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COMPUTATION AND ANALYSIS OF ELECTRICAL LOADS FOR THE APPLICATION OF SOLAR PV POWER SYSTEM IN MATERNAL AND NEONATAL HOSPITAL MINNA.

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ABSTRACT

This study focuses on load assessment and analysis of a solar energy system for Maternal and Neonatal Hospital Minna, Niger State. The aim is to compute and analyse the electrical load of the hospital in readiness for solar PV application. The study involves the survey of the site through several visitation of the premises for some physical and structural features in the environment which form critical parameters or serve as guide to certain design considerations in the solar photovoltaic power system design for the hospital. The analyses of the equipment were done by considering the power wattage of each equipment and appliances according to the hours of their usage thereby ascertaining the energy consumption and demand. The result shows that energy consumption of the hospital is 301034.86 VA while the total energy demand of the hospital is 2602700VAh. It was obvious that certain medical equipment such as Neonatal incubator, Blood Bank Refrigerator, Autoclave machine, Patient monitor, Concentrator has high energy consumption due to their operating capacity and energy. Due to delicate medical services provided by these equipment, it is a matter of necessity to scout for sustainable alternative power supply that will guarantee power sufficiency through the application of solar PV for a reliable power delivery.

1. INTRODUCTION

The inconsistency in the public power system in the country has caused a lot of organizations to scout for other reliable and alternative source of power supply. Several organizations have not been able to sustain the use of generators due to the recent hike in fuel prize in the country.

Nigeria's poor power supply situation has not only resulted in the death of industries but also contributed to the high mortality rate. This has negatively impacted the operations of hospitals and medical facilities (Nnodim, 2023).

The inability of the public power organization to provide uninterrupted power supply is frustrating the effort of the hospital as an organization that provides a very sensitive and special medical services to mothers and infants in the state. The effectiveness of the services provided by the hospital can only be augmented by the availability of reliable power supply system. Most of the medical equipment and facilities in the hospital are operated electrically hence the consistency in the power supply to the hospital cannot be undermined. The uniqueness of the services provided is very crucial to the society in ensuring the survival of maternal and neonatal related matters as such the provision of a reliable and efficient power supply system eminent.

Renewable energy such as sun and wind are reliable and efficient alternative sources of power supply. The biggest source of renewable energy known to man on earth is the sun. Solar energy is the most promising and green energy sources to satisfy the energy demands of growing economies (Zhao *et al.*, 2022)
Solar energy is the most promising and green energy sources to fulfill the energy demands of growing economies (Krishna., et al., 2021). Renewable source of energy is a form of energy from a source that does not get use up in supply when used. Renewable energy could be generally defined as a form of energy which is collected from available resources that are replenishable on the timescale of humanity, which include sunlight (solar), tides, wind, rain, geothermal heat, and waves (Belu, 2019). These are the

energy sources that can be readily produced, regenerated or replenished rapidly through natural processes. Their availability is not affected by their consumption rate, hence cannot get exhausted in the nearest future. Though most of these renewable resources could be depleted via human indiscriminate consumption, but they can also be replenished thereby maintaining a steady flow. Renewable energy is said to provide energy in some important areas such as water heating/cooling, air and transportation, electricity generation, and rural (off-grid) energy service, Eustache et al (2019).

Renewable energy has been one of the recent approach to addressing the menace of inconsistency in power supply. The abundant availability of sunlight in this part of the country (Niger state) is an added advantage in considering adoption of alternative and reliable source of power supply. The availability of natural and inexhaustible source of solar energy will go a long way in addressing this menace. The solar energy is one of the types of renewable energy that is widely used recently and it is considered to be one of the harmless sources of energy that is environmentally friendly.

Niger State is one of the states with high potentials for solar energy applications and Chachanga Local Government was described as one of the most suitable potential sites for such exploitation (Ezenwora *et al.*, 2023). Jummai Babangida Aliyu Maternal and Neonatal Hospital is located in Chanchaga L.G.A. Hence the application of solar photovoltaic energy technology for the hospital.

2. METHODOLOGY

2.1 Site Survey and Information

The premises of the hospital was visited severally for some physical and structural features in the environment which form critical parameters or serve as guide to certain design considerations in the solar photovoltaic power system design for the hospital.

