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Load Calculation and Analysis of Engineering Building for Designing Optimal Microgrid Configuration by HOMER®

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ABSTRACT

The primary issues of running decade are stimulating demand of electrical energy and to control the secretion of Green House Gases (GHG) emissions. Renewable energy resources based sustainable microgrid develops as one of the best feasible results for future energy demand while considering zero carbon secretion, fossil fuel independency, and improved reliability. Hence Renewable energy sources are gradually being recognized as important options in supply side planning for microgrids. The main purpose of this paper is to present a load calculation and analysis of an engineering building for designing optimal microgrid configuration located in a remote area. This study is based on the data of a remote area in Malegaon of Nashik district in Maharashtra.

Keywords: Microgrid, Solar energy, Wind Energy.

I. INTRODUCTION

A Microgrid (MG) is essentially a distinctive hybrid electric network including Distributed Energy Resources (DERs), local loads, and Electrical Energy Storage Devices for providing power to specific areas or isolated locality. The main function of MG is declaring system's stability on existence of different network faults. There are several definitions and functional arrangement schemes of Microgrid cited in the literature. MG contains distributed energy resources that restrictions an extensive range of main technologies such as Photovoltaic systems (PV), Fuel Cells (FCs), Gas Turbines, Wind Power, Micro Turbines, AC Storage Internal Combustion Engines (ICs). Though, the PV, FC, ESS, and Micro Turbine need an interfacing inverter and suitable controllers with the power distribution network for allowing elastic operations [2].

Present distribution system is considered and established with an assumption of power flow in a unidirectional mode of operation from the substation to the load. Though, the addition of Microgrid on a distribution feeder variation the concept of unidirectional power flow method of design to a bidirectional structure. Without cautious engineering, Microgrid saturation can potentially have numerous adversative system impacts associated to protection, control, power quality, reliability of power supply, restoration time later outage and working safety.

In this paper load calculation and analysis of an engineering building for designing optimal microgrid configuration located in a remote area is caried out and followed by field study and metrological data, such as solar sunshine hours data, wind speed data. This study is based on the data of a remote area in Malegaon of Nashik district in Maharashtra.

II. METHODOLOGY

The steps followed in this study are summarized below:

Step1: Field study of the proposed site.

Step2: Meteorological data acquisition of renewable sources like solar sunshine hours data, wind speed data.

Step3: Determining the load profile of the target site.

1. Field Study for the System

Latitude and Longitude coordinates of the proposed site at Malegaon district Nashik are 20.5334° N, 74.5205° E respectively.

1.1 Solar photovoltaic system:

The solar photovoltaic system converts sunlight into electricity. In logical terms, PV changes over solar based radiations into direct current. A PV module comprises of various solar cells associated in series or equal.

the PV exhibit as a gadget that produces dc power in direct extent to the worldwide sunlight-based radiation occurrence upon it, independent of its temperature and the voltage to which it is uncovered.

The equation for calculating the output power of PV panels used in HOMER® is as follows

$$\mathbf{Ppv = Psun \times Hpv}$$

Where Psun is power from sunlight of a PV panel. Hpv is PV panel efficiency. It is dependent on photovoltaic technical and PV panel temperature [5].

1.2 Wind Turbine System:

A wind turbine is a system or device that changes over the dynamic energy of the wind into ac or dc power as indicated by a specific power output, which is a diagram of force yield versus wind speed at center point level. Each hour, power output of the wind turbine in a four-step process. In the first place, it decides the typical wind speed for the hour at the anemometer level by comparing to the wind data information. Second, it computes the comparing wind speed at the turbine’s center level utilizing either the logarithmic regulation or the power regulation. Third, it refers to the turbine’s power bend to ascertain its power output at that wind speed accepting standard air density. Fourth, it increases that power output value by the air density proportion, which is the proportion of the real air density to the standard air density.

The power of the wind turbine can be expressed as

$$\mathbf{Pwt = \frac{1}{2} \times \rho \times A \times V^3 \times Cp}$$

Where ρ, A and V are air density, swept area of turbine blade and wind speed respectively. Cp is power coefficient of wind turbine, which depends on architecture, operate mode and rotor speed of wind turbine. Cp values can be available as a graph in technical document.

2. Meteorological Data Acquisition

To determine the solar power, it is necessary to determine the amount of sunlight available at the target site. Similarly, for wind power, the amount of wind speed is needed.

