALLY FRIENDLY POWER SUPPLY IN HEALTH FACILITIES IN THE DEVELOPING WORLD- LESSONS FROM A COMMUNITY COTTAGE HOSPITAL IN SOUTHERN NIGERIA

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Abstract

Erratic public electric power supply has been a perennial problem in Nigeria since its creation by the British in 1914. It affects all sectors of the economy including the health sector with important dependence on fossil fuel driven generators as alternative or back up, with adverse consequences including emission of toxic gases, noise and high costs. Clean and renewable power sources have been recommended as viable and better alternatives.

In a Community Cottage Hospital in southern Nigeria, jointly run by Shell Petroleum Development Company and the Rivers State of Nigeria, solar power introduced in 2010 as alternative electricity supply system. From an average of sixteen hours of power supply a day, a twenty-four electricity power supply a day was achieved since then with a continuing reduction in dependence in fossil fuel. Cost of power was also reduced from 300- 1500 to 180-500 a month. Patronage of the facility by the public has also increased since the installations.

Solar energy systems are easy to install, operate and maintain by small and medium size institutions. With abundant sunlight all year round, this model is recommended for supply of electric power and solar pumps for hospitals, households and similar institutions in Nigeria and the environments.

Introduction

Inadequate electricity power supply has been a perennial problem in Nigeria from the amalgamation of the northern and southern protectorates into the Nigerian entity in 1914 till date.[1] Power outages for several days is common.[2] Thus power supply in the country is unpredictable and affects all sectors of socio-economic life.[3] The health sector and health services delivery are not spared. For instance, erratic electric power supply has been identified as a major impediment to adequate immunization coverage in Nigeria.[4] It is common, but unfortunately undocumented, knowledge that mortalities do occur in several Nigerian health facilities due to interruption of electric power supply to basic lifesaving equipment as airway suction machines and oxygen delivery systems.

Consequent upon insufficient and inefficient power supply in the country, Nigeria has become a "generator economy" depending on fossil driven power generators at huge cost implications, environmental and health consequences.[5] It has been estimated that the cost of generating power constitute about 36 percent of industrial production costs in Nigeria.[1] The health sector could not be spared this huge energy costs. In addition, a study in the city of Lagos has demonstrated very high levels of pollutants such as carbon monoxide, sulphur dioxide, nitrous oxide and suspended particulate matter from diesel powered generator fumes far exceeding the Federal Environmental Protection Agency standards on ambient air concentration of these pollutants, even in residential areas (which usually host health facilities in Nigeria)[6]

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Strong recommendations have therefore been made for migration to the use of renewable, cost effective and environmentally friendly sources of energy such as solar and wind energy in Nigeria.[6,7] This paper describes efforts at a Community Cottage Hospital in southern Nigeria to achieve electric energy sufficiency through the use of solar energy and reduction of costs so achieved. It is hoped that this could as a model for similar institutions in Nigeria and the African region.

Materials and Methods

The work is based on experience in electric power supply at the Obio Cottage Hospital, a Community Health Facility in the Obio/Akpor Local Government Area (LGA) of Rivers State in southern Nigeria. OCH was started in 1978 as a Primary Health Centre mainly for the inhabitants of Obio/Akpor LGA. In 2008, Shell Petroleum and Development Company (SPDC) went into partnership with the Rivers State Government, rehabilitated and upgraded the facility, converting the 4-bed Health Centre operating in a twin bungalow with thirteen staff to a 56-bed Cottage Hospital in four blocks of buildings (Block 1-4) with a staff strength of 168 including 13 doctors and 58 nurses. It has an Out-Patient Department, Obstetrics and Gynaecology Department with ante-natal care services, delivery services taking more than three hundred deliveries a month, and an Obstetrics theatre. It also has a children's ward. In 2016, a small secondary level neonatal unit was established. Annually, the SPDC engages an Obstetrician and a Pediatrician on Sabbatical appointment to provide technical assistance to the hospital. In 2010, a Community Health Insurance Scheme (CHIS) was introduced, which markedly increased patronage of the facility. This has been described elsewhere.[8]

In 2010, solar power was introduced to the facility. A 17.4KVA solar power system was installed. Following the introduction of CHIS and subsequent anticipated increase in patronage, an upgrade of solar power system led to the installation of additional 19.8KVA. All departments in the hospital (including the staff quarters) were connected to solar power system. Tables I & II show how the first solar power was distributed.

