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Integration of PV-Wind Energy to Irrigate the Local Farming - A Step to Sustainable Farming

Sumandeep Singh
Rimt University, India

Abstract: Wind power plant are the power plants where the kinetic energy of flowing wind is converted to electrical energy by the coupled unit of turbine and generator. The energy output from these kind of power plants are dependents upon the wind speed. On the other hand the standalone solar photo-voltaic system, with a reputation being inexhaustible and environmentally benign, has been widely used for power generation.

The cost competitiveness of solar PV is likely to get even more obvious, particularly when compared with the continuous rising of conventional fuel prices and rapid decline of PV module prices. In this study, wind turbine is introduced for the standalone solar systems.

The aim and objective is to generate the power to operate the irrigation project, in summer time more water is required and more insolation is required and vice versa. The study finds the optimized size of such power plant and also investigates economic aspects of such power plant.

I. INTRODUCTION

Wind energy plant are the power plants which produces clean energy. Where the kinetic energy of flowing wind is converted to electrical energy by the coupled unit of turbine and generator. The energy output from these kind of power plants are dependents upon the speed of wind.

The most important supplier of energy for the earth is the sun. The whole of life depends on the sun's energy. It is the starting point for the chemical and biological processes on our planet. At the same time it is the most environmentally friendly form of all energies, it can be used in many ways, and it is suitable for all social systems [1].

Solar PV systems are usually intermittent, unpredictable and weather dependent. Therefore, a continuous and reliable power supply is hardly possible without energy storage.

By employing an energy storage system (ESS), the surplus energy can be stored when power generation exceeds demand and then be released to cover the periods when net load exists, providing a robust back-up to intermittent renewable energy [2]. The ESS is thus a critical component and powerful partner to ensure sustainable supply of renewable energy [3], and the European Commission finds it will play a key role in enabling the world to develop a low-carbon power supply system [4].

Reserve of fossil fuel is depleting as a result the conventional energy sources will be obsolete in near future. Moreover the ill effect of conventional system makes the scenario more worse. In this backdrop the present work try to evaluate the optimal size of PV-Biomass hybrid system to cater the need of a local community in Punjab, India.

Moreover in developing countries like India, the government policies are more lenient towards installation and development of more renewable energy. The proposed site is also suffer from low quality of power as here due to heavy industrialization the power fluctuation is more. In this backdrop the prosed model try to find out optimal size of hybrid system, which can provide clean, green, reliable, high quality and cost competitive energy supply.

A. Modeling of the System

The operating principle of the hybrid solar with windmill can be briefly described as follows. The wind and solar system works in simultaneously to produce the energy required by the load. During the time of excess energy production the battery stores the energy and during deficit it is taken from the battery to cater the load. In this way, a reliable and sustainable energy supply would be guaranteed for 24 h a day if the charging and discharging rates as well as the capacity are sufficient.

The primary components of the system is PV array, wind turbine, balance of system as inverter and converter.

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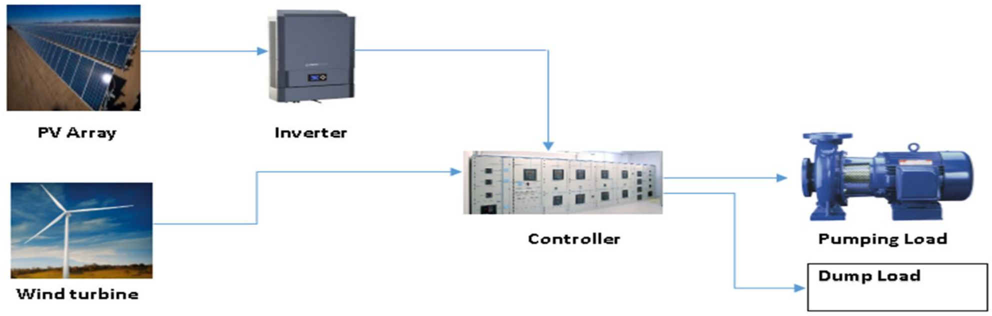

Fig. 1 PV-wind hybrid system

B. *Load Profile*

The proposed system is designed to serve a daily load of 281 kWh/day with a peak load of 56 kW. However, the actual load demand on the site is not measured. Besides, the power demand will rise due to the increasing number of pump load in near future. The system is mainly design to cater the load demand of the agricultural load to run the pump of that locality. Therefore in this study the daily base load to be served by the proposed scheme is assumed as 281 kWh/day and then synthesized in HOMER software by adding randomness of day, to create a quite reasonable load profile. And for simplicity the seasonal variation of load is not considered. The load of the proposed scheme is taken as constant in all the months for the simulated year.

