Design of Solar Powered Unit for ILOKUN Community Rural Electrification

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Abstract:- Solar energy is now common because there is further increase in its demand across the globe. This is because this form of energy can provide steady, stable and clean energy. This design of solar powered unit for Ilokun Community rural electrification is to solve the problem epileptic power supply and black out in the community in case the supply from the grid fails. There are 600 houses in the community and this was divided into 8 areas and each area was made up of 75 houses with total energy demanded by each hour is 800w.Each area has its own solar P v system and components. The Community was sectioned into areas to avoid total black out in the Community if there is failure on the system and with these areas A to H in place only one area will be affected if there is failure. The sizing of PV array, sizing of the charge controller and sizing of the battery were carried out. The total energy that will be demanded by areas A was 78000W.If the effective sun per day is seven hours, 467999watt will be delivered. This module will be connected in parallel to meet the energy demand of the area and this was done likewise up to area H.

***Keywords**:- Photovoltaic, Inverter, Rural, Electrification and Energy.*

I. INTRODUCTION

Electricity can be produced from sunlight through a process called photovoltaic.”Photo” means light and “voltaic” means voltage .Since, the source is usually from the sun, it is called solar cells / photovoltaic. It is a semiconductor device that converts energy from the sun to electrical energy. Solar and Wind energy generators are quite common presently due to advances in the technology. This will lead to further increase in the use of photovoltaic (or PV) and Wind generators and more so that Nigeria’s electricity production continues to fluctuate without appreciable increase in total output. The installed capacity for electricity generation, which is 98% owned by the Federal Government, increased by a factor of 6 over the period 1968 to1991 and by 1991, stood at 5881.6 MW. No further addition to generating capacity was experienced over the subsequent decade (National Energy Policy, 2003).

The policy document clearly admit that the grid extension through conventional petroleum product, gas, coal, electricity) alone will not meet the rural electrification coverage cost- effectiveness within a reasonable time frame and thus make adequate allowance particularly for rural energy supply with non conventional and renewable energy such as solar, wind, small scale hydro, biomass, fuel wood etc. (Jesuleye et *al*,2008). Generators which are often used as an alternative to conventional power supply systems are known to be run only during certain hours of the day, and the cost of fueling them is increasingly becoming difficult (Adejumobi *et al*, 2011). The increasing use of renewable energy sources (especially Solar and Wind) has led to a drive in the research and development of appropriate technologies for energy efficient converters. The use of solar photovoltaic generator sometimes requires one such converter – the inverter. An inverter converts DC power to AC at the required voltage, current and frequency.

➢ *Photovoltaics*

A solar cell, or photovoltaic cell (PV), is a device that converts light into electric current using the photovoltaic effect. The first solar cell was constructed by Charles Fritts in the 1880s(Wikipedia).

➢ *Conventional PV systems*

The array of a photovoltaic power system, or PV system, produces direct current (DC) power which fluctuates with the sunlight's intensity. For practical use this usually requires conversion to certain desired voltages or alternating current (AC), through the use of inverters. Multiple solar cells are connected inside modules. Modules are wired together to form arrays, then tied to an inverter, which produces power at the desired voltage, and for AC, the desired frequency/phase (Wikipedia).

➢ *Photovoltaic Applications categorization:*

- Stand –alone applications (off-grid application): This operates independently off the grid network; it may comprise a control, storage, cable, inverter and loads (lights radio, televisions).
- Grid-connected application: Systems are tied into the grid network. Grid connected applications need inverter to convert the d.c generated by PV-module into a.c .Energy surplus will be fed into the grid, while in times of shortages (night) energy will be consumed from the grid. All d.c output of the PV field, which may be of megawatt range is converted to a.c and then fed into the central utility grid after which it is distributed to the consumers. The grid acts like a battery in a grid –

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connected power system with unlimited storage ability (Olajuyin E.A. and Olubakinde E., 2018).

- *Design analysis*

The sizing of the solar photovoltaic system is very important. If it is too large, it will be too expensive and bulk and if it too small, it may not provide the needed and required energy. This design is for Ilokun Community in Ado Ekiti, Ekiti State Nigeria.

- *Sizing the PV Array*

The number of the houses in Ilokun community in Ado Ekiti is 600. The total energy demanded by each hour is 800W. The 600 houses are divided into eight areas (A to H) each area will have its own solar PV system and its components. There is need to area the community so that in a situation where there is fault the whole community will not be in gross darkness.

For Area A:
Energy demanded = 75 X 800W = 60000W
Total load demanded = the load demanded + 30%Compensation for losses and future expansion.
Total energy demanded = 60000 + 30 X 60000/100 = 78000W
(i) If each of the appliances is used for six hours per day, the watt – hour per day becomes 78000 X 6watt –hour = 468000 Watt hour.

From this equation $E_A = A\ \eta\ H$ …………………… (1)

The area of the PV array is given by the formula
$A = E_A = A\ \eta / H_t$
Where E_A = Total watt –hour /effective sum hour
Effective sum hours = 7 hours
E_A = 468000 watt – hour/7hour
E_A = 66857W

Using the Table below for mono-silicon PV module types, efficiency = 13% =0.13

PV MODULE TYPES	EFFICIENCY (%)
Mono-silicon	13.0
Poly – Silicon	11.0
Amorphous Silicon	5.0

Table 1:- PV module Characteristics.

