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Installation of Solar Carport for the Provision of Car Shade and Lighting of Staff Quarter in Admiralty University of Nigeria (ADUN), Delta State

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Abstract: A study of a 3.5kW solar carport for the provision of car shade and lighting of staff quarter in the Admiralty University of Nigeria, Delta State has been conducted. The energy audit of the staff quarter showed that 120kWh of energy is consumed for the lighting of staff quarter. This study includes the efficient lighting of the staff quarter and the provision of a carport for the university. Energy-saving lamps (LEDs) are used to reduce the staff quarter's lighting energy consumption from 120kWh to 51.4kWh. Cars exposed to the atmosphere without shade are prone to atmospheric, thermal, and oxidative degradations as well as degradation caused by ultraviolet radiation (UV). The adverse condition that the cars are exposed to, at different seasons of the year will reduce the life span of the cars. The calculated average cost for the installation of 3.5kW solar photovoltaic car park for Life Cycle Cost (LCC) of 7 years is eleven thousand and eighty eight dollars ($11,088:00) while the LCC of operating 3.5 kW (4.38KVA) is fourteen thousand three hundred and thirty six dollars, ten cents ($14,336.10) excluding the cost of atmospheric degradation of the environment by SO_x, NO_x, CO_2, CO emissions and also noise pollution from the generator.

Keywords: Solar Car Park, Energy Efficiency, LED, Staff Quarter, Degradation

1. Introduction

Conventional carports provide cars with shelter and protection from atmospheric degradation. Unlike normal carports, solar carports will in addition, generate power. It is a sure way to save on electricity bills. Nowadays, carports are evolving from the conventional mechanical car parking systems to even more sophisticated car parks. The design and construction of solar carports will contribute to emissions reduction, prolonged lifespan of vehicles and reduction of electricity bills. Solar PV facility provides clean energy which is noiseless, modular and extendable with very minimal operating cost which makes it very dependable.

The earliest garages were enclosed buildings because cars could not endure harsh weather conditions as they had open tops, leather seats and were remarkably sensitive. Therefore, they had to be parked inside where they are safe from the unfavourable weather conditions. The facades of the carports were decorated with architectural beautifications. Solar Power Systems are a cost-effective power source for remote located solar powered facilities [1]. Sonera and Naps have together developed a system that operates autonomously and even during the harshest winter weather conditions in the arctic areas. Powering facilities in areas without access to national grids is a challenge for operators because of the high cost or difficulty of providing mains electrical power. Alfred Colby [2], opined that Motorola's green-powered BTS, part of the company's GSM portofolio, can replace or reduce the load on mains power and can also remove the need for power generators that require continual re-fueling and security. By incorporating renewable energy (PV) solutions into communication networks, Motorola is trialling this solution as a feasible option for operators instead of utilizing costly fuel generators or waiting long periods for a mass grid connection. Renewable energy such as PV is expected to have large potential as an alternative energy resource without constraint on energy supply or greenhouse gas emissions such as CO_2 [3]. Once installed, the cost of the solar facility requires minimal maintenance unlike a diesel driven generator which generally requires visits for refueling [4]. This translates into added savings in operating expenditure (OPEX), a key factor to emerging market network operators.

Nigeria is a nation beleaguered by unreliable power access that has impacted the standard of living of its population and reduced economic development [5]. Lack of reliable electricity in Nigeria and sub-Saharan Africa has driven the need for self-generation and consumption of electricity. The predominant means for self-generation has been the use of diesel generators which present both a health and environmental risk [6]. Given the abundance of the natural resource of solar radiation in this part of the world, solar photo-voltaic (PV) systems offer a cleaner viable solution for individuals and businesses alike, where they can be used for primary and backup power generation instead of fuel-powered generators [7].

1.1. Background

According to a study conducted by the San Jose University, the temperature inside a closed car with a basic gray interior can rise up to 62°C in an hour when it's 38°C outside. This sort of heat can cause serious damage to interior resulting in a cracked dashboard and decaying seat covers. The UV rays emitted from the sun have a shorter wavelength making them invisible to the human eye but they degrade the exterior of the car by tarnishing the paint [8, 9]. Battery is yet another component that can easily get damaged in the summers as it is powered by water and acid. The excessive exposure to heat can evaporate the water leaving lead plates exposed. This weakens the battery even faster and by the time weather cools down, it would no longer have the amperage required to start the car. The exposure of engine by leaving car under the sun in higher temperatures makes the engine run out of important fluids and lubricants quicker than in winters. This could lead to engine seizures and other severe engine problems. Changing the engine oil at regular intervals and frequently checking water levels in your radiator during the summers can save a lot of trouble.

