Research Paper Engineering

Microgrid : A Planning Based on Renewable Sources In Amravati District

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ABSTRACT

Micro grid (MG), a recently emerging generation power technology, is predicted to play an important role in future power systems due to its potential and immense benefits. Renewable sources are getting considerable attention in power generation due to growing public concern with environmental degradation caused by conventional electricity generation. Wind is the most promising choice for producing substantial amount of electricity from green energy source.This paper presents concept of Micro grid and planning approach to satisfy the demand of a village alone by it.

Keywords : Introduction, Planning of Micro Grid, Formulation, Conclusion

I. Introduction

During the nineties decade, many electric utilities throughout the world have forced to change their way of operation and business, from vertically integrated mechanism to open market system India is a developing and fast-growing large economy and faces a great challenge to meet its energy needs in a responsible and sustainable manner. In the recent past, India has been growing at an average rate of 8.5%.The energy requirement of India is increased in the last couple of years. India is world's 6th largest energy consumer accounting for 3.4% of Global energy consumption. The total installed capacity of India is 1,74,911.40MW,as on May 2011.

When considering RE power options, both grid-connected and distributed power generation, then renewable technology is an important areas, especially for India, which has a high population living in rural areas. Hence renewable power will be the best option for rural electrification as per rural electrification goal of India.

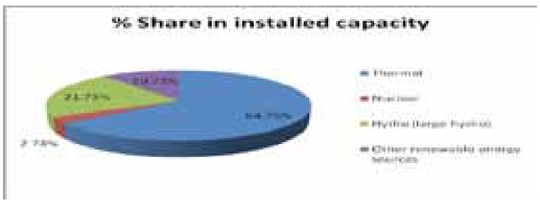


Fig 1 Indian Power sector

II. Planning of MicroGrid

Amravati is a district of Maharashtra state in central India. Total population is 2,607,160 peoples with 5,26,230 households. Makhla village is in chikhaldara taluka in Amravati district, State Maharashtra.

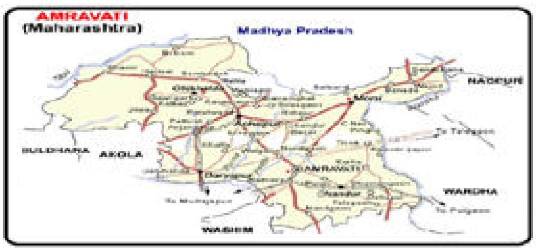


Fig 2 Map of Amravati district

Table 1 shows the load model of Amravati district where during the month of May peak load occurs because during this month summer is at peak so almost all the load are on large pumping of water is also required .The district is situated between 20°32' and 21°46' north latitudes and 76°37' and 78°27' east longitudes,has 12,235 km² area.Makhla is a village in Amravati with total area of 733.26 hectares. Latitude 21.697o N and longitude 77.365o .This village is rich in natural resources.There are around 190 families with a population of 970 persons. So out of them 10% are rich,20% are middle class and rest 137 famlies are poor. Rich people has 4 rooms house with 1 T.V ,4 tube lights, 3 fans, refrigerator and mixer. Medium rich people has 3 room house with 3 tubelights, 2fan,1 T.V. Whereas poor people has 2 room house with 2 tubelights and 1 fan. There are 10 shops with power requirement of 13.675kw per month.

Table 1. Load Model of Amravati District

Week No.	load in p.u	Week No.	load in p.u	Week No.	load in p.u	Week No.	load in p.u
1	0.348	14	0.921	27	0.501	40	0.772
2	0. 346	15	.675	28	0.526	41	0.78
3	0.410	16	0.87	29	0.5	42	0.79
4	0.345	17	0.81	30	0.5	43	0.772
5	0.348	18	0.911	31	0.501	44	0.7
6	0.48	19	0.981	32	0.584	45	0.584
7	0.584	20	1.0	33	0.584	46	0.5
8	0.56	21	0.981	34	0.584	47	0.5
9	0.584	22	0.99	35	0.584	48	0.50
10	0.737	23	0.812	36	0.626	49	0.348
11	0.77	24	.98	37	0.6	50	0.346
12	0.8	25	0.869	38	0.62	51	0.34
13	0.76	26	0.8	39	0.629	52	0.348

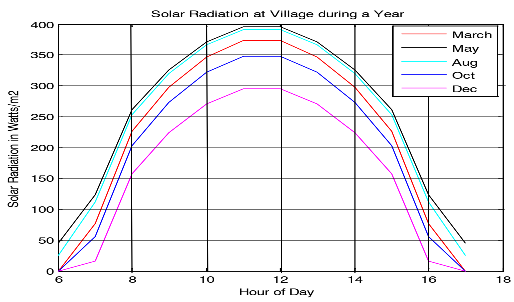


Fig 3. Solar radiation at village during an year.

