Abstract

**Background/Objectives:** Green energy based microgrid system is the development of eco-friendly and cost effective system for electrical supply in the area where grid is not feasible. In this paper, the study and modelling of green energy based micro grid for rural area of Tantivela, Gujarat has been done. **Methods/Statistical Analysis:** In this paper, the analysis has been done on Hybrid Optimisation for Electric Renewables (HOMER) software. Firstly, the geographical data of the area has been collected including the village data and climatic data. By calculating the load demand of the household accordingly the village population and occupation has been estimated. Based on availability of the renewable resources combination of the energy has been modelled. Using the software HOMER software the optimum and cost effective model of standalone micro grid system for rural area. **Findings:** A standalone type microgrid has been simulated which can handle both AC and DC load. For the Maximum Power Point Tracking system perturb and observe method has been adopted. The standalone system different combination of PV array, charge controller, load controller, inverter, and battery need to be decided based on the load demands and parameters. The biomass, wind and solar are taken to be the main renewable energy resources as for generation. The testing and cost analysis has been done in Hybrid Optimisation for Electric Renewable (HOMER) to find optimum combination of energy which will be cost effective, eco-friendly and have viable architecture. After selecting the resources and decide the equipment’s the final simulation is done. In HOMER we analysed cost summary including total net production cost, operational cost and levelized cost and decide on best possible architecture of PV array, biomass, wind, converter, inverter and rectifier. **Applications/Improvements:** By simulating green energy microgrid it makes an optimum use of resources that are locally abundant resources with economic viable, affordable and sustainable. It could be improved by proper transmission network and improve surge power capacity to enhance cost- effectiveness.

**Keywords:** Energy, Green Power, Modelling, Micro Grid, Rural Area

1. Introduction

The proper utilisation of the renewable power yield greater and sufficient weightage to satisfy the need of demand for electrification in many villages where load demand is low. About 30% of the total solar energy is reflected to atmosphere while the portion remaining is absorbed and out of 20% been absorbed\(^1\).

The micro grid involves the transmission line and incorporates distributed energy resources. India has seen a phase shift from non-renewable resources to renewable method for power generation\(^2\)\(^\text{3}\). Gujarat is leading in solar, wind, biomass energy as renewable energy promotion policy. The first wind energy policy was established by Gujarat followed by setting a benchmark for solar energy policy in 2009. The Gujarat potential for solar power stands for 345.71 GW.

Tantivela in Gujarat is a village located in Patan Veraval, Junagadh district. The total number of 253 families are living there with 766 males and 738 females as per census 2011. Sex ratio is 992. Tantivela literacy rate is lower at 56.43% with male literacy at 66.82% while female at 45.59%. The latitude and longitude of Tantivela is 20.9479433 and 70.371406799 respectively.

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2. Data Collection of Village Tantivela

The village Tantivela has a hot semi-arid climate with warm hot temperature throughout the year. Table 1 shows the climate data of Tantivela area. Figure 1 shows the bar graph representation of climate data of Tantivela.

The winters are mild, pleasant and dry with temperature 29°C while night 12°C. The summer is extremely hot with day 49°C and night 30°C. Table 2 shows monthly climatic data of village Tantivela. Table 3 shows the monthly averaged daylight hours (in hours). Table 4 shows the optimum solar tilt angle in degrees.4

Table 1. Climate data of Tantivela

| Month | Record high(°c) | Average high(°c) | Daily mean (°c) |
|-------|----------------|-----------------|----------------|
| Jan   | 32.4           | 28.7            | 21.5           |
| Feb   | 36.7           | 29.4            | 22.3           |
| Mar   | 40.4           | 31.3            | 24.9           |
| Apr   | 41.5           | 31.8            | 27.0           |
| May   | 40.7           | 32.0            | 28.6           |
| Jun   | 34             | 32              | 29             |
| Jul   | 36             | 30              | 28             |
| Aug   | 33.8           | 29.8            | 27.6           |
| Sep   | 41.0           | 30.8            | 27.8           |
| Oct   | 38.7           | 33.5            | 27.9           |
| Nov   | 34.8           | 33              | 26.2           |
| Dec   | 41.5           | 30.4            | 23.2           |

Table 2. Monthly climatic data of village Tantivela

| Month | Air temperature (°C) | Daily solar radiation (kWh/m²/d) | Wind speed (m/s) |
|-------|-----------------------|----------------------------------|-----------------|
| Jan   | 22.2                  | 5.37                             | 3.4             |
| Feb   | 23.2                  | 6.29                             | 3.6             |
| Mar   | 25.3                  | 7.08                             | 4               |
| Apr   | 27.3                  | 7.46                             | 4.3             |
| May   | 29.5                  | 7.47                             | 4.9             |
| Jun   | 30.1                  | 6.17                             | 5.7             |
| Jul   | 28.8                  | 5.31                             | 7.1             |
| Aug   | 27.8                  | 5.34                             | 5.9             |
| Sep   | 28                    | 6.02                             | 3.9             |
| Oct   | 28.4                  | 5.95                             | 3               |
| Nov   | 26.7                  | 5.39                             | 2.7             |
| Dec   | 23.7                  | 5.03                             | 3               |
| Annual| 26.8                  | 6.07                             | 4.3             |

Table 3. Monthly averaged daylight hours (in hours)

| 22 years average | (hours) |
|------------------|---------|
| Jan              | 11      |
| Feb              | 11.4    |
| Mar              | 12      |
| Apr              | 12.6    |
| May              | 13.1    |
| Jun              | 13.3    |
| Jul              | 13.2    |
| Aug              | 12.8    |
| Sep              | 12.1    |
| Oct              | 11.6    |
| Nov              | 11.1    |
| Dec              | 10.8    |

3. Microgrid Analysis

3.1 Standalone Grid Type

In Tantivela we opt for standalone type of grid system because standalone PV system are autonomously and
meet only specific load (electric). The standalone system is not connected to the grid and have batteries connected for the charge system. The batteries store power produced by the solar and then the electric power drawn from the batteries. DC to DC converter as used for maximum power point tracking. Impedance congruency is the major part in maximising power of the PV array. They are not intended to power operating parallel with electric utility. Figure 2 Shows the schematic diagram for standalone grid.