High temperatures can dry out the rubbers in the tyres and make them weaker. The direct sunlight exposure for a prolonged period causes ozone cracks on the sidewalls and tread area of the tyres which can lead to dangerous incidents such as a blowout. Furthermore, the heat can increase the tyre pressure causing irregular wear on the tread area causing noise and vibration which results into an uncomfortable driving experience. The most practical and effective way to protect car from sun damage is to park it under the shade which not only helps in keeping it cooler, but a physical barrier that also blocks out 100% of the UV rays.

1.2. Motivation of Study

The problem of solar radiation and degradation of car exposed to sun is known. Therefore, the need for an environmental friendly source of power that can power carport and save car from harsh environment and provision of electricity.

1.3. Problem Statement

Due to consistent high temperature attributed to strong solar irradiation experienced by vehicles parked in an unshaded area, it is therefore essential to design a solar carport that provides cover for vehicles during unfavourable weather, thereby reducing the heat island effect; and also prevent warping and cracked interiors [10].

1.4. Objectives of the Project

The main aim of this project is to design and construct a solar carport where cars can be parked and electricity is generated.

The project design also protects the vehicle from unfavourable weather condition such as excessive heat and rain by providing cover.

1.5. Justification

It has been investigated by Badewole, A. [11], that the use of a solar carport protects the vehicle and prevent cities from heat island effect thereby channeling the sun's power for electricity generation.

1.6. Significance of the Project

The significance of this project is to develop a solar car park that improves energy yield performance, weather protected, visible expression of sustainability and the support of renewable energy solutions, implementation of power supply sources for the surroundings around the car park, through the use of an environmental friendly system and also improving the aesthetics of the park and the university.

2. Literature Review

2.1. Solar Irradiation in Nigeria

This section reviews the amount of electromagnetic incident on a surface area per unit time. Nigeria is located in Western Africa and the country is endowed with significant renewable solar energy resources [6] and, this is largely due to the fact that the country lies within a high sunshine belt and solar radiation is fairly well distributed across its cities [12]. One of the most viable options needed to reduce the energy crisis in Nigeria is through the utilization of the abundant solar energy falling on her surface [13]. The knowledge of solar energy radiation is very vital for the optimal design and performance of any Solar Energy Conversion (SEC) systems for heating and electricity generation [13]. According to Falayi, E. O. [14], solar radiation reaching the earth's surface depends on the climatic conditions of a particular location and this is thus vital towards the prediction and design of SEC's. Augustine and Nnabuchi [15], mentioned that the best solar radiation information is that obtained from experimental measurements of the direct and diffuse components of the solar insolation at the particular location.

Solar radiation represents the largest energy flow entering the terrestrial ecosystem. After reflection and absorption in the atmosphere, some 100,000 TW usually hit the surface of the earth and undergo conversion to all forms of energy used by humans, with the exception of nuclear, geothermal and tidal energy. This resource is enormous and corresponds to almost 6,000 folds, the current global consumption of primary energy which is 13.37TW. Thus, solar energy has the potential of becoming a major component of a sustainable energy portfolio, with very limited greenhouse gas emission.

Nigeria receives an average solar radiation of about 25.2MJ/m^2 per day in the far north and about 12.6MJ/m^2 per day in the costal latitudes. The average sunshine hours are estimated at 8 hours per day. Many researchers have done a lot of work in reporting the estimation of global and diffused solar radiation in various parts of Nigeria employing various methods and techniques [9]. It was estimated that the solar radiation at Uturu, Abia State with latitude 5.33°N and longitude 6.03°N in October, 2007 using Hargreaves equation and the mean global solar ultra violet (UV) radiation was reported as 1.89±0.82 kWh [16].