2.1 Sunlight availability

The data showing the variation in Solar Daylight hours is as shown in Table 1. Table 2 represents the variation in Sunshine hours Data.

Table 1: Annual Average Solar Daylight hours data

Table 2: Annual Average Sunshine hours data

Avg Daylight hours site (Hours)	
Jan	11
Feb	11.5
Mar	12
Apr	12.6
May	13.1
Jun	13.4
July	13.2
Aug	12.8
Sep	12.3
Oct	11.7
Nov	11.2
Dec	10.9

Avg Sunshine hours at site (Hours)	
Jan	9.9
Feb	9.9
Mar	9.8
Apr	9.9
May	11.9
Jun	10.4
July	6.6
Aug	6.1
Sep	8
Oct	9
Nov	7.4
Dec	7.7

2.2 Wind speed availability

The data showing the variation in wind speed is as shown in Table 3. represents the variation in wind turbine power production at different wind speeds.

Table 3: Annual average wind speed

Avg Wind Speed at site (km/h)	
Jan	8.2
Feb	8.8
Mar	10.1
Apr	12.3
May	16.8
Jun	17.4
July	18.9
Aug	16.3
Sep	11.3
Oct	8.4
Nov	7.6
Dec	7.9

3. Determining The Load Profile

The load profile is assumed considering the power consumption profile of an engineering building situated in Malegaon Dist. Nashik Maharashtra. As per the practical scenario, all the loads have been considered as AC load. The monthly average of 24 hours load profile for this work has been shown in Table 4.

Table 4: Approximate Daily Electric Load Consumption of Site

No.	Place	LED	FAN	Comp	Projector	Sockets
8	Class	32	40	8	8	6
16	Lab	67	78	72	0	8
5	Office	26	16	10	0	4
4	Passage	40	0	0	0	16
3	Seminar Hall	28	23	5	2	10
3	Washrooms	23	0	0	0	0
	Total	216	157	95	10	44

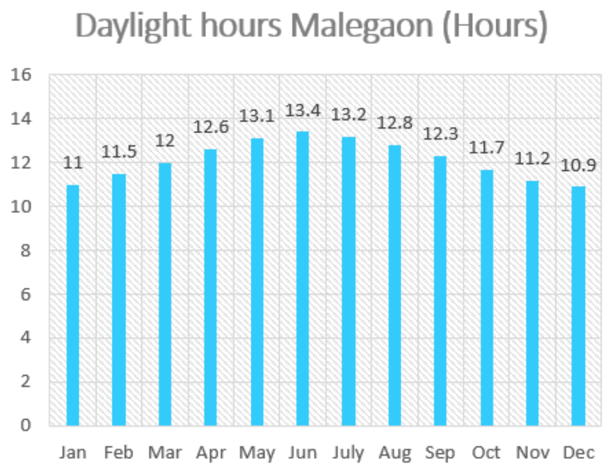
Load	Rating	Quantity	Usage Hrs/Day
Fan	80	157	7
LED Tube	18	216	18
Computer & Devices	80	95	6
Projector	180	10	4
Sockets	120	44	5

III. RESULTS AND DISCUSSION

Each month of the year, the simulation considers into study the solar radiation, Annual Average Solar Daylight hours data, Annual Average Sunshine hours data and the orientation and location on Earth's surface.

1. Average Day Light Hours at Site

Annual Average Solar Daylight hours data for the proposed site is 12.14 hrs. The data showing the variation in Solar Daylight hours is as shown in below graphs mention as Fig.1.



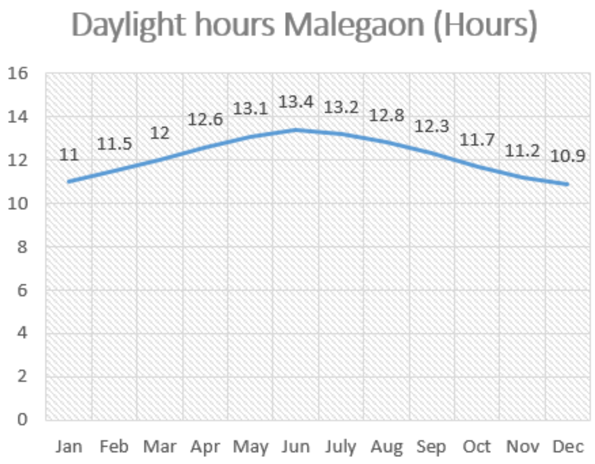


Fig.1: Avg Daylight hours at the site

From the above result we can see the average annual daylight hours at the proposed site and which is showing maximum in the month of June i, e. 13.4 hrs. It can be said that in the month of June more and more energy can be utilized through the photovoltaic system because as the analysis is done and found that in the June month there is more clarity index and no cloud shadows are present so that this component can be easily simulated in a HOMER simulation and the desired output will be collected.