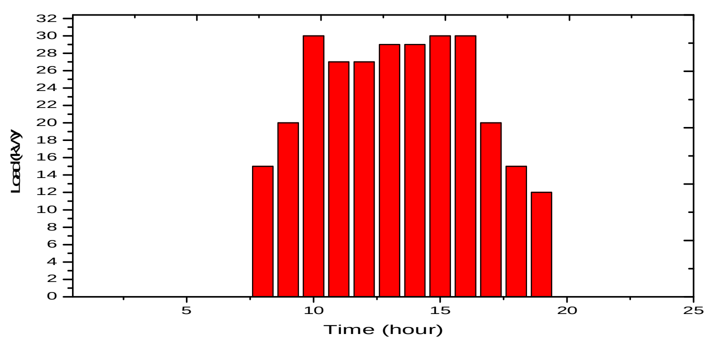

Fig 2 Hourly load demand

C. *Solar Energy Resource*

For the proposed scheme solar energy plays an important role. With the advancement in technology the power production from the PV array is increasing. The power production from the PV array is dependent on the weather condition at which it is being installed. Typical variation of solar radiation in India is found to be 4-6 kWh/m^2/day. The study is conducted at 30.33 degree latitude and 76.38 degree longitude. And for the proposed site monthly average daily solar radiation found to be 5.12 kWh/m^2/day with clearness index of 0.588, the installed capacity of the PV array is 200 kW$_P$.

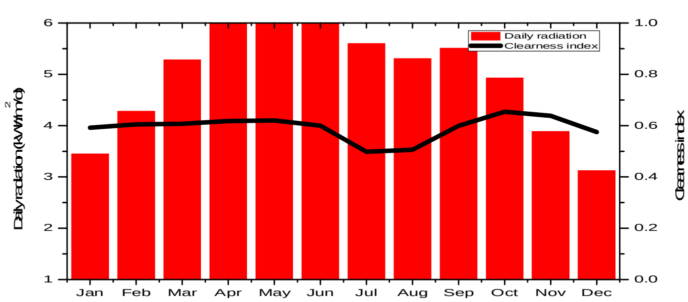

Fig. 3 Monthly variation in solar radiation and clearness index

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D. Wind Resources

Wind and solar PV array are the two power production unit for the proposed scheme. The power output from the PV array is dependent on the weather condition. And also the generation in power production variation in not possible for the PV array. For mitigating the intermittent properties wind is integrated with the PV system. The figure shows the wind speed available for running the wind mill on the proposed site.

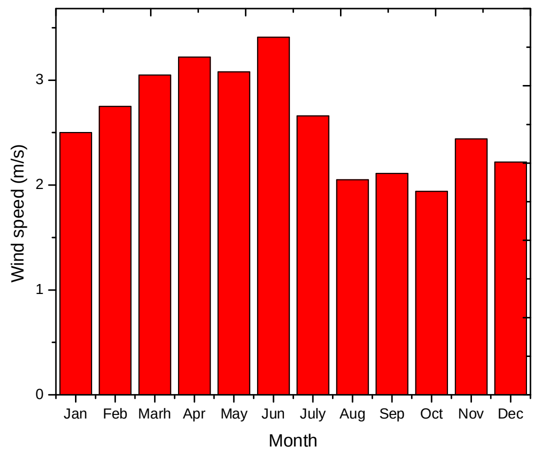

Fig. 4 Wind speed at the proposed site

E. Energy Consumption Of Four Typical Days In A Year

The electricity consumption on the proposed site is estimated as 128 MWh/day. The above fig. represents example of load profile for four different seasons. 1st march is taken as a typical day which represents spring season, similarly for summer 1st may is considered, 1st July represents monsoon season and 1st February represents winter season. The peak load demand occurs during the day time because of the pumping action.