In the course of visitation, the equipment and the appliances that are very essential for medical activities and services in the hospital was accessed along the head of the maintenance officer. The operating power capacity of the equipment and the appliances was taken as aided by the documents provided and physical accessibility too.

2.2 Load Assessment

The electrical loads (equipment and the appliances) to be powered in the hospital will be assessed by extracting their power ratings and other details such as duration of use (in hours), time of use (morning, afternoon or evening) and frequency of use (once, twice or trice in a week). These information will be obtained through engagement with the hospital officials and used to compute the load analysis worksheet.

The worksheet comprise of columns for equipment/appliances, operating power capacity, quantity, total operating power capacity, power factor, apparent power, total apparent power, hours of usage and the energy demand. Table 2.1 is the worksheet for the load assessment and analysis.

Table 2.1: Table of Load Assessment

Equipment/Appliances	Operating Power Capacity (W)	Quantity	Total Operating Power Capacity (W)	Power Factor	Apparent Power (VA)	Total Apparent Power (VA)	Hours of Usage	E = Ivt

Table 2.2: Load Computation

Table 2.2 shows different equipment and appliances whose loads were computed according to the label specifications on each of the equipment and appliances for further analysis.

Equipment	Operating Power Capacity In W/HP		Quantity	
	A	B	A	B
AIR CONDITIONER	1.5 HP	2 HP	82	2
FAN	75 W		274	
INCUBATOR	500 W		13	
CONCENTRATOR	2HP		3	
SUNCTION	1 HP		11	
PATIENT MONITOR	0.5 HP		10	
BULBS	10 W	15 W	2267	44
WATER HEATER	2KW		34	
STERILIZER	12.5 KW		1	
AUTOCLAVE MACHINE	18 KW	2KW	1	6
OPERATING LAMP	150 W		6	
RADIANT WARMER	2 KW		1	
PHOTOTHERAPY MACHINE	500 W		6	
BLOOD BANK	1.5 HP		3	
SCANNING MACHINES	0.5 HP		3	
SUBMASSIVE PUMP	1.5 HP	2HP	2	1
REFRIGERATOR	1 HP		51	
WASHING MACHING	1.5 HP	2 HP	2	2

3. RESULTS AND DISCUSSION

3.1 Survey Result

Jummai Babangida Aliyu Maternal and Neonatal Hospital Minna Niger State is located at No. 2 hospital road with latitude 9^0 37'' N and longitude 6^0 31'' E and has annual sum of global irradiation 0f 2036 kWh/m^2 with annual average temperature of 27.9^o C. The hospital is segmented into five blocks and other units, namely.

Block A: The Antenatal Clinic, Pharmacy and Amenity Ward

Block B: The Gynae Emergency, Antenatal Ward and Gynae Clinic/ward

Block C: The Delivery Unit, Neonatology, and Maternal ICU

Block D: The Laboratory and Administrative block

Block E: The Operating Theatre

The presence and location of trees and other high rise structures that may serve as shade on solar panels, nature of roof plan, roof space and their slope, tilt angle, type of rafter, whether wooden or metal rafter and their orientation. Others are available spaces inside and outside the buildings to be used as battery bank and solar array. Some of these was arrived at through engagement with the users of the facility. The total area of the roof top of the five blocks is 2,862 m^2.

The terrain of the site is quite perfect for utilization of solar PV installation as there are trees or other possible obstructions that may cause artificial shading. The roof orientation is also convenient as required. The total area of the roof top can accommodate much panels as possible.

Figure 1 is the aerial view of the hospital, it captures the entire block of the hospital, ranging from block A to block E, while Figure 2 is the top view of the hospital showing the details of the roof space.

Figure 1: Aerial View of the hospital

Figure 2: Top view of the hospital

Figure 3: Patient Monitor

Figure 4: Radiant Warmer

Figure 5: Concentrator

Figure 6: Blood Bank Refrigerator

Figure 7: Autoclave machine

Figure 8: Autoclave

Figure 9: Neonatal Incubator

3.2 Load Analysis

Table 3.1 contains detailed load assessment and analysis of the equipment and appliances used in the hospital.