Table I: First Solar Power System Installation (Cost of Installation: US$154,000 & N6, 100,000)

	Block 1	Block 2	Block 3	Block 4	Residential area
Inverter	1No. 6KVA Xantrex	1No. 6KVA Xantrex	1No. 2.4KVA Xantrex	1No. 1.5KVA Xantrex	1No. 1.5KVA Xantrex
Batteries	20Nos. Fullriver 210 AH AGM	16Nos. Fullriver 210 AH AGM	16Nos. Fullriver 210 AH AGM	6Nos. Fullriver 210 AH AGM	6Nos. Fullriver 210 AH AGM
PV Panels	24Nos. 200W Evergreen	20Nos. 200W Evergreen	20Nos. 200W Evergreen	12Nos. 200W Evergreen	8Nos. 200W Evergreen
Solar Fridge	Freezer, SunDanzer, 12V DC	Fridge, SunDanzer, 12V DC	-	-	-

Table II: Additional 19.8KVA solar power (Cost of Installation: US$158,041 & 7,933,730)

	Consulting Room	Immunization	Pharmacy	Restaurant & Gate house	New building (Surgery)
Inverter	1No. Xantrex 6KVA XW6048	1No. Xantrex 2.4KVA TR 2424E	1No.Xantrex 2.4KVA TR 2424E	1No. Xantrex 3KVA TR 2424E	2Nos. Xantrex 6KVA XW6048
Inverter	-	-	-	-	1No. Outback 3KVA
Batteries	12Nos. Fullerriver 210AH AGM	6Nos. Fullerriver 210AH AGM	6Nos. Fullerriver 210AH AGM	6Nos. Fullerriver 210AH AGM	44Nos. Fullerriver 210AH AGM

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PV Panels	12Nos. Sun 200W 24V DC	6Nos. Sun 200W 24V DC	6Nos. Sun 200W 24V DC	6Nos. Sun 200W 24V DC	48Nos. Sun 200W 24V DC
SolarFridge	-	SunDanzerfridge, 12V DC	-	-	-
Solar water pump	All units				

Thus, all the four blocks, refrigerating system for vaccines and drugs, equipment in the New-Born Unit including infant incubators, suction machines, and oxygen concentrators were provided with solar energy back-up. Solar water pump, installed in the second face (table ii) to ensure regular water supply in all the units.

Results

Before the introduction of the Green energy, very limited electrical appliances were used at OCH. These included few lighting points, fans, refrigerator, 2KWA autoclave, ten air conditioners and ten functional beds. The unit cost for power varied from less than a dollar $0.9 with a fixed charge of less than $80 per annum. Public power was only available for 10 hours per day and a 20KVA generating set could only be fueled to support power supply for additional six hours daily. This meant running the facility for eight hours daily without power (Fig. I). Energy consumption was estimated to be less than 150kWh per month (1,800kWh/ annum) which was insufficient for optimal operations.