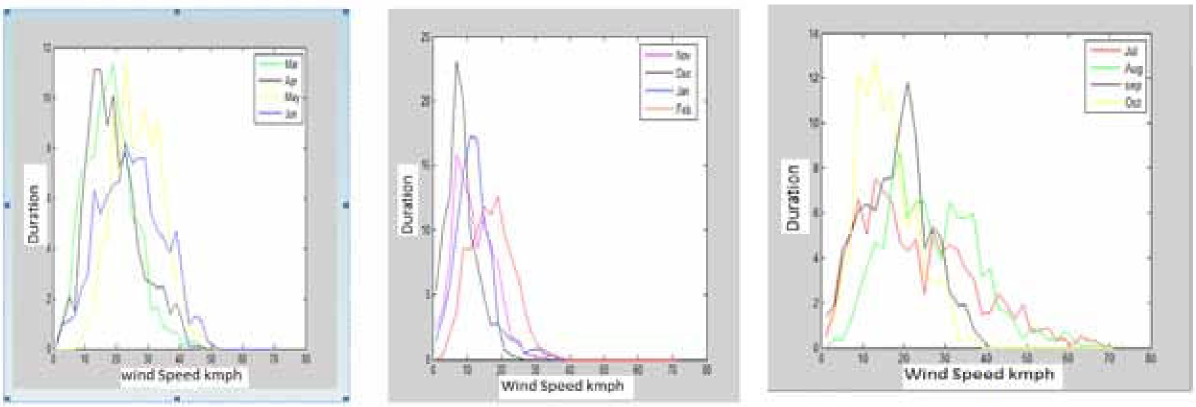


Fig 4. Wind variation at village during an year

III.Formulation

Power generation from wind power system:

The output of power generation P is based wind power turbine. The amount of wind power generated depends on the density of air, wind turbine rotor area, and the wind speed. The relationship is shown in Equation (1.1).

$$P = \frac{1}{2}\rho \cdot A \cdot v^3 \quad (1.1)$$

where, P = Wind power generated in W (watts)

ρ = Density of dry air in kg/m3 (kilograms per cubic meter)

A = Rotor swept area in m^2 (square meter)

v = Wind speed in m/s (meters per second)

Wind power generation is proportional to the cube of the wind speed. It indicates that accurate wind speed modeling is essential. Wind power generation mainly depends on the availability of wind and the design parameters of the WTG unit. The main characteristics that influence generated power are the cut-in wind speed, cut-out wind speed, rated wind speed, and the rated power.

The wind turbines are generally designed to start running at specific minimum wind speed. This wind speed is called the *Cut-in wind speed,* V_{ci}. The generated power increases non-linearly with the increase in the wind speed from V_{ci} to the *rated wind speed* V_r. A WTG generates the rated power P_r at the rated wind speed. Wind turbines are designed to stop at high wind speed in order to avoid damaging the turbine. This maximum allowable wind speed is called the *cutout wind speed*, V_{co}. The power generated remains constant at the rated power level P_r when the wind speed varies between the rated wind speed and the cutout wind speed. Equation 3.2 indicates the mathematical relation between the power output from a WTG and the available wind speed 1.2.

$$P = \begin{cases} 0 & 0 \le V \le V_{ci} \\ (A + B\cdot V + C\cdot V^2)\cdot P_r & V_{ci} \le V \le V_r \\ P_r & V_r \le V \le V_{co} \\ 0 & V \ge V_{co} \end{cases} \quad (1.2)$$

Where V = wind velocity at time t

V_r = rated wind speed
P_r = rated wind power
V_{CI} = cut in wind speed
V_{CO} = cut out wind speed
P = power at time t

$$A = \frac{1}{(V_{ci}-V_r)^2}\cdot\left[V_{ci}(V_{ci}+V_r) - 4V_{ci}V_r\frac{(V_{ci}-V_r)^3}{2V_r}\right];$$

$$B = \frac{1}{(V_{ci}-V_r)^2}\cdot\left[4(V_{ci}+V_r)\frac{(V_{ci}+V_r)^3}{2V_r} - (3V_{ci}+V_r)\right]$$

and $C = \frac{1}{(V_{ci}-V_r)^2}\cdot\left[2 - 4\frac{(4V_{ci}+V_r)^3}{2V_r}\right]$

