SCOPE OF WIND-SOLAR HYBRID SYSTEM AS RENEWABLE ENERGY SYSTEMS IN INDIA

Akhilesh P. Patil, Rambabu A. Vatti, Anuja S. Morankar

Department of Electronics and Telecommunication Engineering/Vishwakarma Institute of Technology, Pune, India

ABSTRACT

Energy demand is increasing day by day all over the world. Due to this demand, the reserves of fossil fuels like coal, oil and natural gas are depleting rapidly. To cope up with this unbalancing situation, we should keep more optimistic view about the renewable energy sources. The sources like solar, wind, hydro have the substantial capabilities to compensate for the increasing energy demands. As far as India is concerned about its geographical location, it has the abundant source of solar energy (about 5,000 trillion kWh/year) as well as wind energy (about 300 watts/m²). But both of these energy sources have some disadvantages, to counteract with them, the efficient way to use the sources is by combining them. The technique is called solar-wind hybrid energy source. The paper is survey of solar and wind energy sources as independent sources. It gives general idea about hybridization of these sources to increase the efficiency.

Keywords: Renewable Energy, Small Wind Energy (SWE), Hybrid Systems, Central Electrical Authority, Solar Photovoltaic (PV)

1. INTRODUCTION

India is predominantly a low wind speed country although the western and southern states have average wind density of 300 Watts/m²[1]. The solar radiation received by India is around 4,980 trillion kWh/year. India has around 270 sunny days in most part of the country. The average insolation received by India is about 5.5 kWh/sq. meter over a horizontal surface. Thus Solar PV is a very important power source for meeting rural electricity demand[1]. Although it is quoted that India’s Wind energy potential is 45,000 MW. This holds good for Wind farm development but should not be a deterrent for SWE (Small Wind Energy)[1]. The advantage with independent SWE is that it can be installed wherever open space is available and at a height of 15 meters so that wind is captured sufficient enough to excite a generator to produce power so as to increase the efficiency.
According to the progress report of rural electrification provided as on 31/3/2013 by the Central Electrical Authority 33,466 out of 5,93,732 remain un-electrified. So it is expected that this technique can overcome the energy crisis in India[2].

2. SURVEY OF WIND ENERGY IN INDIA

Winds in India are typically influenced by the strong South-West Summer Monsoon winds between April to September and the weaker North-East Winter Monsoon winds.

In India there are a total of around 1100 wind monitoring stations located in 33 states and union territories established. States with high potential for wind energy include Andhra Pradesh, Gujrat, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Rajasthan, Tamil Nadu. There are total of 233 sites with annual wind power density greater than 200 Watts/m$^2$[3].

2.1 Wind survey of Pune and Nasik

In this paper we have selected two locations for the purpose of analysing the wind and solar data which are Pune and Nasik.

![Wind Speed in Pune, Maharashtra, India](image1)

**Fig 1:** Wind speed in Pune (m/s)[4]

![Wind Speed in Nasik, Maharashtra, India](image2)

**Fig 2:** Wind speed in Nasik (m/s)[5]
From the two graphs above it can be said that during the months of April-August there is a high potential for harnessing wind energy in these two areas by the small wind generators which can operate within these wind speeds since their cut-in wind speed requirements are managed.

However there are certain drawbacks associated with the wind power generation. Firstly the strength of the wind is not constant due to which the power generated varies greatly and also wind generating systems cannot work in stormy situations. Secondly, Large Wind turbines are noisy, so wind farms are located quite far away from human settlements. Furthermore wind power system cannot be installed in states such as Jammu and Kashmir even when there is great scope for wind power generation but the difficulties in terrain pose a problem.

3. SURVEY OF SOLAR ENERGY IN INDIA

India is densely populated and has high solar insolation, an ideal combination for using solar power in India. In Rajasthan large solar project has been proposed to cover around 35,000km$^2$ area of the Thar desert and it is estimated that it would generate around 700 GW to 2100GW[6].India ranks $7^{th}$ in PV cell production and $9^{th}$ in solar thermal power generation. This increase in capacity is due the greater contribution by the private sector in the manufacturing of solar energy devices. The growth of Indian solar energy sector is expected to be around 25% every year.

