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A Comparative Analysis of Actual System with Simulation based Model for Solar/Wind Source
(A Solution To Electrical Shortfall and Global Warming)

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Abstract: This paper presents a comparative analysis of a physical model with Simulation for Hybrid Power Generation System. The Modeling and Simulation presented in this paper are based on two renewable sources i-e wind & solar. Both the mentioned sources were utilized with concerned power generation system i-e wind turbine and solar panel respectively. To enhance power generation capacity of solar panel, dual axis solar tracker was designed and significant change in average power generation capacity of solar panel was observed. As dual axis solar tracker was capable of inclining the solar panel to the sun throughout the year with servo based maneuvering to reciprocate minor changes in sun's position during summer and winter. The paper is concerned with profound study regarding deviations in system parameters with variance in environmental parameters i-e insolation and temperature for solar source and velocity of wind along with Betz limit for wind source. It was made tangible by considering almost all the parameters involved in actual power generation to be included in simulation of the system and the results obtained from simulation were compared with those of real system & notable results were achieved with negligible differences in both actual and simulation based model.

Keywords: Hybrid Power Generation, HBGS, Modeling and Simulation, M & S, Dual Axis Solar Tracker.

I. INTRODUCTION

The Rapid growth of technology and infrastructure has made our lives easier. The advent of technology has also increased the need of electricity (Antsaklis Nerode. and 1999). Our project will provide an optimum solution to this power shortfall. Hybrid Power Generation and Control is introducing efficient, cheap and environment friendly sources to generate power.

In HPGS multiple renewable sources are gathered to provide efficient generation of electrical power (Solero *et al.*, 1996). Utilization of two main sources i-e wind and solar is mostly demanded in Hybrid Systems, because a number of countries have excess of these sources which are capable of producing electricity through them (Morse *et al.*, 1999). When distinguishing these sources percentage wise, wind source remains top of the list for power generation and it is widely used throughout the world (Hepbasli and Ozgener. 2004). Solar source lacks behind and was not considered efficient but, after the solar trackers were introduced, solar source became the most reliable among other sources and its demand is increasing day by day(Qin and Song., 2000).

The aims and objectives of the proposed model are:

i. Protection of environment from global warming by using renewable sources.
ii. Remote areas become capable of producing sufficient power, where line from grid could not be provided, because of higher line losses.
iii. Saving natural reservoirs, by depending upon renewable sources.
iv. Provision of cheaper and long lasting electricity, so it is affordable to a common middle class man.
v. To save major part of economic budget expend yearly on power generation by fuels.
vi. Availability of both AC and DC at output becomes possible.

The block diagram of our project is shown in **(Fig. 1)**

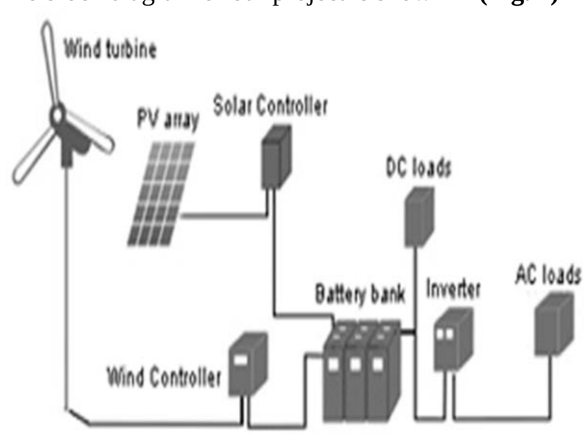

Fig. 1: Block Diagrams

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Although the system can be used in the remote areas to provide electricity to residential as well as to commercial customers, because the designed system in any aspect doesn't depend upon MAINs supply from Grid.

2. IMPACT ON GLOBAL WARMING

Traditionally used Non-renewable sources for electricity generation matter a lot to global warming, burning fossil fuels releases carbon that has previously been locked up in coal, oil and natural gas for millions of years. The carbon in these fossil fuels is transformed into carbon dioxide (CO2), the predominant gas contributing to the "greenhouse effect," during the combustion process (Morse *et al.*, 1999).