Effective harnessing and utilization of the abundant solar radiation using solar energy technologies to augment energy supply from fossil fuel energy resource would enhance the availability of energy for socio-economic activities. So, with reference to Hill, R. [12], the location of the country lies within a high sunshine belt making it a favourable location for the construction of this project. Solar inverters convert direct current (DC) electricity which comes from solar panel to alternating current (AC). The amount of power from the solar panels is regulated by the charge controller to protect the battery from overcharging by solar energy panels. Solar batteries are known for their heat sealed finish and thus, vanishing any source of leakages. There is ample literature on solar off-grid applications mainly in rural areas [17, 18] and various literature on urban solar communities in the developed world [19] or hybrid system designs that consist of solar-PV and diesel generators [20].

2.2. Solar Carport

There have been various types and designs used for constructing a carport. The first type to be considered is the multi-storey carport. These are buildings designed for car parking where there are a number of floors on which parking takes place. It is commonly found at railway stations, airports, hospitals and in city centres. The second type to be considered is the modular car park, these are steel car parks that serve as a solution in the absence of sufficient space and can be expanded upwards. The development concept of traditionally building modular car parks is made by the modular assembling method of vertical and horizontal elements (column and beams) with a ceiling made of concrete and tarmac; more modular units can be built for parking in different sizes and shape. This solution makes possible the development of a parking structure even in cases of some particular constraints.

2.3. Acid Rain Damages Cars

Anything water-based that comes from the sky can be classified as acid rain. This includes dew, rain, and snow. Most, weather elements settle on cars, and can cause major problems when it comes to a vehicle's exterior. The acidity in the water can cause the paint and even the metal to weaken over time. Acid rain and the dry deposition of acidic particles contribute to the corrosion of metals (such as bronze) and the deterioration of paint and stone [21]. These effects seriously reduce the value to society of buildings, bridges, cultural objects (such as statues, monuments, and tombstones), and cars. Over the past two decades, there have been numerous reports of damage to automotive paints and other coatings. The reported damage typically occurs on horizontal surfaces and appears as irregularly shaped, permanently etched areas. The damage can best be detected under fluorescent lamps, can be most easily observed on dark colored vehicles, and appears to occur after evaporation of a moisture droplet. In addition, some evidence suggests damage occurs most frequently on freshly painted vehicles. Usually the damage is permanent; once it has occurred, the only solution is to repaint.

The general consensus within the auto industry is that the damage is caused by some form of environmental fallout. "Environmental fallout," a term widely used in the auto and coatings industries, refers to damage caused by air pollution (e.g., acid rain), decaying insects, bird droppings, pollen, and tree sap. The results of laboratory experiments and at least one field study have demonstrated that acid rain can scar automotive coatings. Furthermore, chemical analyses of the damaged areas of some exposed test panels showed elevated levels of sulfate, implicating acid rain.

3. Methodology of the Project

The project comprises of two parts which are as follows:

1) Construction of solar carport.
2) Installation of 3.5kW of Solar roof carport.

3.1. Design Specification/Parameters

The following specification and design parameters are used in this work;

1. 350W$_p$, 24V module used;
2. System voltage is 48V;
3. Sunshine Hour is 8 hrs/day;
4. Average radiation intensity is 600W/m^2 (Out of 1000W/m^2);
5. 200Ah, 12V Batteries @ 80% Depth of Discharge (DoD) used;
6. Days of Autonomy (DoA) are 3 days;
7. 15% Energy added to take care of losses; and

8. 40A, 48V rated Charge Controllers used;
9. Daily hourly use 9 hours.

3.2. Design Methodology

The design of the solar car park is simple, a structure with rooftop made of solar panels and a galvanised steel pipe supports, attached with a storage box for the DC/AC inverter and battery. A charger controller and cable, security light, indoor lights are included in the design. A polycrystalline solar module with power rating of 350W. The design is the same as a normal car park space with a slight space allowance which will accommodate six cars.. There is also a battery bank, the battery is used to save the energy that is produced by the solar panel in the day.

3.3. Construction Overview

The site chosen for the study is the staff quarter carport. It consist of six galvanized steel pipes to serve as support for the roof, twelve 350W photovoltaic modules which is going to be fixed on the roof and a eight 200Ah batteries will be used to store energy coming from the photovoltaic panels. Also, an inverter is going to be used to convert from DC to AC. A charge controller which is going to serve as circuit breaker to cut off power from the panel to the battery when the battery is fully charged. The system works in such a way that when there is sunlight during the day, the solar panel converts the light energy from the sun to electricity and stores it in the battery in form of DC power which is then later used in the absence of sun.