Table 3.1: Load Analysis

Equipment/Appliances	Operating Power Capacity (W)	Quantity	Power Factor	Apparent Power (VA)	Total Apparent Power (VA)	Hours of Usage	E = Ivt (VAh)
A.C	745.1	84	0.85	876.59	73633.41	8	589067.3
FAN	75	274	0.7	107.14	29357.14	18	528428.6
NEONATAL INCUBATOR	500	13	0.98	510.20	6632.65	20	132653.1
CONCENTRATOR	1491.1	3	0.98	1521.53	4564.59	12	54775.1
SUNCTION	745.1	11	0.95	784.32	8627.47	6	51764.84
PATIENT MONITOR	372.85	10	1	372.85	3728.50	16	59656
BULB	10	2311	0.95	10.53	24326.32	12	291915.8
WATER HEATER	2000	34	1	2000.00	68000.00	6	408000
STERILIZER	12500	1	0.9	13888.89	13888.89	3	41666.67
AUTOCLAVE MACHINE	18000	1	0.9	20000.00	20000.00	3	60000
OPERATING LAMP	300	3	0.9	333.33	1000.00	12	12000
RADIANT WARMER	2000	1	0.9	2222.22	2222.22	6	13333.33
PHOTOTHERAPY MACHINE	400	3	0.8	500.00	1500.00	8	12000
BLOOD BANK	490	2	0.65	753.85	1507.69	25	37692.31
SCANNING MACHINE	3000	3	0.9	3333.33	10000.00	6	60000
SUBMERSIBLE PUMP	2235	3	0.7	3192.86	9578.57	12	114942.9
REFRIGERATOR	350	51	0.85	411.76	21000.00	6	126000
WASHING MACHINE	450	3	0.92	489.13	1467.39	6	8804.348
					301034.86		**2602700**

Table 3.1 contains the details of the equipment and appliances, the operating power capacity, Quantity and other important factors for load analysis. The energy consumption is 301034.86 VA while the energy demand is 2602700 VAh considering the hours of usage by individual equipment and appliances.

Figure 10 presents graphical representation of the equipment and hours of usage in the hospital