Fig. 2

The greenhouse effect allows energy from the sun to pass through the earth's atmosphere and then traps some of that energy in the form of heat. This process has kept global temperatures on earth relatively stable (Morse *el al.*, 1999).

3. AVAILABLE SYSTEMS

Power Generation can be accomplished in a number of ways traditional methods follow sources from non-renewable energies like coal, oil, gas etc. and are mostly installed at some specific region away from populated area, such systems have two drawbacks

(1) Contribution in Global Warming
(2) Transmission losses.

While the systems based on renewable sources are mostly portable which might base on wind source, solar source, tidal source etc., the type of the source used depends upon the environmental conditions of area, where the systems are to be operated (Marques *et al.*, 2003).

4. SOLAR MODELING

Solar cell is basically a p-n junction fabricated in a thin wafer or layer of semiconductor. The electromagnetic radiation of solar energy can be directly converted to electricity through photovoltaic effect (Solero *et al.*, 199).

$$I = I_{PV} - I_O\left[e^{\frac{q(V+IR_S)}{akT}} - 1\right] - \left[\frac{V + IR_s}{R_p}\right]$$

Further, the values of Ipv and Io can be calculated from given equations respectively,

$$I_{PV} = [I_{PV\_STC} + K_i \Delta T]\frac{G}{G_{STC}}$$

$$I_o = I_{O\_STC}\left(\frac{T}{T_{STC}}\right)^3 exp\left[\frac{qE_g}{ak}\left(\frac{1}{T_{STC}} - \frac{1}{T}\right)\right]$$

Where,

I_{pv}= photo voltaic current
I_o=saturation current of the diode
q=electron charge in coulombs
$=1.602*10^{-19}$C
K=Boltzmann constant
$=1.380*10^{-23}$ J/K
a=diode ideality factor
R_s=series resistance
R_p=parallel resistance
T=Temperature in Kelvin

Fig. 3

Resistance(Ω)	Module Voltage(V)	Module Current(A)
0	0	4.8A
3.5	16.25	4.6
4.61	18.4	3.8
7.8	20.2	2.12
9.7	20.6	1.9
13.8	21.2	1.62
28	21.8	0.8
118	22	0.2
Infinity	22.5V	0

Solar Module Testing Observation

Abovementioned results are observed while testing current and voltage levels of Solar Panel by varying resistance as load.

Impact of adding cells in series and parallel

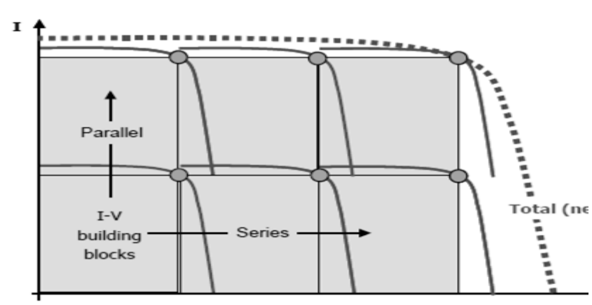

Fig. 4

It can be premised (from figure 4) that adding cells in series enhances voltage level of the system by the factor of multiple of individual cell's voltage, similarly for parallel connections, current level is increased (Delyannis., 2003).

Simulation results of I-V curve for different temperature ranges.

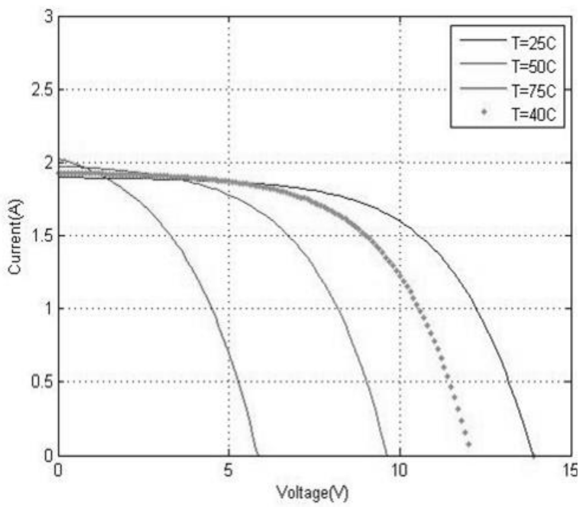

Fig. 5

At 40 degree centigrade, which is normal temperature during sunny days throughout year shows nominal results. (Power extracted by 24watt panel) current=1.93A, Voltage=11.9, while insulation was taken at ideal value i-e G=1.