The largest solar PV plant in the world is the Agua Caliente Solar Project installed in USA having the capacity of 397 MW when complete. In India the largest solar PV plant is the Charanka Solar plant in Patan district of Gujarat having the capacity of 214 MW.

3.1 Solar Irradiation Survey of Pune and Nasik

In this paper we have selected two locations for the purpose of analysing the wind and solar data which are Pune and Nasik. 

![Solar Irradiation in Pune, Maharashtra, India](image)

**Fig 3: Solar Irradiation in Pune(kWh/m$^2$/day)[7]**
Due to the combination of the Small wind Generator and Solar PV systems, the hybrid system presents a number of advantages over traditional systems:

- Higher Efficiency: Due to the combination of the two the efficiency is increased as power is now generated by the two sources.

**4. EFFECT OF COMBINATION**

From the two graphs above it can be said that during the months of February -May there is a high potential for harnessing solar energy in these two areas by using the Solar (PV) panels. However there are certain drawbacks associated with the solar energy generation. Firstly it can be harnessed only when it is daytime and sunny. Secondly the solar collectors, panels and PV cells are relatively expensive to manufacture due to the highly sophisticated process (especially in PV cells manufacturing).

Moreover, Solar power is used to charge batteries so that solar powered devices can be used at night. However, the batteries are large and bulky and need storage space. They also need replacing and maintenance from time to time.

Hence to compensate for these drawbacks, we have to combine both these that is Solar and Wind resources to get energy more efficiently.

**Fig 4: Solar Irradiation in Nasik (kWh/m²/day)[8]**

![Solar Irradiation in Nasik](image)

**Graph 1: Power curve of wind turbine**

![Power curve of wind turbine](image)
Graph 2: Sample solar (PV) generation for a 1kW unit for a day in summer.

Graph 3: Wind solar Combined power generation.

From the above Graph 3, this system configuration is ideal for months March to Aug. These above readings are average for the month. The wind energy and sun shine radiation & hours may differ depending upon local conditions such as pollution in air, new obstructions, solar panel cleaning frequency etc. The availability depends upon the functioning of System as per specifications which in turn will depend up on maintenance scheduling, spare parts availability, aging parts replacement which has to be taken care in life cycle management of the project over 20 years minimum.

Thus since the power generated by the hybrid system is more than the standalone Solar(PV) systems or Wind energy Systems, the efficiency of this system is more as compared to individual solar and wind.

- Cost Efficiency and Reliability: Since two power sources are used in the Hybrid –systems the reliability is increased and the total dependence on one technology is reduced. The system is also more cost efficient when compared to only solar as the cost of installing large PV panels is higher as compared to the cost of installing PV panels along with wind generators.
- Repair and Maintenance: Repair and maintenance is less as even if one source goes down we can still rely on other source for power generation.
5. INSTALLATION CAPACITIES AND CONFIGURATION

The table below shows the total installation capacity in terms of KW and the individual capacities for the solar(PV) and wind energy system, along with the battery requirements.

<table>
<thead>
<tr>
<th>Power</th>
<th>1.5kW</th>
<th>4 kW</th>
<th>10 kW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wind Turbine</td>
<td>1kW</td>
<td>3 kW</td>
<td>5 kW</td>
</tr>
<tr>
<td>Solar Panel</td>
<td>500W</td>
<td>1 kW</td>
<td>5 kW</td>
</tr>
<tr>
<td>Wind/PV Hybrid Controller</td>
<td>1.5kW</td>
<td>4 kW</td>
<td>10 kW</td>
</tr>
<tr>
<td>Inverter</td>
<td>2kVA</td>
<td>5 kVA</td>
<td>12kVA</td>
</tr>
<tr>
<td>Batteries(12V,200AH)</td>
<td>4pcs</td>
<td>16 pcs</td>
<td>24 pcs</td>
</tr>
<tr>
<td>Energy Produced approx.(kWh)</td>
<td>220kWh per month</td>
<td>640 kWh per month</td>
<td>1440 kWh per month</td>
</tr>
</tbody>
</table>

Table 1: Installation capacities[9]

The Hybrid system works efficiently in remote industrial or commercial work stations such as military and railways where grid power is frequently in a short supply due to the remoteness of the areas.

