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Standalone PV System Design and Sizing for a Household in Anand

Kaushal Shah[1], Sachin Patel[2]

[1]*Electrical Engineering, G.H. Patel College of Eng. & Technology*
[2]*Electrical Engineering, G.H. Patel College of Eng. & Technology*

Abstract — *this research work is carried out for the standalone PV system for a household in Anand in India. The rapid population growth and increase in industrial activities necessitate the injection of solar photovoltaic technology into the nation's energy mix. Therefore, we made an attempt to design a standalone solar photovoltaic system for residential application. For sustainability, reliability and accessibility of power, the use of stand-alone solar photovoltaic technology is recommended. For this work we consider appliances which have consume direct current and alternative current. The total load power of these appliances is 437.5 W. The array to load ratio determined as well as the daily watt-hour load shows that the use of hybrid system in this design is not recommended. To power these appliances, 58 batteries in the battery bank with system battery capacity of 200 Ah. The use of stand-alone solar photovoltaic technology is recommended for sustainability, reliability and accessibility of power.*

Keywords- *Photovoltaic systems, Stand-alone, Appliances, Power, household.*

I. INTRODUCTION

In recent years use of photovoltaic modules has become more and more popular in the developed and major developing parts of the world, where national support programs have accelerated the spreading of grid connected PV systems. India is highly populated country and has very good solar irradiation availability which gives an ideal condition to use Solar Power in India. Power is the very important lifeline of any development of the nation especially developing country like India. In India, the power requirement is being met by three main sources that are Thermal, Hydro and Nuclear. While Hydro and Nuclear have their own limitations, Thermal Power is often challenged by the major problem associated with the availability of fuel. In India, almost all the Thermal Power Plants uses Coal as a fuel. But we know that this type of fuels will not be there forever. We have to find any other source as a solution of power generation. To overcome this situation, use of renewable energy sources is must. We can say that India is very lucky country because it comes in the Sunny regions of the world. And it has very high value of average solar irradiation throughout the country. In India, total on an average 250 sunny days during one year. It provides us the great opportunity to use Solar Energy as a source of energy. According to numbers India has electrified more than 10,000 villages by using renewable energy sources. By using Solar PV modules, we can convert the solar energy into Electricity. The efficiency of any PV Array lies between 10%-18%. We can use Solar Panels to provide electricity to any house, building or even an industry. The government also provides subsidies if we want to implement any renewable power supply system for our house or any other building. The Solar System may be of two types: 1) Grid Connected or 2) Stand Alone. In case of grid tight system, we can inject the extra energy generated from our solar system in grid and government pays us as per the rate and the total injection. In Stand Alone System there is no connection between grid and our system. The system is designed as per the requirement or load and we can use as the energy source or sometimes as a backup source. By using this kind of renewable sources, we can save high amount of money spent by government in transmission, distribution and other extra stuff**.** [1]

II. DESCRIPTION OF THE SYSTEM

2.1 Photovoltaic Power System Components:

Solar Photovoltaic system includes different components that should be selected according to your system type, site location and applications. A Balance-of- System that wired together to form the entire fully functional system capable of supplying electric power and these components are:

1. **Photovoltaic (PV) module:** It is made from semiconductor and convert sunlight to electricity. The PV converts sunlight into DC electricity. The most common PV modules include single and polycrystalline silicon and amorphous silicon with other technologies entering the market.
2. **Battery**: It stores energy for supplying to electrical appliances when there is a demand. Battery bank, which is involved in the system to make the energy available at night or at days of autonomy (sometimes called no-sun-days or dark days), when the sun is not providing enough radiation. These batteries, usually lead-acid, are designed to gradually discharge and recharge 80% of their capacity hundreds of times. Automotive batteries are shallow cycle batteries and should not be used in PV systems because they are designed to discharge only about 20% of their capacity [1].
3. **Inverter**: It converts DC output of PV panels or wind turbine into a clean AC current for AC appliances or fed back into grid line. It is one of the solar energy system's main elements, as the solar panels generate DC voltage.

Inverters are different by the output wave format, output power and installation type. It is also called power conditioner because it changes the form of the electric power. The efficiency of all inverters reaches their nominal efficiency (around 90 percent) when the load demand is greater than about 50 percent of rated load [2].

2.2 Configuration of the system:

The photovoltaic systems are classified according to how the system components are connected to other power sources such as standalone (SA) and utility-interactive (UI) systems. In a stand-alone system depicted, the system is designed to operate independent of the electric utility grid, and is generally designed and sized to supply certain DC- and/or AC electrical loads.