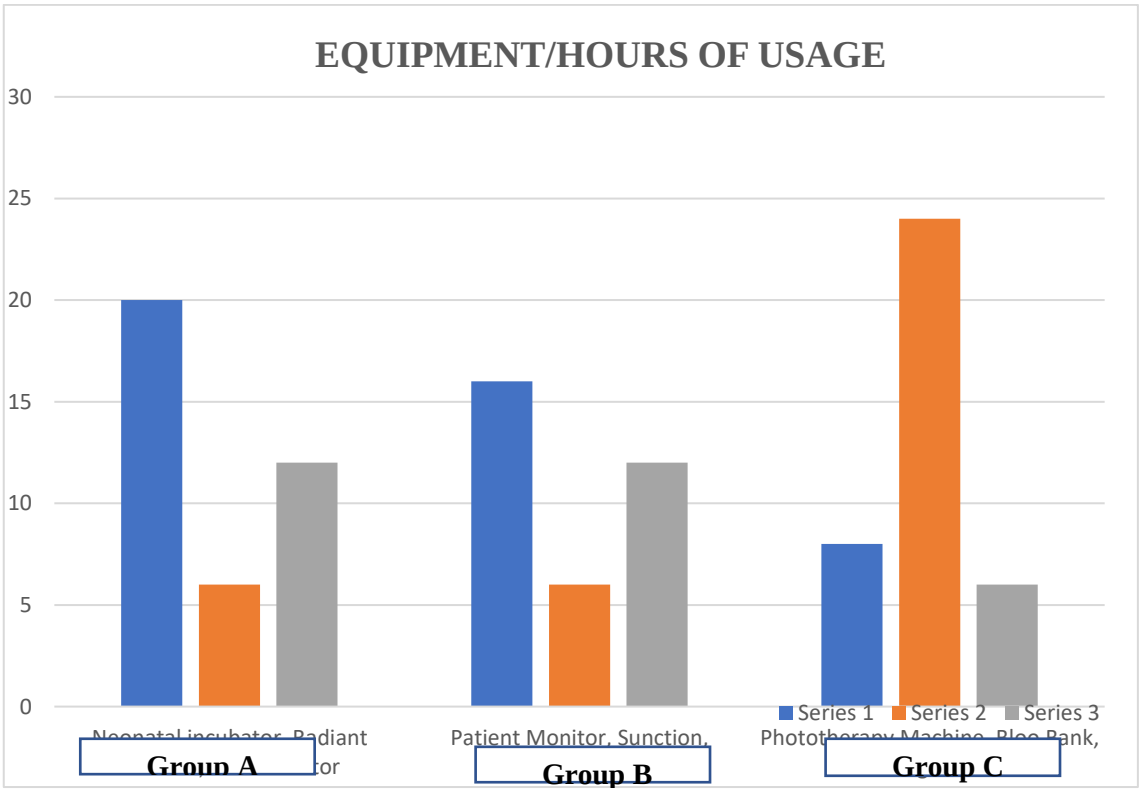

Figure 10: Graphical Representation of the equipment and hours of usage

Figure 10 is the graphical representation of the load assessment and analysis done for the medical equipment and the appliances used in the hospital.

Group A is made up of Neonatal incubator which runs on power supply for at least twenty hours daily, a Radiant warmer that runs for six hours and concentrator that runs for twelve hours daily. Group B contains Patient monitor that runs for about sixteen hours daily, a sunction machine that runs for six hours and Operating lamp that requires availability of power not less than 12 hours per day.Group C contains a phototherapy machine, a blood bank refrigerator that must consistently be on a power supply and a scanning machine that is expected to runs for at least six hours daily, Figure 11 show graphical representation of the appliances and hours of usage in the hospital

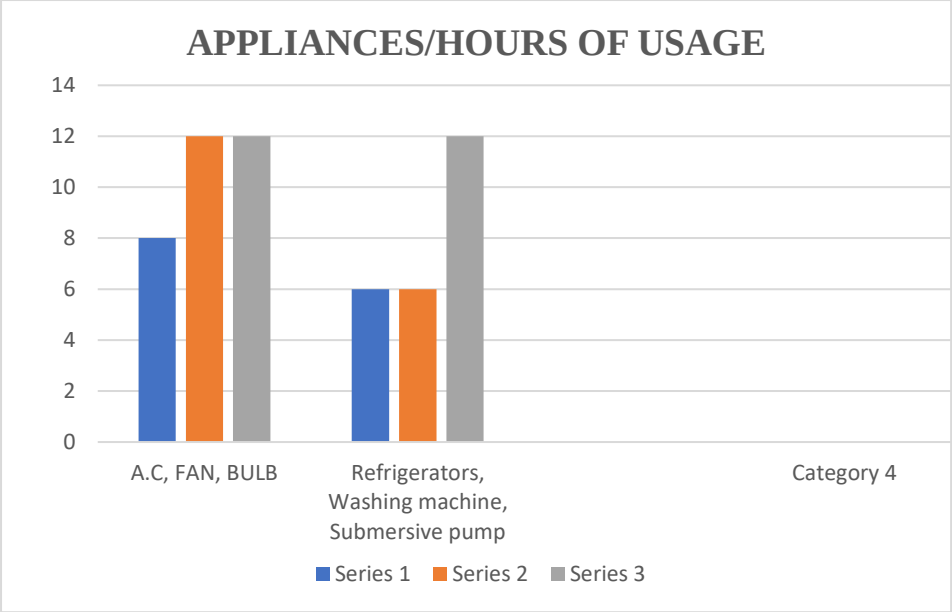

Figure 11**:** Graphical Representation of the appliances and hours of usage

Figure 11 is made up of some appliances that are also very important, the Air conditioner operates for about eight hours daily, the fans run for at least eighteen hours daily and the bulbs are powered for about twelve hours daily. The refrigerator and washing machine operates for at least six hours every day and submersible pump work for twelve hours daily. Therefore, the total energy consumption of the equipment and appliances determines energy demand with some allowances for further additional installation of equipment and appliances. The allowance for additional installations is determined by the type of model chosen for the design and installation.

4. CONCLUSION

The energy demand of every proposed project is determined by the energy consumption. The more the energy consumption, the higher the energy demand and cost of implementation. The energy consumption of the hospital is 301034.86 VA, while the total energy demand of the hospital is 2602700VAh. The equipment and the appliances does not have the same energy consumption, hence different energy demand for different equipment. The consumption of energy by equipment and appliances is dependent on the type of services offered by the equipment. Some of the equipment require twenty-four-hour power supply to provide the needed service. The delicate medical services provided by the hospital prompted this research work that is capable of aiding further actions for designing and implementing Solar PV energy for the hospital as alternative and sustainable power supply.

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