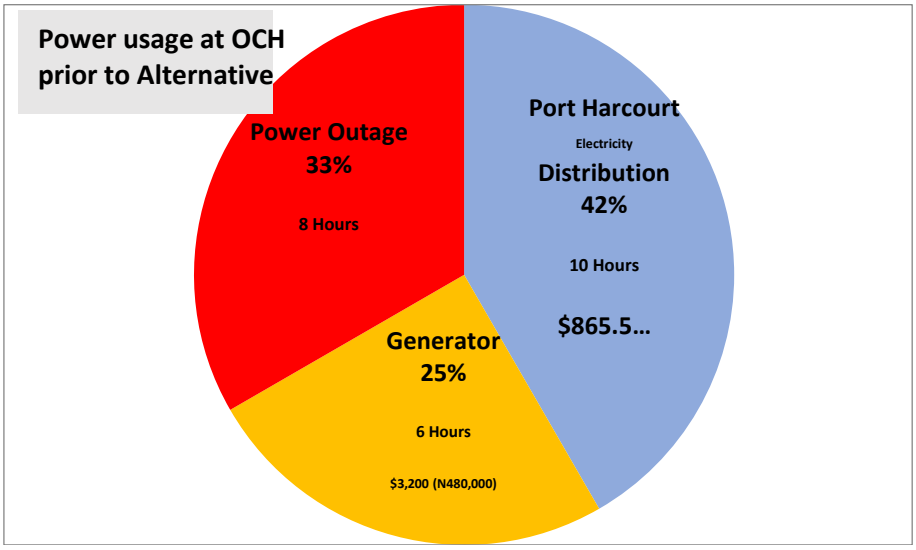

Figure I: Power Usage at OCH prior to Alternative Source

With the introduction of the green energy in 2011, energy consumption level increased and the facility had uninterrupted power supply (24 hours a day, 7 days a week). Electrical consumption increased with the use of hospital specific equipment including more lighting points, fans, refrigerators and laundry machines; 55 air conditions, ultrasound scan machine, four infant incubators and 25KVA autoclave.

The cost of energy consumed, rather than increase with the increase in consumption reduced significantly due to use of green energy. Despite the varying tariff for unit cost of public energy including maintenance cost for generator and solar, the average cost of energy still remained low as seen in figure 2.

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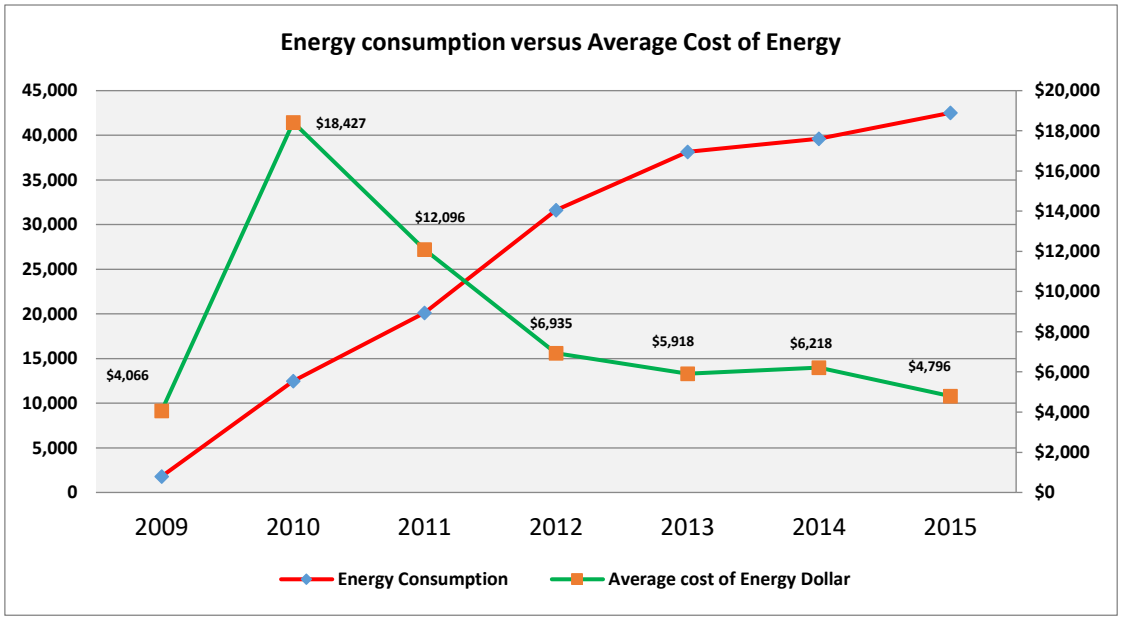
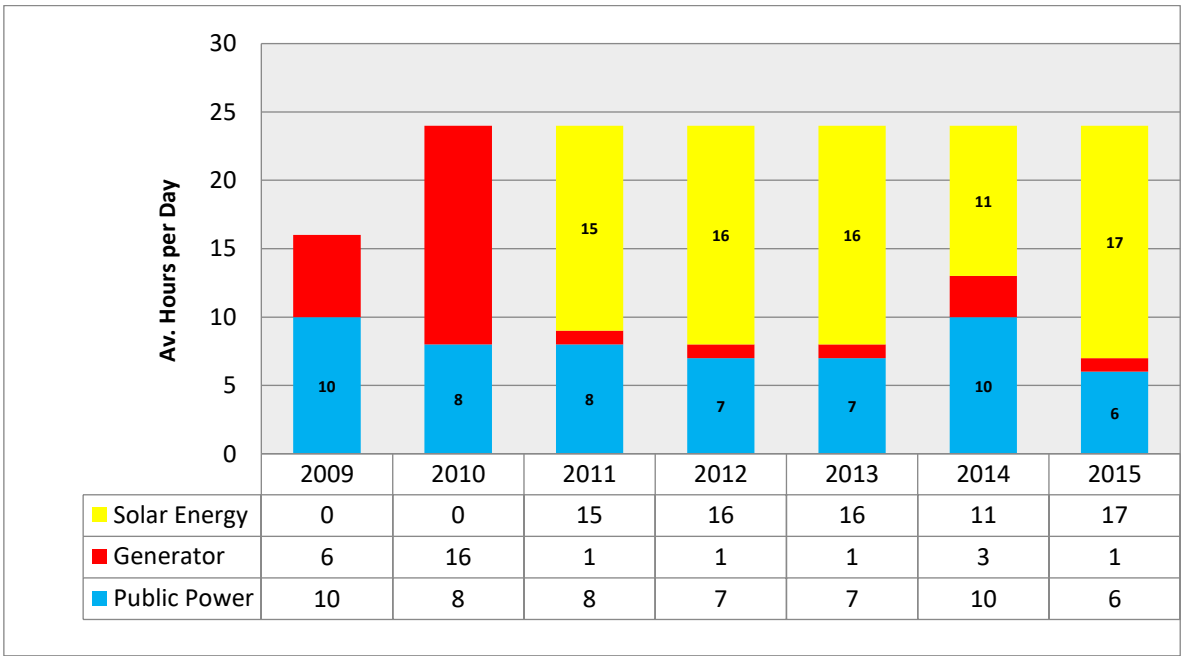


