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Statistical analysis of solar-wind hybrid system using SYSTAT software

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ABSTRACT

Energy plays an indispensable role in modern society. We all depend on a constant and reliable supply of energy - for our homes, businesses and for transport. Most of the renewable energy comes either directly or indirectly from sun and wind and can never be exhausted. It can be expected that possible applications of hybrid systems could be considered for the efficient utilization of these resources round the year together with possibilities of obtaining Carbon credits in the Carbon Trading. In this research paper, experimental data consisting of hourly records over a specified period were recorded in the Energy Park of UIT-RGPV Bhopal for a 1.6.kW SPV- Wind Hybrid System and Feasibility analysis is done using SYSTAT software.

Key words: Solar energy, Wind energy, Solar -Wind hybrid systems, SYSTAT software,

INTRODUCTION

There is rising need for alternate and renewable sources of energy, especially in developing countries, whose progress and economic growth may strongly be indexed to its development. With the ever increasing growth in energy consumption and rapidly depleting fossil fuel reserves, it is feared the world will soon exhaust its fossil fuel reserves. The electrification level in rural areas in south East Asia is about 51%, compared to 90% in urban areas. (Shrestha RM, 2004) It is estimated that wind power in many countries is already competitive with fossil fuel and nuclear power if social/environmental costs are considered. (Beurskens, 2001).

This paper provides a framework for understanding correlation between two power sources. The objective of the current work is to provide a way of using and relating continuous renewable energy sources. The hybrid system is a combination of two energy system or power system. In hybrid system use two or a more fuels for the same device. It is a continuous power generation system for time when intermittent renewable resources, such as wind and solar, are unavailable. The hybrid system provides continuous uninterrupted power supply throughout the year. As the availability of the above power sources is mainly depend on the environment condition. And due to the complementary nature. Only one power source available at a time. The hybrid system provide stable output in case of fluctuating source and it is minimizes the dependence of the output due to seasonal change. Hybrid system can make more reliable sense than that of the wind, solar or biomass alone. (Ulgen K., Hepbasli Arif2003)

Methodology

In the proposed renewable work various statistical analysis methods are used to find out

mean variance and standard deviation result the data related to solar and wind power resources is collected from whiter and monitoring seasons installed at Rajiv Gandhi Proudyogiki Vishwavidyalaya (RGPV) Bhopal .the data which we obtained analyses by using Systat software is generally used for plotting various interactive graph, mathematical modeling for performing various statistical analysis. It is very user friendly software is that the potential of power sources of solar and wind is adequate at Bhopal site .but problem is that both are complimentary (only one power source available at time) hence to obtain smooth and sustainable power source data with respect to mean value throughout the year is to be analyses. This analysis will provide roadmap guide line to the future research work. Sigma Stat 3.5 provides a wide range of powerful yet easy-to-use statistical analyses specifically designed to meet the needs of research scientists, engineers, and statisticians, without requiring in-depth knowledge of the math behind the procedures performed. Sigma Stat® 3.5 provides a wide range of powerful yet easy-to-use statistical analyses specifically designed to meet the needs of research scientists, engineers, and statisticians, without requiring in-depth knowledge of the math behind the procedures performed. This chapter describes the organization of this manual and introduces you to most Sigma Stat features. It also covers some basics about using Sigma Stat.(www.systat.com) The correlation between the Solar Power availability and the Wind Power availability can best be explained by calculating the correlation coefficient. (Togrul, M.C. Tris and I.E. True. 1996)

EXPERIMENTAL

A typical solar PV wind hybrid system is having following major components.

- Solar photovoltaic modules
- Mounting structures for solar Photovoltaic modules
- Junction Boxes
- Solar charge controller
- Photovoltaic Batteries
- Wind generator
- Wind charge controller
- Inverter unit
- Installation kits
- Interconnecting cables
- Earthing kit