3.4. Photovoltaic Array Background

A Photovoltaic (PV) array will be the energy source used in this project. PV arrays essentially consist of a number of internal silicon based photovoltaic cells combined in series and in parallel, depending on the voltage or current requirements. These cells are used to convert solar energy into electricity. This occurs when the photovoltaic cells are exposed to solar energy causing the cells electrons to drift which, in turn, produces an electric current. This current varies with the size of individual cells and the light intensity.

3.5. Construction Work

The various procedures and materials to be used in the course of the construction work are listed below;

Materials for construction;

1) Galvanised Steel Pipes

The type of metal pipe to be used for this construction is a 3 inches galvanised steel pipe. The galvanised steel pipe will be divided into six different metal piece. The first three metal pipes are of the same length 2.88 m, while the other three are also of the same length 2.6m but are smaller than the first three pipes, the reason is due to the inclination angle to be obtained for the solar panel. The main reason for choosing galvanised steel pipe instead of any type of material is because it's high strength and corrosion resistance.

2) Metal Box

This metal box is to be constructed by welding steel plates using electrodes and the arc welding machine. The metal box is to be used for the safe keeping of the inverter and the batteries to be used alongside the solar panels. The reason for choosing steel plates is due to its high strength to withstand heavy load.

3) Wood for Roofing

Different sizes of dry woods will be purchased at the saw mill and be used for the roof work to be carried out after rigging the poles into the ground. The steel pipes serve as the support for the roofing work. The type of wood to be purchased are; 2x4m wood twelve pieces, the 2x3m wood and facing board.

4) Cement

This develops strong adhesive properties when mixed with water. One bag of cement is to be purchased, and mixed with sand and gravel for use when rigging the poles into the ground, the mixture will ensure the steel pipes stand firm in the ground when dry.

5) Sand and Gravel

The sand is to be used alongside the gravel and cement for the construction work. The type of sand to be used is the sharp sand, the gravel are small stone fragments for laying on the beds of construction works to ensure a strong foundation.

6) Electrical Components

The electrical components that will be used in the course of this project includes; wires, lamp holders, wire clips, 13 amps sockets and pallets. 100 m length of 1.5 mm wire will be used for the wiring of the construction work to provide lighting for the environment and the wire clips will be used to neatly hold the wires in place. The 13 amps socket and pallets are to be used to construct an extension box to be used for the charging of very few electrical appliances such as phone.

7) Solar panels

This is an array of connected solar modules and cells, it serves as the source of solar power by converting the sun's radiation to electricity and using it to generate current in D. C, and the D. C voltage is then converted to A. C by the inverter and stored in the battery.

Financial Analysis

The present-wort technique was used to arrive at the Life-cycle cost (LCC). The unit energy cost signifies the cost of unit energy produced by a power system throughout its life span, with all costs discounted to its present value. In this method, all future costs, namely: Maintenance, repair, fuel or energy, and the salvage value are utilized to obtain their present worth [3]. Mathematically, the unit energy cost is expressed as follows [22].

$$\text{UEC} = \frac{Life\ Cycle\ Cost\ (LCC)}{Life\ Span\ x\ Energy\ Generated\ per\ Year} \quad (1)$$

The Unit UEC is in $/kWh. The life cycle cost is the cost of both non-recurring (first cost) and recurring costs that occur over the life cycle of the system, with all future sums converted to their present values. For a non-recurring fixed sum of money 'A' in the future, its present value PV is obtained by

$$PV = A \text{ X discount factor (dF)} \quad (2)$$

$$\text{Where } dF = 1/(1+dr)^n \quad (3)$$

And n = No of years into the future

dr = Discount rate which takes into account long term interest and inflation rates.