Figure 2 Energy Consumption versus Average cost of Energy after introduction of Solar Energy

The Green energy initiative reduced cost of power from an average of $300 - $1500/month to $180 – $500/month, excluding set-up costs. A net decrease in cost by 53% was connected to the dropped in generator diesel by 50%. The average annual savings after solar installation was almost equal to the cost of power with green energy.

Theinconsistency in public power supply of not more than 10 hours per day and high running cost of generator has intensified reliability on Green energy as a more sustainable source of energy in this resource limited setting Fig. 3.



	2009	2010	2011	2012	2013	2014	2015
Solar Energy	0	0	15	16	16	11	17
Generator	6	16	1	1	1	3	1
Public Power	10	8	8	7	7	10	6

Figure 3: Source of Energy and Number of Hours Supplied

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Discussion

Erratic power supply at power outages adversely affects all sectors of the Nigerian economy.[3] Excessive dependence of electric power generators as alternative or supplement to public power supply in Nigeria has many adverse implications including effects on air quality,[6] noise and high costs.[3] It also yields itself to pilfering of fossil fuel.

A mixed supply of energy with more emphasis on renewable and clean energy.[7]The experience of Obio Cottage Hospital demonstrates the effectiveness of this recommendation. With the introduction and increased use of solar energy in the facility, a twenty-four hour a day supply of electric power was achieved. This is a rare feat in a Nigerian health facility and demonstrates, in addition to other things, the strength of public-private partnership, health care delivery- in this case, the government of Rivers State of Nigeria and Shell Petroleum and Development Company (SPDC).

Nigeria has abundant sunlight all year round and increasing dependence on this clean and renewable source of energy should be the direction the country should go. Apart from other benefits, it is highly cost effective.[3]The initial costs of installing the solar facilities in OCH were recovered within a year of operation. These facilities are easy to install, operate and maintain by medium and small size institutions in Nigeria.

Additional benefits of installation of solar energy facilities at OCH included increased public confidence in the facility, evidenced rapidly by increased patronage of the facility in the period since installations.[11] Regular power supply certainly contributed to this increased confidence and utilization of OCH by the public. Water demand in hospital environment is extremely high. The solar system can also ensure keeping borehole pumps active ensuring maximum daily water supply all year round.[12, 13] This has also been demonstrated with the use of the solar water pump.

Conclusion

Power supply is chronically insufficient and erratic in Nigeria. This adversely affects regularity and quality of services in Nigerian institutions, including hospitals. Steady, clean and renewable energy sources have been recommended as part of the solutions to this problem and mitigate environmental degradation. The installation of solar energy appliances at Obio Cottage Hospital, Rivers State, Nigeria has demonstrated the effectiveness of this modality of energy supply in the Nigerian situation and is recommended as a model for similar institutions in the country and beyond.

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