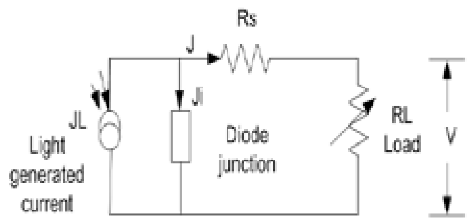
Power generation from solar power system:

It is possible to convert solar energy directly in to electric energy by photovoltaic process. The photovoltaic effect is the generation of an emf as a result of the absorption of ionizing radiation. A solar cell uses a p-n junction. Its current and voltage relationship is given by

$J_i = J_o(\exp(Ve/KT)-1)$

$J = J_L - J_i = J_L - J_o(\exp(Ve/KT)-1)$

The amount of irradiation and irradiation time become the key factors for the solar power system.



The maximum power is given by, $P_{max} = V_{mp} \times I_{mp}$

Small Hydro Conversion System

To determine the power potential of the water flowing in a river or stream it is necessary to determine both the flow rate of the water and the head through which the water can be made to fall. The *flow rate* is the quantity of water flowing past a point in a given time. Typical flow rate units are litres per second or cubic metres per second. The *head* is the vertical height, in metres, from the turbine up to the point where the water enters the intake pipe or penstock. The potential power can be calculated as Theoretical power (P) = Flow rate (Q) x Head (H) x Gravity (g) (G= 9.81 m/s^2) When Q is in cubic metres per second, H in metres and g = 9.81 m/s^2) then, P = 9.81 x Q x H (kW) . .Table 2. Monthly data for year 1956 with the capacity and the rated head

Sr. No.	Operating Conditions of Reservior		Closing conditions of reservoir (Water), Mm^3	Total water level (TWL)	Discharge, Q (m^3 / sec)	Maximum water level (MWL)	Head, H (m) (MWL - TWL)
	Water Reservoir Level, m	Water, Mm^3					
1	438.55	6.389	440.59	434.87	0.1961	439.91	5.04
2	440.59	9.148	444.24	434.758	0.0075	443.022	8.264
3	444.238	16.27	451.13	434.765	0.0151	448.834	14.069
4	451.133	38.03	452	435.68	3.7323	451.711	16.031
5	452	41.76	451.24	435.71	4.0088	451.746	16.036

6	451.24	38.49	448.51	435.86	5.1668	450.33	14.47
7	448.51	27.93	444.07	435.92	5.6953	447.029	11.109
8	444.067	15.86	440.59	435.59	3.199	442.908	7.318
9	440.592	9.151	440.42	434.75	0	440.533	5.783
10	440.416	8.857	439.98	434.75	0	440.269	5.519
11	439.977	8.135	439.26	434.75	0	439.738	4.988
12	439.262	7.26	438.57	434.75	0	439.03	4.28

Following table predicts the domestic electricity requirement of the 190 families.As per the sources data available first the individual sources are considered to satisfy the demand and accordingly capacity of generator is calculated.Then combination of two sources is tried out and finally combination of three sources are planned in a optimum state.

Table 3: Energy Requirement for poor family

Local load	Specification	Power Watts	Quantity	Working time	Energy required per day Wh	Total
Lighting	Light bulb	9	2	5	90	45.210 kWh
Fan		40	1	6	240	

Table 4: Energy Requirement for middle class family

Local load	Specification	Energy Watts	Quantity	Working time	Energy required per day Wh	Total
Lighting	Light bulb	9	3	5	135	32.810 kWh
Fan		40	2	6	480	
T.V		70	1	5	350	

Table 5: Energy Requirement for rich family

Local load	Specification	Energy Watts	Quantity	Working time	Energy required per day Wh	Total
Lighting	Light bulb	9	4	5	180	52.25 kWh
Fan		40	3	6	720	
T.V		70	1	5	350	
Fridge			1		800	
Mixer			1		700	

Now when solar panel of 60kW capacity and wind of capacity100kW is combined then they are able to satisfy the load demand and these two hybrid capacity are not bringing about any loss of load .The combination of 120kW wind capacity and 50 kW hydro capacity satisfying the demand only load loss occurs in October month.also in some month both hybrid combination has twice power generated than demanded which can be stored and supplied during deficient month.