Simulation results for different values of irradiance

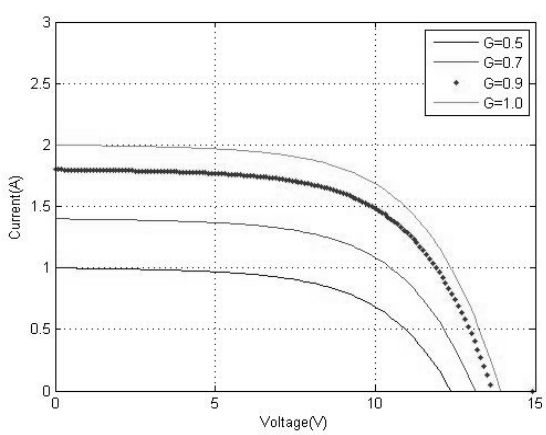

Fig. 6

Irradiance has $G = 0.9w/m^2$, temperature is taken as T=40 degree centigrade, due to which current value is decreased and voltage value is enhanced to some extent (Dos Reis *et al.,* 2004).

Simulation results of P-V curve for different values of Temperature

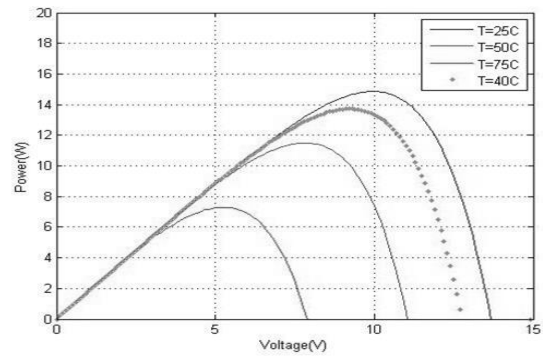

Fig. 7

Irradiance is chosen as $G = 0.9w/m^2$, nominal results of Power are observed.

Simulation results of P-V curve for different values of Irradiance

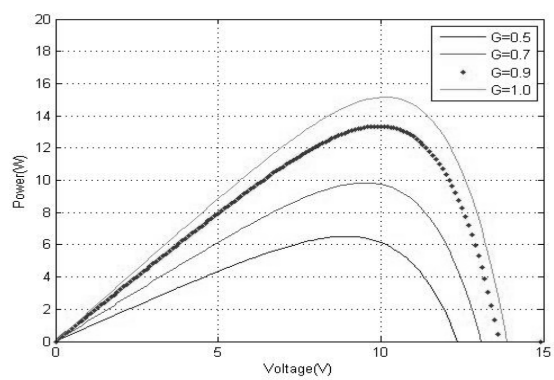

Fig. 8

Temperature is kept at T=40 degree centigrade and P-V values obtained are prolific.

Dual Axis Solar Tracker

It has 2 degree of freedom hence provide alike efficiency in every season, architecture of designed solar tracker is shown below

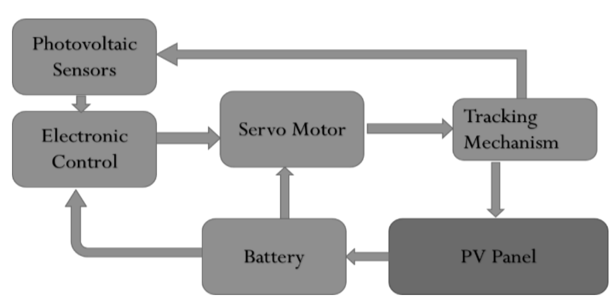

Fig. 9

Multiple light sensors are used for each servo motor to determine its precise position, each sensor is 45 degree apart attached on top of the solar panel to cover up all the 180 degrees.

