Validating Simulation Result of Solar Hybrid System for Domestic Consumers using HOMER Software

Balaram Das, GRKD Satya Prasad, Ch. Saibabu, Swarna Prabha Sadangi

Abstract: Consumption of fossil fuel and its effect on the environment has become a major universal problem. It is therefore necessary to use renewable energy resources (RES) such as solar, wind, etc. to decrease dependency on conventional energy resources. Currently, solar rooftop PV hybrid energy systems are becoming popular to overcome the disadvantages of conventional energy sources. This paper presents a simulation-based strategy with the help of HOMER software to control the optimum utilization of renewable hybrid energy system for private buildings where it helps to maximize the building's renewable power ratio and minimizing complete net current costs and CO2 emissions so that it's a viable solution to address to the power shortage and Greenhouse gas emissions. Finally, manual calculations measured with net-meter are being validated with HOMER software and the results are more accurate with a variation of 1%.

Keywords: Combined PV, Clearness index, Solar PV, Zero Energy Buildings.

I. INTRODUCTION

A typical hybrid renewable energy system is the combination of minimum two or more than two energy sources. It is used to provide the pollution free and less cost energy and increase the system efficiency. It is popular due to it fulfill the energy requirement of rural people where regular power supply was not provided. In cities, renewable energy schemes was given preference for business or residential buildings. [1]. This article provides a comprehensive research on a economic implementation of the hybrid renewable energy system consists of PV - wind battery structure for a household load of residential building [2][6]. This will generate more output power from wind during the winter and from solar panels during the summer [4]. This hybrid system helps in increasing the efficiency and decreases the environment effect [5][6].

The suggested renewable design Solar PV system is designed to power one room with multiple loads. The simulation findings validated that the hybrid system's main load requirement of 2.760 kW hr per day composed PV system of 1.5 kW, wind turbine of 400W, inverter of 600 W, and five batteries of 200Ah [10]. Further this system can be integrated to Zero Energy buildings (ZEB) also, so that this data is a future reference to such type of projects. The concept of ZEBs is the amount of energy used in the building is coming from only renewable energy sources.

II. HYBRID SYSTEM

In fields where solar and wind trends are explicitly high, a renewable hybrid energy system composed of wind and solar becomes cost effective; otherwise they are too expensive [15]. A renewable hybrid energy system made up of wind and solar becomes cost effective in areas where solar and wind patterns are explicitly high; otherwise they are too expensive [3]. The effectiveness of getting-and-going of these sources also comes first. So before installing a hybrid system to meet our electricity requirements at home, we need to built high performance windows and lighting to minimize consumption of electrical energy [3][14]. Only then it can create sense to have a wind-solar amalgam system. Otherwise, a very big and costly arrangement will be needed [14].

The advantage of this type of system is that it can reach easily to any remote place and fulfill the basic needs of rural life where grid supply has not been reached. Energy generated by both solar and wind gears is stored for use whenever needed in a battery bank. A hybrid renewable energy system uses more than one sources of generating energy, usually wind and solar [14]. The key result of solar - wind hybrid arrangement is that it improves the reliability of the system when wind and solar power generation are arranged. The size of battery arrangement can also be moderately decreased. During the time when there is no sun, the wind is abundant [3][14].

Usually during the periods where the sun resources are more, wind speeds are constantly small. On the other end, the wind is stronger in seasons when there are fewer sun resources around. [4][5]. Unfluctuating on the same day, there are distinct patterns in airstream and solar contacts in many areas globally or in particular phases of the year [5]. A hybrid solar-wind energy system requires an compound investment than a single bigger scheme; large solar photovoltaic and wind systems are comparatively lower in cost than smaller hybrid systems [14]. But the hybrid renewable source is an outstanding choice when paramount progress is made in production and routine interactions that materialize when the solar and wind energy resources have opposite cycles and intensities on the same day or in certain seasons. [5].