The discount rate is expressed as (Harvey, 1993)

$$dr = \frac{i-f}{i+f} \quad (4)$$

where i = interest rate and f = inflation rate

For an annual sum 'B' or annuity, the discount factor utilized was as follows [23].

$$dFb = \frac{(1+dr)^n - 1}{[dr\ (1+dr)^n]} \quad (5)$$

Thus, the present value of an annuity B was calculated as:

$$PV_b = B\ x\ dF_b \quad (6)$$

The following assumptions were made for the purpose of this study:

Assumptions
Load = 3.5kVA
Sunshine hours = 8hrs/day
Solar system operating voltage = 48V dc
Interest rate= 19%
Inflation rate = 12% – 13%
Systems life span= 20yrs
Losses between load and solar modules= 15%
Battery depth of discharge = 80%
Battery lifespan = 5yrs
Inverter life span = 10yrs
Charge controller life span= 10yrs

4. Results and Discussion

Table 1 shows the bill of engineering measurement and evaluation for 3.5 kW PV installation and Table 2 shows the Life Cycle Cost (LCC) for 7 years. The facility is expected to operate optimally for 7 years and may need replacement of the battery if necessary after 5 years. The table 1 shows that other components will be fully functional up to 7 years and above. In some cases, all the balance of system (BOS) are under guaranty by the suppliers. Previous work by Solar Force Nigeria limited on Minigrids in Nigeria, have guaranty of 7 years active performance. The operation and maintenance of the solar carport require cleaning and checking the connections occasionally which is almost at zero cost; since the works department staff on university who are on payroll will oversee the cleaning of the solar panels to prevent dust particles from affecting the performance of the modules. The works department will also inspect the batteries, charge controllers, and wires to ensure the connections are intact.

Table 1. *Bill of engineering measurement and evaluation for 3.5 kW PV installation.*

S/N	ITEM DESCRIPTION	QTY	UNIT COST $	AMOUNT ($)
1	Module 350W, 24V	12	360	4, 320
2	Deep Cycle Batteries 200Ah, 12V	8	492	3, 936
3	Charge Controller 40A, 48V	2	166	332
4	Inverter 5 KVA, 48Vd.c/230Va.c	1	1,000	1, 000
5	Supporting Structure	-	600	600
6	Cost of Accessories	-	400	400
7	Transport/Contingency	-	100	100
8	Engineering work/Installation		400	400
	TOTAL			($ 11,088:00)

Table 2. *LCC of Solar PV System in dollars ($) for 7 years.*

Years	0-1	2-4	5-6	7
Capital Investment				
Modules	4320	4320	4320	4320
Deep Cycle Battery 200Ah,12V	3936	3936	4428**	4428**
Inverter 5kVA, 48V	1000	1000	1000	1000
Charge Controller 40A, 48V	332	332	332	332
Sundry	1500	1500	1500	1500
Operation & Maintenance (O & M)				
Two Attendants*	-	-	-	-
Battery replacement**	-	-	-	-
Controller replacement	-	-	-	-
Inverter replacement	-	-	-	-
	($ 11,088:00	($ 11,088:00	($ 11,580:00)	($ 11,580:00)

*Two Attendants to be provided at no cost by University works department & **New replaced battery cost.

The LCC of the solar carport for 7 years is ($11,580:00) which is less than the cost and the operation of 3.5 kW diesel generator working for 11 hours a day. The calculated cost of operation of 3.5 kW generator which runs for 11 hours to provide electricity for lighting of the staff quarter at fuel cost of $0.420/litre, and purchase of two generators and their servicing for 7 years are estimated at $14,336.10 as shown in Table A1. Table A2 provides the data sheet for the consumption rate of the generator (Litre/hour). Beyond electricity generation for lighting, the solar carport protects the cars from strong UV radiation and acid rain degradation.

5. Conclusions

This paper studied the use of solar PV systems in Admiralty University of Nigeria to prevent the effect of solar radiation on vehicles exposed to the sun and also the generation of electricity. The study is also meant to discourage the use of diesel generators which pose risks to health and the environment. The use of solar PV carport systems has a strong potential for increasing electricity availability and reducing or eliminating atmospheric degradation of cars parked uncovered. The combination of solar PV systems and power from the grid can help to achieve continuous power supply. While the cost of solar PV systems is on the decline, the initial investment cost continues to pose a barrier in developing countries like Nigeria. The paper also presents a strong implementable option for enabling access to a cleaner, renewable source of energy through solar PV carport in tertiary institutions with almost zero operating cost. Solar PV is cheaper when Life Cycle Cost (LCC) of seven (7) years and above are compared to diesel source of energy.