From the data obtained from Table 1, considering a 4kW Hybrid system which generates around 640kWh per month the daily power generation accounts to be around 21kWh. The consumed units per-month for a small rural household is around 280 kWh (considering only day to day essential appliances such as tube lights, fan, refrigerator, television sets etc.) so the daily consumption is 9.33kWh, so there is a surplus of around 11.6kWh which can be sold to the electricity company such as MSEB at their fixed rate.

The cost of installation of a Wind solar hybrid system is around Rs 2.5lakh/kW (according to the data by MNRE). So for a plant of 4kW the cost is Rs 10 lakh. The MNRE provides subsidies at rate of Rs 1.5lakh/kW, so for a 4kW plant the subsidies are around Rs 6 lakh thus making the actual installation costs around 4 lakh.

The wind solar Hybrid system is a one-time installation system with less maintenance costs and once the cost of installation are paid off the system can supply energy at nearly free cost.

5.1 Chances of failure
The wind solar hybrid system works efficiently the whole year except for the situations when both sun and wind are not available to make the system work. (eg. on a night with very low wind speeds, or on a hazy or cloudy day). In such cases the batteries can be charged by taking the electricity from the grid.

5.2 Areas over the World where the System can be installed
The wind solar hybrid system can be installed in the areas where there is sufficient sunlight throughout the day and average wind speeds in the range of 5-10m/s or more. The wind speed should be more than the cut-in Wind speed (varies according to the manufacturer) for the turbine to work.
The countries like Australia, United States of America, Canada, Germany, Spain, India, and China have tremendous potential for the wind solar hybrid system installation. In India states of Maharashtra, Goa, Rajasthan, Gujarat, Andhra Pradesh, Karnataka, Kerala, and Tamil Nadu have tremendous potential for the wind-solar hybrid systems. A cumulative capacity of 1647 kW of wind–solar hybrid system has been installed. The states of Maharashtra ranks first with a total cumulative of 1034 kW, followed by Goa, Manipur, West Bengal and Punjab [6].

6. METHODS TO INCREASE THE EFFICIENCY OF THE HYBRID SYSTEMS

To increase the efficiency of the overall solar–wind hybrid system, technique called as Maximum power point tracking (MPPT) can be used. This tracking technique can be useful for both the solar as well as wind energy generation and increasing their corresponding efficiencies.

In case of wind energy systems the Maximum power point tracking controllers can be used to track the maximum power from the power generated by the Wind Energy Conversion Systems (WECS) . The MPPT controllers used for the Wind Energy can be stratified as , power signal feedback (PSF) control, tip speed ratio control (TSR) and hill-climb search (HCS) control[10].

In case of Solar energy these are used to track the solar radiation patterns in such a way so that we can get the maximum output power. The Maximum Power Point Tracking system is not a mechanical tracking system since there is no physical movement of the module, but it is an electronic system that automatically tracks the maximum power point[11][12].

7. CONCLUSION

The paper concerns with the Importance of the renewable energy sources specifically the solar and wind, the need for their combination to make a hybrid system so that they can counteract each other’s drawbacks and come up with a solution to tackle the limitations of the seasonal variations. This will increase the overall efficiency of the system. The graphical representation of this hybrid system as well as its statistical analysis of the availability of solar and wind energy in India emphasizes the usability of the system. To gain the overall gain of the system, techniques like MPPT can be used.

8. REFERENCES

[1] Jaideep N. Malaviya:”Wind-Hybrid Systems and Rural Electrification: Experiences from India

[2] Rural Electrification In India –report by Central Electrical Authority as on 31/3/2013


[10] Jogendra Singh Thongam and Mohand Ouahrouche, Department of Renewable Energy Systems, STAS Inc. Electric Machines Identification and Control Laboratory, Department of Applied Sciences, University of Quebec at Chicoutimi Quebec Canada: MPPT Control Methods in Wind Energy Conversion Systems