Integrating power, overall efficiency can be improved by efficient devices and maintain energy for a hybrid system compared to separate tools [6]. With redundant techniques and get-up-and-go storage, achieving advanced reliability
can be skilled. Some hybrid energy system includes both, which can boost the quality and willingness of energy in the chorus.

Table 1: Loads of consumer

<table>
<thead>
<tr>
<th>Components</th>
<th>Rating</th>
<th>Quantity</th>
<th>Running hrs</th>
<th>Total energy consumption</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tube light</td>
<td>40 W</td>
<td>1</td>
<td>10</td>
<td>400W</td>
</tr>
<tr>
<td>Incandescent lamp</td>
<td>60W</td>
<td>1</td>
<td>5</td>
<td>300W</td>
</tr>
<tr>
<td>Fan</td>
<td>80W</td>
<td>1</td>
<td>17</td>
<td>1360W</td>
</tr>
<tr>
<td>TV</td>
<td>100W</td>
<td>1</td>
<td>8</td>
<td>800W</td>
</tr>
<tr>
<td>Laptop</td>
<td>60W</td>
<td>1</td>
<td>3</td>
<td>180W</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td></td>
<td>3040W=3.04 kW</td>
</tr>
</tbody>
</table>

III. IMPLEMENTATION OF PROJECT

Fig 1: Layout of project work

Fig 2: Load duration graph

Implementation of Project:

The project has been planned as per the local authority guidelines and Solar energy policy. But, before going for purchasing of the equipment, financial validation is required to invest in this type of projects.

Hence, the entire process has been simulated by using Simulation approach by integrating all real constraints of the project including local weather conditions.

IV. ANALYSIS

In fig. 2 the load duration graph is shown and the loads used in our project are for a small residential building consisting of a tube light, an incandescent lamp, a fan, a TV and a Laptop. The total running hours of different loads are 24hrs [14][12][9]. The maximum load is 230 watts for 4 hours and the minimum load is 80 watt for 12 hours. So, based on the data given in Fig. 2, an Inverter of 600 watt output can be installed for safe operation. Equation (1) can be used to find the input current given to the inverter.

\[ I_{IN} = \frac{WATT_{OUT}}{V_{IN} \times EFFICIENCY} \ldots \ldots \ldots (1) \]

\[ WATT_{OUT} = \text{Output of inverter} \]

\[ V_{IN} = \text{Voltage input to inverter i.e. 12V} \]

\[ EFFICIENCY = 87\% \text{ of inverter} \]

\[ I_{IN} = \frac{12 \times 0.87}{600} = 57.47 \text{ Amp } \ldots \ldots (2) \]

Next step is to determine the battery capacity which is equal to \( I_{IN} \times \) total running hours = 57.47 amp * 24 hrs = 1379.28 AH.

The battery storage capacity can be decided by AH rating, and it can be calculated based on the autonomy of power which the house requires. Hence, in this case depending on the load current and number of hours usage will decide the capacity of the battery. [7]

V. LOCATION AND GEOGRAPHICAL FACTORS

While selecting the wind turbine, the location, place, and other geographical factors are very important.

Project financial constraints will depend on many factors like project location, type of panels, Fill factor of panels, tilt angle of panels, maintenance features of panels, Inverter technology, MPPT features, quality of the DC cables etc..

The scope of this research paper is limited to the assessment of Solar PV power with grid integration, hence the above all selection criteria features are predefined as per the HOMER software constraints.

Solar Radiation

The solar radiation in buildings site is reaching 5.4 kWh/m² in summer season and in winter and rainy season it is around 3.2 kWh/m². The annual average of solar radiation is estimated to be around 4.4 kWh/Sq.m. By analyzing diffusion and sky clearness index the percentage of solar radiation further reduces to around 10%.
Below Fig. shows the clearness and daily radiation of PV array for different month of a year[16]. This one is found by taking the latitude which is 18.9 and longitude of 89.0 of Gunupur town. Based on this the Clearness and daily radiation is found from January to December. It was found that Clearness is highest in the month of February with Daily radiation of 5.494 kWh/m2/d But daily radiation is more in the month of April with clearness of 0.591 index.