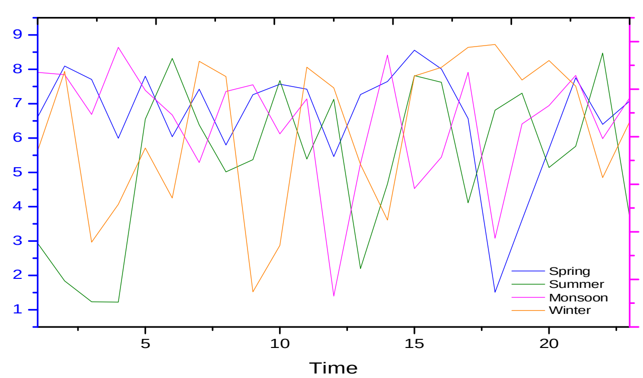

Fig. 5 Electricity consumption of four typical days in a year

According to the weather at the proposed site the different seasons are as follows

1) *Summer:* mid-April to mid-June
2) *Monsoon:* mid-June to mid-August
3) *Autumn:* mid-August to mid-October
4) *Late Autumn:* Mid-October to mid-Decembe
5) *Winter:* Mid-December to mid-February
6) *Spring:* Mid-February to mid-April

F. Water Pumping Capacity

Assuming 10 meter depth of bore well the water lifted on each month is described here. It is evident that during summer the water lifting capacity is more due to availability of huge insolation at the propose site and during winter its less. Its describing the complementary nature of the system.

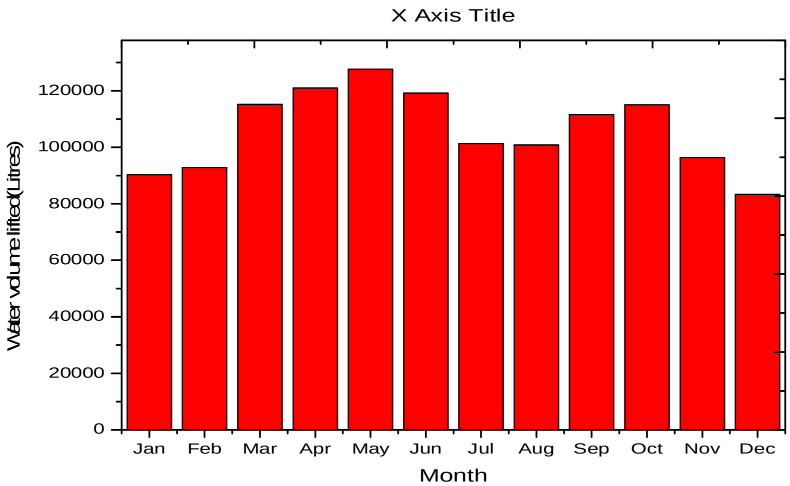

Fig. 6 Water volume lifted

G. Economic Analysis

PV (kW)	AIR	Conv. (kW)	Initial Capital	Operating Cost ($/yr)	Total NPC	COE ($/kWh)	Ren. Frac.	Capacity Shortage
40	1	10	$ 1,172,500	167,175	$ 3,309,552	7.780	1.00	0.80
45	1	10	$ 1,225,000	167,175	$ 3,362,052	7.699	1.00	0.79
47	1	10	$ 1,246,000	167,175	$ 3,383,052	7.678	1.00	0.79
48	1	10	$ 1,256,500	167,175	$ 3,393,552	7.669	1.00	0.78
49	1	10	$ 1,267,000	167,175	$ 3,404,052	7.661	1.00	0.78
50	1	10	$ 1,277,500	167,175	$ 3,414,552	7.655	1.00	0.78
40	2	10	$ 1,225,000	175,753	$ 3,471,715	8.159	1.00	0.80
45	2	10	$ 1,277,500	175,753	$ 3,524,215	8.068	1.00	0.79
47	2	10	$ 1,298,500	175,753	$ 3,545,215	8.043	1.00	0.79
48	2	10	$ 1,309,000	175,753	$ 3,555,715	8.033	1.00	0.78
49	2	10	$ 1,319,500	175,753	$ 3,566,215	8.024	1.00	0.78

Fig 7 Optimization result of pumped storage

The first 3 column shows icon , next three column indicate number or size of each component, the next six column shows key simulation results, such as capital cost of the system, operating cost, Net present cost, levelized cost of COE, renewable fraction and capacity shortage. The optimal configuration is the one having lowest NPC which comprises of 40 kW_P PV, 1 kW_P wind turbine, 5 kW converter. The COE is found to be 7.28/kWh and100% renewable fraction and capacity shortage of 37%.