Each motor continue to rotate in the direction of maximum light falling on the sensor and stops when the sensor in the middle produces comparatively maximum output, whose face is at 90 degree (parallel to solar panel).

Experimental results show that by using dual axis tracker efficiency of typical solar panel can be increased further from 35% -40%. As shown in the following "Efficiency VS Time" graph for a normal sunny day.

Performance comparison with and without Tracker

It can be observed through following graphs that best results are obtained when dual axis tracker was used,

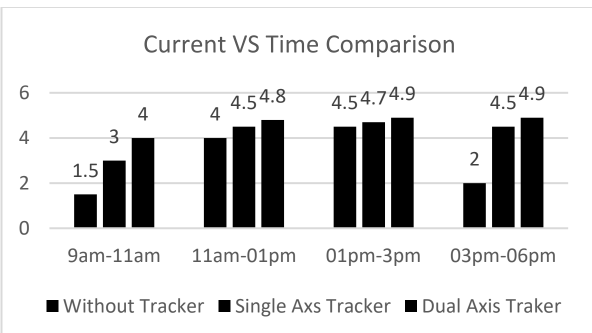

Fig. 10

Hardware of Solar Part

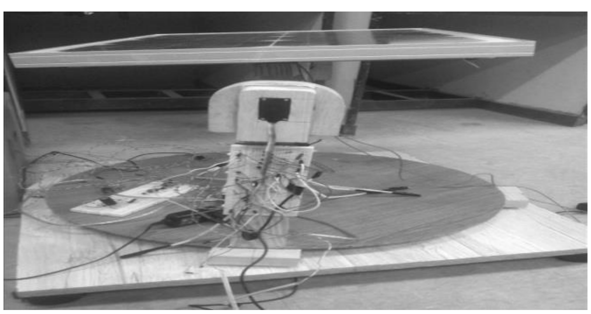

Fig. 11

5. WIND MODELING

- **Basics**

Solar radiations differentially absorbed by earth surface are converted through connective processes due to temperature differences to air motion.
According to Newton's second law of motion $F = ma$, thus the kinetic energy becomes $E = mas$.
From kinematics of solid motion, $v^2 = u^2 + 2as$
Thus, $a = (v^2-u^2)/2s$

Assuming the initial velocity of the object is zero, we have that
$a = v^2/2s$
Hence Kinetic Energy becomes $E=1/2(mv^2)$
The power P in the wind is given by the rate of change of kinetic energy, i.e.
$P = dE/dt(1/2)(dm/dt)v^2$
But mass flow rate $dm/dt= \rho A v$

- $\mathbf{P = 1/2(\rho A v^3)*Cp}$

Parameters considered

- ***P=Power(W)***
- ***ρ=density of air(depends upon height and temperature)***
- ***V=velocity of air***
- ***A=Area swept by the turbine blades(pi*r^2)***
- ***r=length of single blade***
- ***Cp=Betz Limit***
- ***Speed of rotor***

Basic Operation

- ***At 3.5m/s, turbine starts rotating with 30rpm***
- ***At 9m/s it reaches 100rpm***
- ***At >12m/s it reaches upto 150rpm and generates maximum rated power***
- ***>16m/s is dangerous for rotor so usually stopper is applied at higher speeds.***

Wind Speed (m/s)	Cp (0.59) ideal	Gear Train	RPM OF TURBINE	RPM OF Generator	Power output (W)
2	**0.45**	**1:4**	**17**	**68**	**0. 15**
4	**0.45**	**1:4**	**38**	**152**	**0.9**
6	**0.45**	**1:4**	**57**	**228**	**1.3**
8	**0.45**	**1:4**	**82**	**328**	**4.9**
10	**0.45**	**1:4**	**108**	**432**	**7.5**
12	**0.45**	**1:4**	**143**	**572**	**11.2**
14	**0.45**	**1:4**	**185**	**740**	**24**

It can be revealed from above chart that as wind speed increases output power is increased in direct proportion, gear train used is 1:4 which enhances the generator speed four times to that of turbine. It was further observed in practical system that while reaching maximum RPM of Generator further increase in speed did not cause increase in power but it could be dangerous for generator as it may lead to damage of rotor therefore brakes or regulators were used.