Grid energy of 1105 units purchased which is 37% of total units produced. Out of total energy 1847 kWh/yr is consumed by AC primary load which is 66% of total energy and 956 kWh/yr of energy sold to grid which is 34% of total energy.

<table>
<thead>
<tr>
<th>Month</th>
<th>Units Purchased (kWh)</th>
<th>Units sold (kWh)</th>
<th>Total Purchases (kWh)</th>
<th>Max. demand (kW)</th>
<th>MD Charge ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>January</td>
<td>104</td>
<td>104</td>
<td>0</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>February</td>
<td>77</td>
<td>99</td>
<td>.22</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>March</td>
<td>90</td>
<td>109</td>
<td>.19</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>April</td>
<td>85</td>
<td>97</td>
<td>.12</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>May</td>
<td>84</td>
<td>87</td>
<td>.3</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>June</td>
<td>95</td>
<td>48</td>
<td>48</td>
<td>1</td>
<td>7</td>
</tr>
<tr>
<td>July</td>
<td>97</td>
<td>48</td>
<td>48</td>
<td>0</td>
<td>7</td>
</tr>
<tr>
<td>August</td>
<td>105</td>
<td>50</td>
<td>55</td>
<td>0</td>
<td>8</td>
</tr>
<tr>
<td>September</td>
<td>95</td>
<td>65</td>
<td>30</td>
<td>0</td>
<td>6</td>
</tr>
<tr>
<td>October</td>
<td>90</td>
<td>85</td>
<td>4</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>November</td>
<td>90</td>
<td>79</td>
<td>10</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>December</td>
<td>93</td>
<td>87</td>
<td>6</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>Annual</td>
<td>1105</td>
<td>959</td>
<td>146</td>
<td>1</td>
<td>63</td>
</tr>
</tbody>
</table>

Table shows the amount of energy purchased and sold in each month of a year. It is found that in the month of August highest energy purchased i.e. 105 kWh and in the month of February lowest energy purchased which is 77 kWh. Highest energy sold in the month of March i.e 109 kWh where net purchase is -19 kWh and lowest energy sold in the month of June and July where net purchase is +48 kWh. So total energy purchased is 1105 kWh and total energy sold is 959 kWh with net purchase of 146 kWh. Similarly, with the option of Net metering, the number of units generated in system either exporting or importing will give a option to the consumer about the idea of battery usage. A net metering option is always preferable comparing to the battery investment and its overall maintenance. Each State is having its Net metering policy and as per rules and regulations the system can be integrated to the grid and in an overall the benefits will be more by comparing with the overall investment of the system.

VI. RESULT AND DISCUSSION

Above figure, concludes that the simulation result of average by monthly wise electric production of a hybrid system. The system is connected to 1000 kW Grid and 1.25 kW Photo Voltaic system. Apart from that 1kW Inverter and 1kW of rectifier is also connected in the system. It shows how much fraction of total energy used from renewable energy used. It is found that out of total energy production, PV array produce 1898 units which is 63% of total energy produced, and from

VII. CONCLUSION

The hybrid Energy system integrated with grid for a domestic house is validating with simulation result as indicated in results. Hence, before planning for any solar rooftop either off-grid and on-grid HOMER simulation is giving best results.

A manual measurement of energy generated in a given month are almost matching with the simulation result with HOMER. Hence, with this approach for any design of large-scale PV system can be designed before project real implementation.

For Detailed Project Report (DPR) this type of approach is very useful for manual analysis by authenticating with simulation method.

REFERENCES

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Balaram Das received B.Tech (EEE) from & M. Tech in ECE, from BPUT with First Class. At present working as Associate Professor in Department of EE, GIEIT University. He is a Life member in ISTE, SESI, CSI and IE. His area of interest is Power systems, Renewable power systems, Zero Energy Building, and Predictive Maintenance.

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