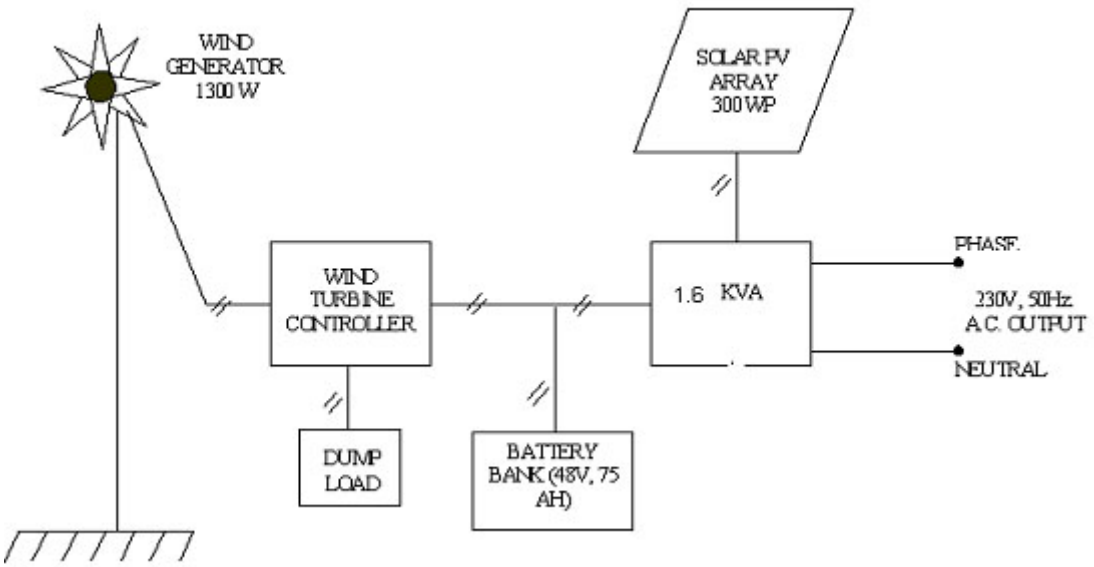

Fig. 1: kW solar, wind hybrid system

Instrumentation used for data collection from the Solar- wind hybrid system includes Anemometer, Radiation Pyranometer, Temperature recorders and weather monitoring station etc. (Pecen Recayi etal 2004).

The existing 1.6 kW Solar - wind hybrid system installed at the Energy Park of RGPV is schematically shown at Fig.1. The system consists of 0.3 kW solar arrays and 1.3 kW wind electric generator. The battery bank is of 75 Ah and the inverter together with Power conditioning unit provides AC out put at 220 V and 50 Hz. The output from the system is fed to street lighting system of the university providing sustainable power for over 8 hours every night.

Efforts are under way to couple this system with 10 kW biomass Gasifier and a Fuel cell for various R & D projects being taken under the guidance of Ministry of Non Conventional Energy Sources (MNES). For long time operations and consistent records, daily and even monthly averages are better representative figures. (Gunes, M. 2001).

Operation of the system

The Solar radiation falling on the modules is converted in to electricity by photovoltaic principle. The generated current is used to charge the battery bank. Energy generated will be maximum when the solar insolation is maximum vice versa. Accordingly average peak sunshine hours of 5.0 Peak hours/ day have been considered. Energy generated by the module is stored in the battery bank by charging the battery bank. Solar charge controller accomplishes this. The Solar charge controller does the function of charging the battery bank along with preventing battery from overcharged or over discharged. Wind generator on the other side also charges same battery bank through wind charge controller. Interface consisting of a step up gear and a coupling transmits the rotary mechanical energy to an electrical generator. (M. Akhlaque Ahmad, 2006) The output of generator is connected either to load or power grid. The purpose of controller is to sense wind speed, wind direction, shafts speeds and torques, output power and generator temperature. A weather monitoring station is installed in Energy Center University Institute of Technology Bhopal. This gives various data such

Table 1: **Field Trial Run of 1.6 kW Solar -wind hybrid System at the Energy Park of the RGPV Bhopal**

Month	Wind Speed m/s @ 18 m height	Wind Generator O/p in kWh	PV O/P kWh	Total kWh	Total internal Load kWh	Excess kWh
Jan 07	3.10	39.2	35.6	74.80	73.0	1.80
Feb 07	3.10	39.2	37.8	77.00	73.0	4.00
Mar 07	3.10	39.2	39.3	78.49	73.0	5.49
Apr 07	3.10	39.2	36.9	76.12	73.0	3.12
May 07	3.10	39.2	37.4	76.63	73.0	3.63
Jun 07	5.40	177.6	30.7	208.34	73.0	135.34
Jul 07	5.40	177.6	22.2	199.82	73.0	126.82
Aug 07	5.40	177.6	21.1	198.68	73.0	125.68
Sep 07	4.90	147.2	25.6	172.85	73.0	99.85
Oct 07	3.60	61.6	37.1	98.70	73.0	25.70
Nov 07	3.10	39.2	37.3	76.47	73.0	3.47
Dec 07	3.10	39.2	34.7	73.87	73.0	0.87
TOTAL	3.9 (avg.)	1016	395.8	1411.8	876	

as wind speed, wind direction, temp, rainfall condition etc. The battery bank is sized to provide load energy requirement for minimum of 3 days of autonomy (2 no sunshine/cloudy days) the battery bank shall be discharged up to 80% of depth of discharge. Energy stored in the battery bank is DC type. This DC energy is inverted using an inverter to get AC supply (Hepbasli A, 2004).

The set up of hybrid system consist of two power sources solar and wind. These two systems are combine and generating power throughout the year. The solar and wind data is collected from Field Trial Run of 1.6 kW Solar -wind hybrid System at the Energy Park of the RGPV Bhopal.