Simulation result of Power VS speed of wind with variation in Betz Limit(ideal Cp=0.59)

It is clear from following graph that after attaining the maximum rated value of power, further increase in wind speed is futile further brakes or regulator are used to avoid any destruction through rotor.

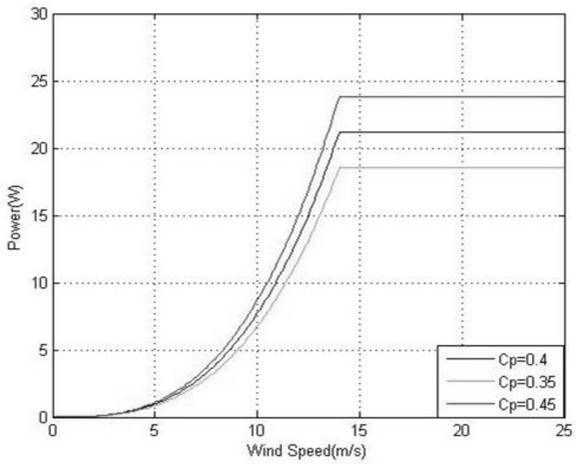

Fig. 12

Hardware of Wind Turbine

Fig. 13

6. CONCLUSION

Designed model is capable of generating the nominal amount of Power, while results obtained from practical model were compared with simulated results where negligible differences were found. During simulation realistic values of environmental parameters were considered like insolation, temperature, betz limit etc. The model is portable and can be used for both domestic and industrial purposes, Efficiency of designed system is increased further upto 40% by constructing dual axis solar tracker and mechanically designed anemometer for wind turbine, power generation capacity can be increased by adding number of solar panels and wind turbines, increasing the size of turbine increases power production to greater extent.

Although our system only utilizes two sources, but both of these sources are abundant in Asian countries, the idea can be extended for other countries, by considering the environmental conditions of specific region where the system is to be installed.

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REFERENCES:

Antsaklis, P. J., and A. Nerode, (1998). Hybrid control systems: An introductory discussion to the special issue. IEEE Transactions on Automatic Control, 43(4), 457-460.

Delyannis, E. (2003). Historic background of desalination and renewable energies. Solar energy, 75(5), 357-366.

dosReis, F. S., K. Tan, and S. Islam, (2004). Using PFC for harmonic mitigation in wind turbine energy conversion systems. In Industrial Electronics Society, IECON 30th Annual Conference of IEEE (Vol. 3, 3100-3105. IEEE.

Hepbasli, A., and O. Ozgener, (2004). A review on the development of wind energy in Turkey. Renewable and Sustainable Energy Reviews, 8(3), 257-276.

Marques, J., H. Pinheiro, H. A. Gründling, J. R. Pinheiro, and H. L. Hey, (2003). A survey on variable-speed wind turbine system. network, 24, 26.

Morse, A. S., C. C. Pantelides, Sastry, and S. S. J. M. Schumacher, (1999). Introduction to the special issue on hybrid systems. Automatica, 35(3), 347-348.

Qin, S., and Y. H. Song, (2000). The analysis of architecture of hybrid control system. Automation of Electric Power Systems, 24(11), 5-9.

Solero, L., F. Caricchi, F. Crescimbini, O. Honorati, and F. Mezzetti, (1996). Performance of a 10 kW power electronic interface for combined wind/PV isolated generating systems. In Power Electronics Specialists Conference, PESC'96 Record., 27th Annual IEEE Vol. 2, 1027-1032. IEEE.