The total radiation on the tilted surface H_t is given by this equation below.
$H_t = HR$ …………………………………………… (2)

Where H is total radiation on the horizontal surface and R is the total radiation tilt factor.

The tilt factor is given as
$R = H_{b,}\ R_b/H + H_d\ (1+\cos\ T)/\ 2H + P\ (1-\ \cos\ T/2)$ …………………. (3)
$R_b = \cos\ (L-T)\ \cos\partial\ _{\cosh} + \sin\ (L-T)\ \mathrm{Sin}\partial / \cos L \cos\partial \cosh + \sin L\ \sin\partial$ ………..(4)
L = Latitude of the community = 7.5^0N
T = Tilt angle = 22.5^0
∂ = Declination for December = - 23.0
b = Solar hour angle at 4pm = 60^0
p = Diffuse reflectance = 0.2
R_b = cos (7.5 -22.5) cos – 23cos 60 + sin (7.5 – 22.5) sin(-23)/ cos 7.5 (-23) cos 60 +sin 7.5 sin (-23)
R_b = 1.347

Using this equation
$R = R\ H_b\ R_b /H + H_d\ (1+ \cos\ T/2H + p(1- \cos\ T/2)$
R is now calculated as
R = 15.127 x 1.347/21.837 +6.710 (1+cos 22.5)/2(21.837) 0.2)(1-cos 22.5)/2
R = 1.237

Assuming we use H = 21 .837 MJ/m^2
H = 21.837 X 10^6 /3600Jh/m^2
= 6066Wh/m^2

The effective peak sun hour for Ilokun community = 7hours
Therefore, H = 6066/7 = 866.6w/m^2
$H_t = H_R$
H = 866.6w/m^2, R = 1.237
H_t = 866.6 X 1.237 = 1072w/m^2

The area of solar PV is given as
$A = E_A = A\ \eta / H_t$ = 66857/0.13X1072w/ m^2
A = 480 m^2

A solar PV array with area 480 m^2 will be used for each areas with 13% efficiency 66857w will be produced for every 1 hour and for seven hours . If the effective sun hour per day is 7hours we have 7 X 66,857 = 467,999watt will be delivered.

Similarly, with the availability of a 200w, 24v module , 342 of such module will be connected in parallel to meet the energy demand of one of the areas and this will be done for the rest of the seven areas (B, C, D, E, F G and H) and the community will be powered.

- *Sizing the charge controller*

Each areas size of the charge controller = peak rated current from the array multiplied by the safety factor.

The power of each PV module is 200w at 24v and current for each module 200/24
= 8.3A
= 28044A

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Safety factor = 1.4
The size of the controller of 4000A, 24V will be used for each area

➢ *Sizing the inverter*

Power from the array = 66857w with a power factor of 0.75, the rate of the required inverter for each area is 66857kw/0.75 = 89.14KVA.

Therefore, an inverter of 110KVA will be used for each area as to cater for expansion

➢ *Sizing the Battery*

The total load is 468000watt-hour per day**.** Daily load in ampere-hour = load (watt-hour) system voltage (V).

$$\frac{468,000}{24} = 19500\text{amp-hours}$$

For 6days back up (assuming there is no sun), the total ampere-hour becomes 19500 amp- hour X 6 = 117000amp-hour for six days without sun. Thus, as battery 117000 Amp-hour should be used for each area. With the availability of 24V, 350amp-hour battery, the desired 195000 amp-hour can be achieved by connecting 285 of such batteries in parallel. The same process will carried out for other areas

➢ *Bill of Engineering Measurement and Evaluation (BEME)*

The bill of engineering measurement and evaluation for this design; design of a solar powered unit for Ilokun community rural electrification in Ado Ekiti , Ekiti State is given in the Table below.

S/N	Component	Quantity for an Area	Quantity for the Community	Unit Price (₦)	Total Price (₦)
1.	Solar Module	66857W	8 X 66857W	1watt=480	256730880
2.	Battery	285	8 X 285	60,000	396000000
3.	Inverter	1	8 X 1=8	3000,000	24000000
4.	Charge controller	1	8 X 1	200,000	1600000
Total					**678330880**

Table 2:- Bill of Engineering Measurement and Evaluation

II. CONCLUSION

A solar powered unit for Ilokun Community rural electrification was designed to supplement supply from Benin Electricity Distribution Company (BEDEC).Solar is converting of energy from the sun to electrical energy with the help of an inverter. The houses were sectioned into 8 areas and each area has its own PV system and components to avoid total black out in the whole community incase of power failure and so with this arrangement it is only a section of this community that will be affected if failure occurs. Sizing of PV array, sizing of charge controller sizing of battery were carried out.

It is important that the community provide adequate security for the system and they should be well maintained and in case of fault on the system an expert should be invited to do the repairing and the maintenance. The Government at all levels should encourage the use of solar energy and they must also finance researches and project in solar energy and other renewable energies .The researchers should focus more on renewable energy. This solar rural electrification can be done for a large community, Town, Local Governments and States e.t.c.

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