These sources are combined. Which is generate AC voltage and then can be transfer in DC voltage to charge the battery. The controller protects battery from overcharging or a discharging. the inverter used to change DC voltage to AC voltage depending upon using power at different sources. (Ding J, Buckeridge J S, 2000)

Statistical Analysis

Mean

The mean is the average value for a column. If the observations are normally distributed, the mean is the center of the distribution. The arithmetic mean, or average, of all the cells in the column, excluding the missing values. This is defined by:

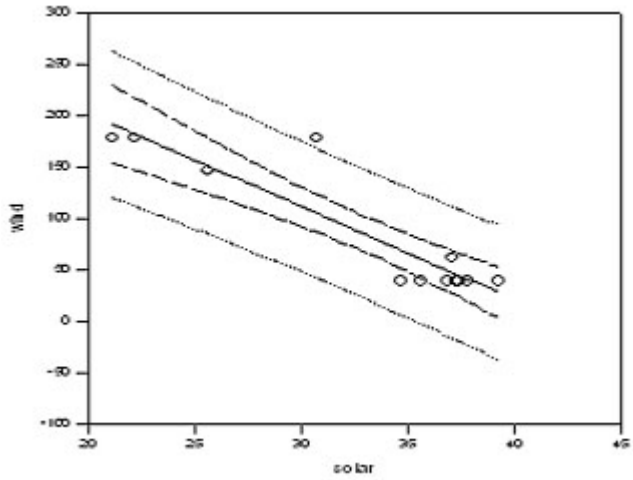

Fig. 2: Simple scatter plot

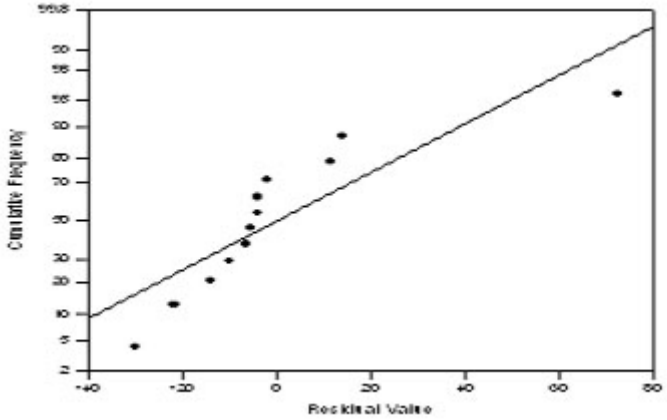

Fig. 3: Normal probability plot

$$X=1/n\sum_{i=1}^{n}X_i$$

Standard deviation

Is a measure of data variability about the mean. The sample standard deviation is defined as the square root of the mean of the square of the differences from their mean of the data samples xi in the column. Missing values are ignored

$$S=[1/n\text{-}1\sum_{i=1}^{n}x_i-\bar{x})^2]^{\frac{1}{2}}$$

Standard Error

The standard error is the standard deviation of the mean. It is the sample standard deviation divided by the square root of the number of samples. For sample standard deviation

$$\text{Std Err} = S\sqrt{n}$$

The mean square within groups (also called the residual or error mean square)is

$$\frac{\text{sum of squares between groups}}{\text{degrees of freedom between groups}}=\frac{SS_{between}}{DF_{between}}=MS_{between}$$

The mean square within groups (also called the residual or error mean square

$$\frac{\text{sum of squares within groups}}{\text{degrees of freedom within groups}}=\frac{SS_{within}}{DF_{within}}=MS_{within}$$

F Statistic

The F test statistic is the ratio:

$$\frac{\text{estimated population variance between groups}}{\text{estimated population variance within groups}}=\frac{MS_{between}}{DF_{within}}=F$$

RESULTS AND DISCUSSION

Multiple Linear Regressions

Multiple regressions are a mathematical technique used in both technical and fundamental analysis. The technique uses a number of variables to predict some unknown variable. If for instance it was felt that the growth rate, debt to equity ratio and the yield of a stock might be useful in predicting a valid range for a price earnings ratio, then multiple linear regression would be used by a financial analyst with a range for each input, producing a range of possible Price/Earnings ratios that might be supported by the current and projected fundamentals of a stock or stocks in question (Ray M., Sharma H.S. 2001)

The dependent variable can be predicted from a linear combination of the independent variablesSOLAR <0.001

All independent variables appear to contribute to predicting (P < 0.05).

Multiple Linear Regression

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Data source: Field Trial Run of 1.6 kW Solar -wind hybrid System
WIND = 40.812 - (0.0925 * solar)
N = 12

R = 0.913	Rsqr = 0.834	Adj Rsqr = 0.818			
Standard Error of Estimate = 2.759					
Coefficient	Std. Error	t	P	VIF	
Constant	40.812	1.361	29.992	<0.001	
SOLAR	-0.0925	0.0130	-7.098	<0.001	1.000
Analysis of Variance:	DF	SS	MS	F	P
Regression	1	383.489	383.489	50.380	<0.001
Residual	10	76.119	7.612		
Total	11	459.608	41.783		

Normality Test

Passed (P = 0.474)

Constant Variance Test

Passed (P = 0.117)

Power of performed test with alpha = 0.050: 0.996

CONCLUSION

In this paper taking Solar -wind hybrid energy system consisting two or more renewable energy and provide good stability of power. And due to the complementary nature. Only one power source available at a time. This software correlates the two power source solar and wind and gives a positive result for its relation. And give all results are Passed like Normality Test, Constant Variance Test, etc. The collected data from Field Trial Run Solar -wind hybrid System at the Energy Park of the RGPV Bhopal analyzed in order to plan for the structure of the system.

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