Finally Micro grid comprising of solar (30 kW) , wind (80 kW) and hydro (50 kW) is more promising than other combination as capacity of all the sources is reduced and no load loss is occurring shown in Fig.4

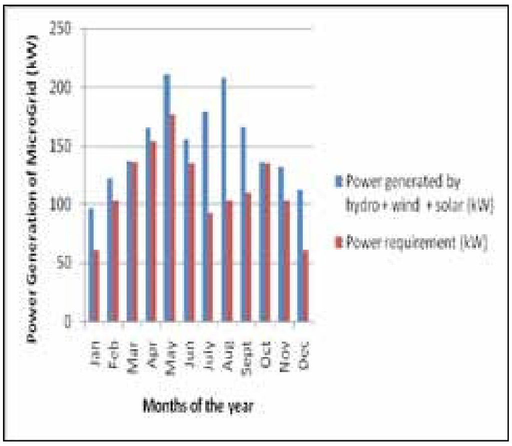


Fig 4.Power generated by Micro Grid

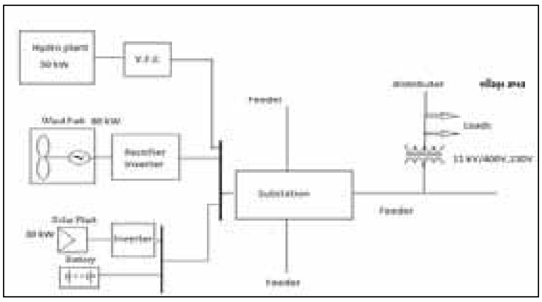


Fig.5 A Micro Grid System

In fig 7 no rainfall months are taken in to analysis that if hydro capacity is kept off during month of February to May no load loss occur .In fig 8 weak month of solar radiation are considered that if solar capacity is off during month of June to September then load loss is occurring in the month of June. Rest of the months solar capacity is considered only when its weak month are considered then the loss in the month of June occurs which can be overcome by using suitable storage capacity as there is twice the production in the month of August and September.Again it is economical if during weak month capacity is kept off.

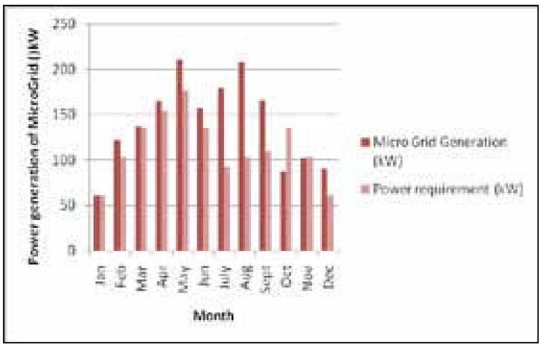


Fig 6.Power generated by Micro Grid (during weak wind velocity)

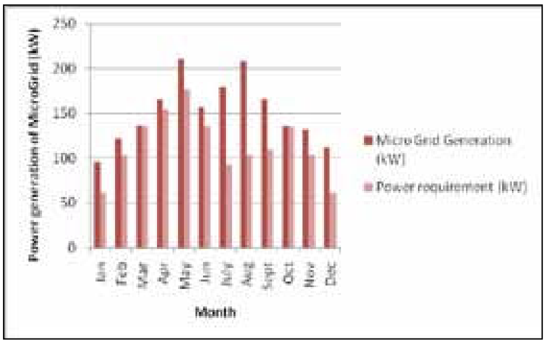


Fig 7.Power generated by Micro Grid(weak rain

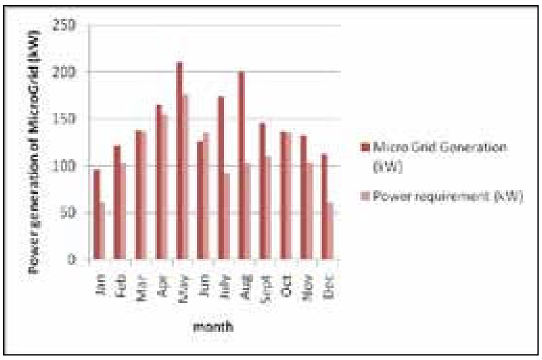


Fig 8.Power generated by Micro Grid(during weak solar radiation)

IV. Conclusion

Micro Grid can be planned and is capable to supply the demand side with reduced capacity. If in some month one of the source is unable to cope the demand or it is less than other two sources play the role of supplying the demand. So this can be applied to any source. A MicroGrid consisting of 30 kW solar capacity,50 kW hydro capacity and 80 kW wind capacity seems to be more reliable and no load loss occurs than considering single or two sources together.

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