3.2 Maximum Power Point Tracking

Maximum Power Point Tracking (MPPT) technique is used to maximise power output. Maximum Power Point Tracking (MPPT) convey signal of power from collector panels and directs it to DC-DC solar inverter and from there directly and the remainder goes to battery bank. In Tantivela village, Perturb and Observe algorithm is used as maximum power point tracking method because in this case the controller control the potential till the power does not gain again. Perturb and Observe method depends on gain of curve of power against voltage below Maximum Power Point Tracking (MPPT). It has higher efficiency than other maximum power point methods including incremental conductance method. Figure 3 Shows the algorithm on which the Perturb and Observe maximum power point tracking works. Figure 4 Shows the graphical representation of Perturb and Observe method.

3.3 Determining the appropriate Battery, Charge Controller and Inverter

A battery transform chemical energy into electrical energy in case of discharging and transform electrical energy into chemical energy when charging. There are two types of batteries used in solar system namely: Primary which

| Solar panel tilt | (degrees) |
|------------------|-----------|
| Jan              | 55        |
| Feb              | 63        |
| Mar              | 71        |
| Apr              | 79        |
| May              | 87        |
| Jun              | 94        |
| Jul              | 87        |
| Aug              | 79        |
| Sep              | 71        |
| Oct              | 63        |
| Nov              | 55        |
| Dec              | 48        |

Table 4. Monthly optimum solar panel tilt angle (in degree)

Figure 2. Schematic diagram of Standalone Grid.

Figure 3. Algorithm of Perturb and Observe MPPT method.

Figure 4. Graphical representation of Perturb and Observe MPPT method.
includes zinc carbon batteries, alkaline batteries and Secondary: lead acid, lithium ion. Capacity is the system to measure the battery energy storage and rating is done in ampere hours (Ah) or kWh. Rated capacity - Ah, mAh. In Tantivela village we choose lead acid type battery with battery voltage 12V and battery capacity 83.4Ah\textsuperscript{6,7}.

Charge Controller controls the amount of charge been supplied to battery\textsuperscript{8}. Many a times a charge controllers also provide over discharge safety for battery by removing dc loads at low SOC. The charge controller rated continuously current must be 130\% than of the PV short circuit output current. Figure 5. Shows the schematic diagram of how the charge controller works.

Inverters are the devices that changes the DC power into AC power. When choosing the inverter one should look for higher efficiency within build MPPT system. Inverters should be low in harmonics and have longer lifespan. There are different connection for inverters namely module, string and central. Out of the three module method was opted for the connection because if any malfunctioning in one of the panel will not affect the functioning of the rest. Module method also has panel level monitoring and respond higher yield from over shadowing. The demerits of module type connection of inverters are they have complexities in installation and cost increases due to monitoring purpose.

4. Analysis in Homer

Hybrid Optimization Model for Electric Renewables (HOMER) software has been used for the analysis of the optimum combination of all the resources needed for the cost effective model of the green energy based micro grid for rural area in Tantivela\textsuperscript{8}. Figure 6 Shows the daily load profile for the village Tantivela.

The energy sources used for the green energy based model are solar energy, wind energy and biomass energy. Surette battery S6CS2P has been used for providing the supply on the days of autonomy. Figure 7 Shows the resources been used for the Hybrid Optimization Model for Electric Renewables (HOMER) software analysis of the micro grid system. Figure 8 Shows the optimum combination of the resources. Figure 9 Shows the final result of the analysis in HOMER software\textsuperscript{9,10}.

5. Result

The analysis of the resources which are to be used with proper optimal combination has been found out and the result has been tabulated\textsuperscript{10,11}. The structure should be as sufficient to provide a viable and according to the electricity market conditions\textsuperscript{12}. Table 5 Shows the cost analysis of the model been made in Hybrid Optimization Model for Electric Renewables (HOMER) software. Table 6 Shows the architecture which is most viable and cost effective for the village Tantivela.
6. Conclusion

In this paper, a model has been suggested for the village Tantivela in Gujarat. The green energy based micro grid comprises of solar, wind and biomass energy. Since it is green energy based system, hence minimum pollution and is viable to the village. As per the analysis done in Hybrid Optimization Model for Electric Renewables (HOMER) software the cost summary has been made and the total net production cost was $2,150,245 with operational cost $ 164,256 per year. Since, the cost is high, hence government can support for the setting of the micro grid. As per the architecture of the system suggested. Photovoltaic array of 150kW with wind turbine of generic 10kW and 40kw biomass is most cost-effective model as per the load demand. Similar design model can be also be designed for other region wherein grid is not possible or pot viable. These standalone grid can also be possible where the load is high and supply is less hence a small portion of load demand can be met by using renewable energy sources in that region.

7. References

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