6. Recommendations

1) It is strongly recommended that efforts should be made by the university management to reduce the solar degradation of staff and university vehicles.
2) Construction of solar carports in the university will protect the vehicles from the intense heat of the sun and prolong the life span of the vehicles.
3) The electricity generated from the solar PV array will power the lighting of staff quarter and thus reduce the cost of electricity bill.
4) Beautification of the campus will be enhanced if the solar facility is installed.
5) Staff and Students can carry-out many research works on the solar facility.
6) Emissions reduction will be enhanced due to clean energy source (PV).

Appendix

Table A1. *Cost Analysis of Operation of 3.5kW Generator.*

Assumption: 1 litre of fuel is consumed in 1 hour by 3.5kW Generator		
1	Cost of 1 litre of fuel:	$0.420
2	1 litre of fuel is consumed in 1 hour	
3	Total hours of fuel consumption in a day:	11 hours
4	Total hours of fuel consumption in a year:	11 x 365 = 4,015
5	Total hours of fuel consumption in 7 years:	11 x 365 x 7 = 28,105
6	Total cost of fuel consumption in 7 years:	11 x 365 x 7 x 0.420 = 11,804.10
7	Total cost of two (2) 3.5 kW Generators	($766 x 2)* = 1,532.00
8	Cost of maintenance for 7 years:	= 1,000.00
	Total	= $14,336.10

Note: *The cost of one generator is $766 but two Generators will be purchased because of replacement after 5 years.

Table A2. *Kohler Power India 3.5kVA AND 5kVA.*

Specifications	**3.5 kVA**	**5 kVA**
Engine model	KD441-GSI2	KD441-GSI2
Engine aspiration	Natural aspiration	Natural aspiration
No. of cylinders & arrangement	1, Vertical	1, Vertical
Displacement, L (cu. in.)	0.44 (26.85)	0.44 (26.85)
Bore and stroke, mm (in.)	86 x 76 (3.38 x 2.99)	86 x 76 (3.38 x 2.99)
Compression ratio	20.3:1	20.3:1
Governor type	Mechanical	Mechanical
Governor class	Class A2	Class A2
Frequency regulation, steady state	ISO 8528 G1	ISO 8528 G1
Air cleaner type, Qty	Dry, 1	Dry, 1
Rated speed (rpm)	3000	3000
Max. power kWm (BHP)	6.1 (8.18)	6.1 (8.18)
Diesel Fuel Consumption		
100% Load (Lph)	0.8	1.4
75% Load (Lph)	0.7	1
Lube Oil Consumption		
100% load (Lph)	0.006	0.006
Fuel System		
Fuel prime pump	Mechanical	Mechanical
Fuel filter: Type, Qty	External, 1	External, 1

Specifications	**3.5 kVA**	**5 kVA**
Recommended fuel	HSD-ASTM D2	HSD-ASTM D2
Fuel tank capacity, L	15	15
Fuel filter change period	Initial - 50 hrs / 3 months, Subsequent 250 hrs / 6 months whichever is earlier	Initial - 50 hrs / 3 months, Subsequent 250 hrs / 6 months whichever is earlier
Lubrication System		
System type	Forced Lubrication	Forced Lubrication
Lube oil type	Kohler Oil	Kohler Oil
Oil pan capacity with filter, L	1.5	1.5
Oil filter: Quantity, Type	1, Cartridge	1, Cartridge
Oil and oil filter change period	Initial - 50 hrs / 3 months, Subsequent 250 hrs / 6 months whichever is earlier	Initial - 50 hrs / 3 months, Subsequent 250 hrs / 6 months whichever is earlier
Exhaust System		
Maximum allowable back pressure, KPa (in. Hg)	5 (1.48)	5 (1.48)
Exhaust outlet size at engine hookup, mm (in)	40 (1.57)	40 (1.57)
Silencer Type, Quantity	Residential, 1	Residential, 1
Exhaust temperature at rated kW, °C (F)	550 (1022)	550 (1022)
Air System		
Combustion air, LPM	530	530
Heat rejected to ambient air: Generator, kW (BTU/min)	2.85 (162)	2.85 (162)
Generator set air cooling system	Blower / Fan	Blower / Fan
Engine Electrical System		
Starter Motor rated voltage VDC	12 V	12 V
Battery charger	12 V, 5 Amp	12 V, 5 Amp
Ground (negative/positive)	Negative	Negative
Battery type-Battery rating (Amp-hour) Quantity	Lead acid 35 1	Lead acid 35 1
Battery Voltage, VDC	12	12

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