III. LOAD CALCULATION

Firstly, before choosing any other components load calculation is required. Rating of load, time it will run, type of load etc. In our case the load calculation is as below:

S\N	Appliance	Quantity	Power Rating (w)	Usage (h/d)	Energy per hour (AC)
1	32'' Plasma TV	1	125	5	625
2	Satellite Receiver	1	25	5	125
3	Fridge	1	150	8	1200
4	Fluorescent Lamps	6	15	5	450
5	Cell Phone	4	2.5	5	50
6	Ceiling Fan	6	120	7	5040
Total			**437.5W**		**7490Wh**

Table: Load Calculation

Here we have to consider losses as well. The total losses starting from the solar panel output to the losses in the load are approximately 30%.
Now, total Watt Hour per day can be *given by = 7500*1.3 = 9750 Wh. Round off value of which is 900 Wh. So, here we get the value of load which is to be run by solar system.

IV. SOLAR PANNEL SELECTION AND RATING

It is very important step, because it will decide the rest of the ratings like Battery and Inverter. For the calculation of the rating of Solar Panel parameters called Solar Irradiation and sun hours in a day is very important. This values are not constant everywhere.
So, firstly we find these values. According to the values we got from internet we form a table having the values of Anand city of previous year. Also we find out the solar irradiation values of Anand month wise of previous year. We know that the values of sun days and sun hours are not constant for every month. India has four seasons. So, we have divided the values we got into four parts and take its average value.

Anand, Gujarat, India

Latitude : 22.55 **Longitude : 72.95**

- Winter : January, February, December
- Summer : March, April, May
- Monsoon : June, July, August, September
- Post Monsoon : October, November

	Temperature (°C)			UV Index	Sun hrs.	Sun days.
Months	**Max.**	**Min.**	**Avg.**	**Avg.**	**Avg.**	**Avg.**
Jan'18	32	17	26	7	124	30
Feb'18	37	20	30	8	111.5	28
March'18	39	23	33	9	124	29
April'18	42	27	36	9	120	29
May'18	41	29	36	8	143.5	28
June'18	35	29	33	6	128.3	8
July'18	35	28	32	6	63.8	1
Aug'18	32	26	30	7	43.7	0
Sep'18	35	26	32	8	108.5	12
Oct'18	36	25	32	7	122	23
Nov'18	35	21	29	8	91	30
Dec'18	34	19	27	7	101	31

Table: Last Year Anand Whether with Solar UV Index

Monthly Average of solar irradiation

Monthly Average of solar irradiation			
Jan	6.49	**Jul**	2.66
Feb	7.22	**Aug**	2.52
Mar	7.20	**Sep**	4.90
Apr	6.89	**Oct**	6.90
May	7.22	**Nov**	6.42
Jun	5.31	**Dec**	5.97

By using the above data we have calculated the size of solar panel needed. The size of panel required season wise we get is as below:

- Winter : 10000/3.7388 = 2675 W
- Summer : 10000/ 4.3055 = 2323W
- Monsoon : 10000/2.9375 = 3405 W
- Post Monsoon : 10000/ 3.55 = 2817 W

Here the values are rounded off. And we can say that solar panel required having a rating of 3500Watt, 12 Volt.

V. BATTERY SELECTION

The output from solar panel is DC power. Solar Panel can generate the energy only during day time. So, to store the energy battery is required. By using battery we can give supply constantly to the load via inverter. There are various

kinds of batteries are available with different ratings. So, to rating of battery is must should be capable of storing energy. Rating of any battery is rated in terms of Ampere Hour. Calculation for battery rating is as below:
But, we know that battery is not ideal has some losses. Also we have to consider that we can't let battery to fully discharge. For lead acid battery 60% DOD (Depth of Discharge) is considered.

BATTERY SIZING								
AC AVERAGE DAILY LOAD	÷	INVERTER EFFICIENCY	=	TOTAL(Wh)	÷	DC SYSTEM VOLTAGE	=	AVE AMP HOUR PER DAY LOAD
10000	÷	0.85		11764.70	÷	12	=	980.39
AVE AMP HOUR PER DAY LOAD	×	DAYS OF AUTONOMY	÷	DISCHARGE LIMIT	÷	BATTERY AMP HR. CAPACITY	=	BATTERIES IN PARALLEL
980.39	×	7	÷	0.6	÷	200	=	57.18
DC SYSTEM VOLTAGE	÷	BATTERY VOLTAGE	=	BATTERIES IN SERIES	×	BATTERIES IN PARALLEL	=	TOTAL BATTERIES
12	÷	12	=	1		58		58

- **So we require 58× 200Ah Batteries are to be connected in parallel.**

VI. INVERTER SIZE SELCTION

Total connected load to PV panel system = 437.5 watts
Inverter are available with rating of 100, 200, 500 VA, etc.
Therefore, the choice of the inverter should be 500 VA.

VII. CONCLUSION

The geographic location of Anand makes it to have 3 major microclimatic seasons namely winter, cloudy and clear sunny seasons with an average solar irradiance annually of 5.8 kWh/m^2. In this design, to meet the power demand of 437.5 W of the appliances; the solar photovoltaic systems with 58 batteries are required. The stand-alone solar photovoltaic have high initial cost but its durability, reliability, sustainability, ease of maintenance, environmental friendliness, and make the system attractive for residential and other pertinent applications.

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