2. Average Sunshine Hours at Site

Annual Average Solar Sunshine hours Data for the proposed site is 8.88 hrs. The data showing the variation in Solar Daylight hours is as shown in in below graphs mention as Fig.2.

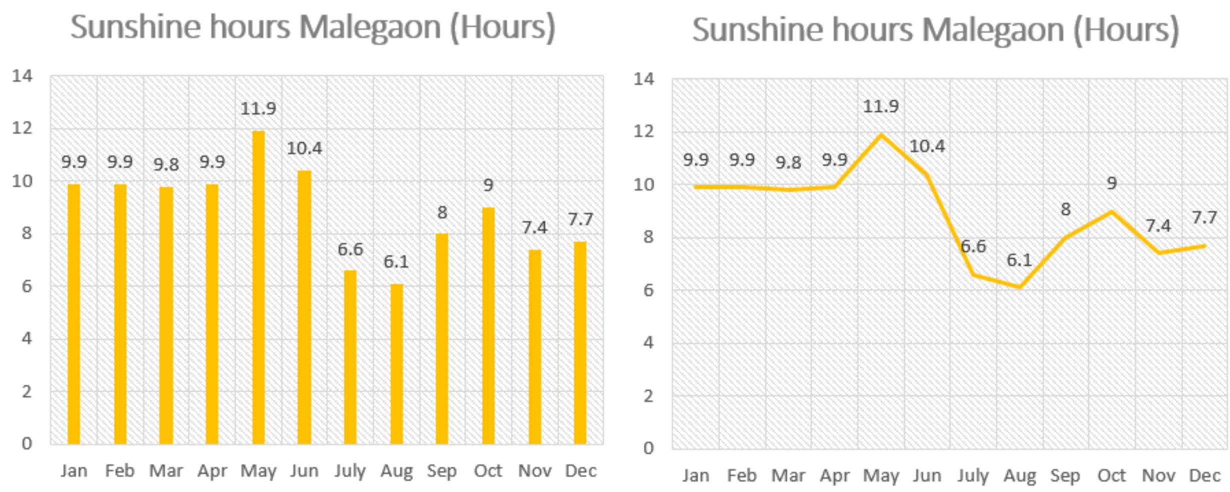


Fig.2: Avg Solar Sunshine hours at the site

From the above result we can see the average annual solar sunshine hours at the proposed site and which is showing maximum in the month of May i, e. 11.9 hrs. It can be said that in the month of May more and more energy can be utilized through the photovoltaic system because as the analysis is done and found that in the month of May there is more clarity index and no cloud shadows are present also sunshine hours are more so that this component can be easily simulated in a HOMER simulation and the desired output will be collected.

3. Average Wind Speed Data at Site

Wind speed and tower height are the main factors which can affect the electrical power supply from wind energy. Annual average wind speed at the proposed site is 12 km/h. The data showing the variation in wind speed is as shown in below results mention asFig.3.