II. CONCLUSION

In this study the integration of wind mill in PV system is examined. The results are showing successful integration of the scheme. It concludes that with the integration, the power output of the system increases, the two schemes integrated in the study are also complementary in nature, the capacity shortage is 37% which also increases reliability of the scheme, the levilised cost of energy is decreased from 8.50 INR/kWh to 7.28 INR/kWh, proposed scheme is also having negligible emission and hence ecofriendly.

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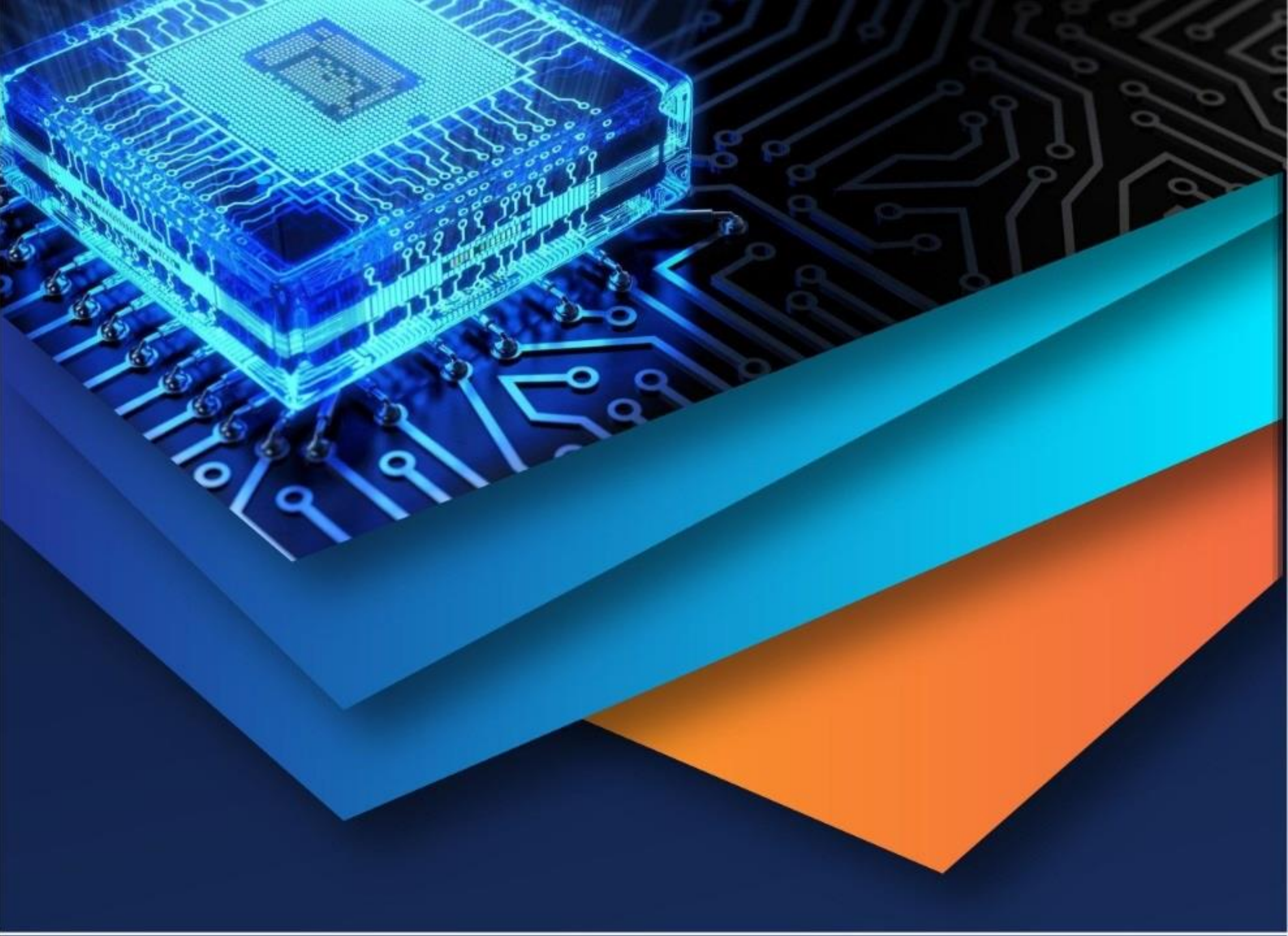

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