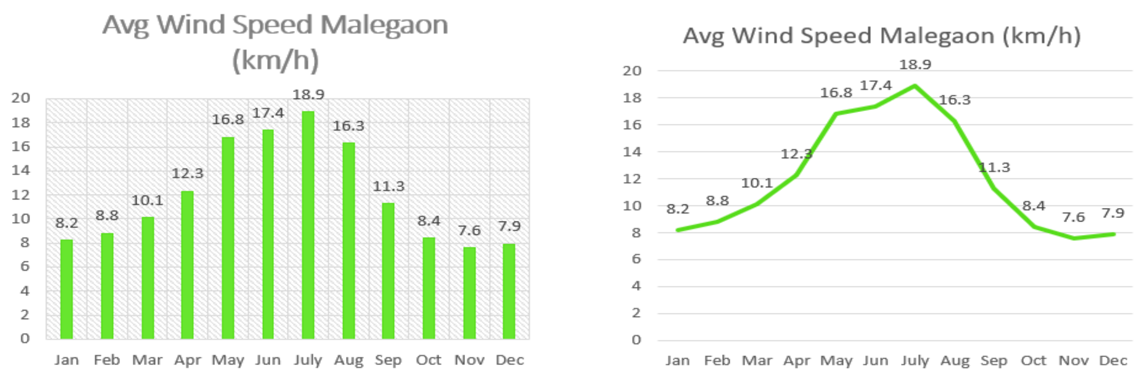


Fig. 3: Annual average wind speed at the proposed site

From the above result we can see the average annual average wind speed at the proposed site and which is showing maximum in the month of June i, e. 13.4 hrs. It can be said that in the month of July more and more energy can be generated through the wind turbine system because as the analysis is done and found that in the July month there is more wind are present so that this component can be easily simulated in a HOMER simulation and the desired output will be collected.

4. Load Profile at Site

As per the practical scenario, all the loads have been considered as AC load. The monthly average of 24 hours load profile for this work has been shown that the average monthly load is approximately 15kw. Whereas this load consumes 129.78 units of electricity per day and 3955.914 Units per month.

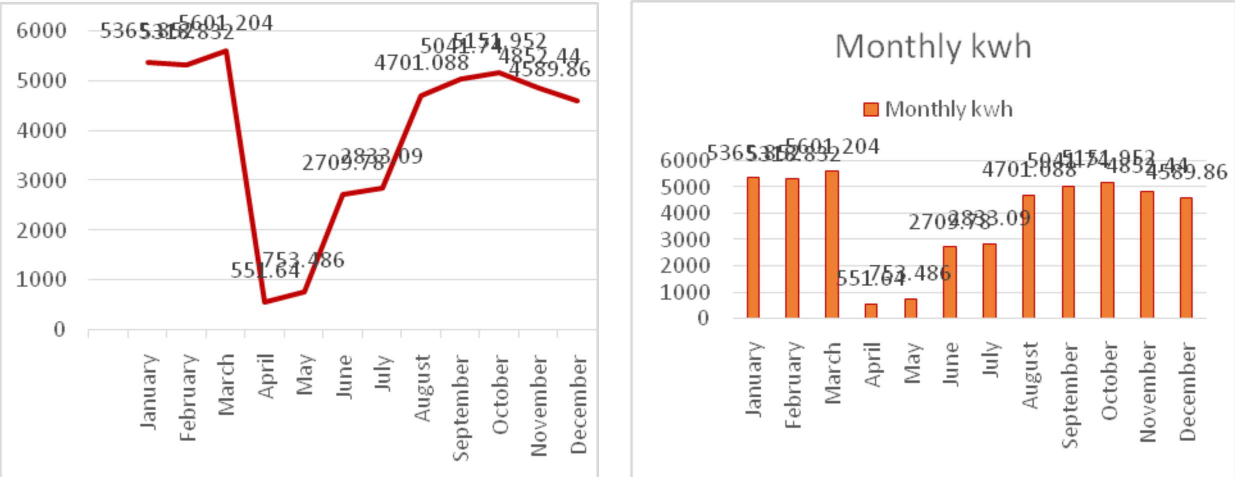


Fig.4: Load profile at the proposed site

Case 1: From above result it can be said that in the month of Jan and Feb there is academic going on so the maximum load is noted as we move to the month of March, due to some hot condition as compare to the Jan & Feb it is some what heated so it can be easily noted that high consumption of electricity in march.

Case 2: In the month of April and May there is no class conduction due to COVID-19 pandemic online classes were being conducted so the load is suddenly decreased. Again, the load is increases in the month of Jun & Jul as some staff were allowed to come int the college by following norms by the Indian government regarding COVID-19.

Case 3: Again, the load is increases in Aug, Sep & Oct because some students were allowed to attend the classes offline mode by taking proper vaccination and by following rules of central government and govt. of India.

IV. CONCLUSION

The considered site is an educational institute and the solar radiation and wind speed data are corresponded to the city of Malegaon, District Nashik Maharashtra. Educational institutes have a responsibility to become a role model for the nation to save energy and promote optimization. These institutes support many students, research scholars, faculties and training facilities which can be a good platform to raise the awareness and promote energy saving. In this paper load calculation and analysis of an engineering building for designing optimal microgrid configuration is carried out and in result section all cases discussed as per the analysis.

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