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Design And Development of Solar Wind Hybrid Systemfor Electrical Power Generation

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ABSTRACT: The main objective of the author is todesign and development of solar wind hybrid system model for electrical power generation. Several researchers have developed the solar wind hybrid system for various applications. The electrical power demand is increasing day by day so need of alternate power source become very useful to generate electrical power from the natural resources in order to compensate the electrical power demand. The consideration of solar wind hybrid supplypresents significant potential for cost reduction. The investment variables concern the location of solar windplant, and its sizing. The system demands driven, meaning that its primary aim is to fully satisfy the energydemand of the customers.The hybrid power generation is a new innovative concept which have designed and developed in this paper. It is one of the non-conventional energy since the generated power from the natural resources and also during non0availability of insolation, the power generated by wind mill is exported to the power grid.

KEY WORDS*:* Insolation, Solar power, wind power, Solar-wind hybrid power, Solar wind hybrid system

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I. INTRODUCTION

Nowadays the price of fuels is increasing drastically mainly because of scarcity and high demand.Moreover these fuels eject out greenhouse gases which is slowly destroying the environment. Considering allthese factors the people these days are largely depending on natural resources for energy for many applicationslike cooling, heating, electricity, etc. Solar, wind and Bio energy can be widely used these days if theenvironment or the place is rich in that source of natural resource. The availability of resources play a majorfactor for producing energy from this resources. Among all renewable energy sources solar and wind energy aremore attractive to the people because these resources are available at the site at free of cost.A stand-alone solar or wind energy system is insufficient to supply continuous power citing thefrequent seasonal and periodical changes [1]. The drawbacks from solar and wind now a day thepeople are thinking towards hybrid technology i.e. combination of solar and wind. The hybrid system can getenough energy from both sources and even if the energy from one source is low at the point it will becompensated by the other. Hybrid systems has gained popularity in the past, for its application in remote systemssuch as radio telecommunication and satellite earth stations, or at localities inaccessible to the conventional

power grids [2, 3, 4]. Today, upgrading the current single sourcesystems (Solar and wind) into hybrid systems for grid-connection applications has been a major area offocus [5].

Researchers have recommended many optimization procedurals such as graphical construction,probabilistic method and iterative techniques. [6] contributed in the field of performance ofhybrid distributed energy systems: Solar photovoltaic, battery and combined heat and power. Until recently, therelatively high levelized cost of electricity from solar photovoltaic (PV) technology limited deployment;however, recent cost reductions, combined with various financial incentives and innovative financing techniques,have made PV fully competitive with conventional sources in many American regions. Their results show thatconservatively sized systems are technically viable in any continental American climate and the details arediscussed to provide guidance for both design and deployment of PV + battery + CHP hybrid systems to reduceconsumer costs, while reducing energy- and electricity-related emissions.The design and application of a novel hybrid sun–wind-tracking system studied [7]. Theirprincipal experiment was focused on comparison between dual-axes sun-tracking and hybrid sun–wind-trackingphotovoltaic (PV) panels. Their results show that, the overall daily output energy gain was increased by 49.83%compared with that of a fixed system and an overall increase of about 7.4% in the output power was found forthe hybrid sun–wind-tracking over the two-axis sun tracking system. The photovoltaic–micro wind based hybrid systemswere studied [8] to solve theproblems in hydro power plants during extreme winter season. With the objective to minimize costs. A hybrid solar-wind energy plantmodel wasdesigned[9], which included optimised variables namely, count of photovoltaic modules and wind turbines, windturbine height and turbine rotor diameter. The results show that the hybrid plant delivered energy that combinedthe nature of the two complementary energy sources, and supplied energy reliably all along the year. [10] focused on integrating wind turbine, photovoltaic and fuel cell along with ultra-capacitor systems for gridindependentapplications. Testing the dynamic characteristics of their suggested hybrid model under parameterssuch as wind speed, solar radiation and demand load, for a per day analysis, they found that their modeldisplayed fantastic performance. The hybrid model of integrated methodologies involvinganalytics and parameters to determine the early cost of castings. By testing their model in a unified industrialproduct and process designing environment [11], the cost determined by a product designer matched closely with thatestimated by an experienced foundry engineer. Their study also shows that web-enabling of the entire systempromotes collaboration between product designer, tool-maker and foundry engineer for cost reduction. The four important factors that influence the rising demand for electricitynamely climatic changes was studied [17], forecasted growth rates of EU Member State economies, variations in consumptionrates and bringing in of latest technologies. They also did a framework for assessing power schemes for powerfrom renewable energy sources considering the indeterministic competitive market milieu. They expected themodern deregulated electricity market to be ready to respond to this challenge. They based their expectation ontheir prediction of an adequate and economical supply of energy within this new model and promising newopportunities it would offer for incomings as well as present power producers. A batteryoperated model for hybrid wind-solar energy systems was proposed [12], which included design factors such the time fractionnecessary for the hybrid system to meet the load and the cost of the system. In his study he introduced newnotions that integrated the autonomy and economics of the system employed in the optimisation of thetechnological and economical analysis. He suggested that rather than excessively raising the size of thehardware, an auxiliary source could be employed additionally within the system, resulting in increasedtechnologically and economically optimum systems.A hybrid solar-wind system was proposed [13] that was employed as the power sourcefor the grid-connected applications in three Iraqi cities. In their studies, the reverse osmosis desalination plant operated usinga grid-connected power supply system that combined the power from photovoltaic power generation. The techniques to model was discussed [14, 15], the constituent parts of the HRES, itsdesign and analysis. They justified the increasing popularity for the hybrid solar/wind energy systems using theliterary works focussing on improving the HRES design. An analogy tooptimise the storage capacity of a battery bank and a photovoltaic array was developed [16] considering a single hybrid solar/windpower system. In their study, the wind speed and irradiance data were compiled on an hourly basis per day for aspan of 30 years and using these data, the average generated power was calculated for very same durations. A developed simulation models [18] for a hybrid wind/solar system which are used to calculate optimizedcombinations of PV module, wind turbine, and battery bank parameters for a given loss of power supplyprobability (LPSP). The proposed algorithm was found to deliver a good optimised sizing performancesuggesting a hybrid solar/wind system to be the best solution.Every effort to explore an efficient and economical renewable energy source requires atleast a singleoptimised sizing technique. The use of photovoltaic arrays, battery banks and wind turbines shoot up theinvestment costs and hence, such a sizing technique ensures that the hybrid system operates at an optimuminvestment value and power assurance.

3. Components in Solar-Wind hybrid power Generation System

Fig.1 shows a schematic representation of the proposed hybrid solar-wind power generation system. As per thedesign, the system includes a wind turbine, photovoltaic array, battery bank, regulation and conversion (Inverter/Converter), AC or DC load and associatedaccessory devices and wires. In this case the system is setup such that during the day time solar panel extractsenergy and directly supply to the power grid and in case excess energy it produced, it gets stored. Wind energy isalso produced such that it goes to the battery and then the grid system to make sure the battery is not always indrained condition. During the night time wind energy is continuously produced like in the day time and also thestored energy in the battery is used to run the grid. To analyse the performance of the hybrid system, the overallsystem is modelled and analysed towards optimum cost.

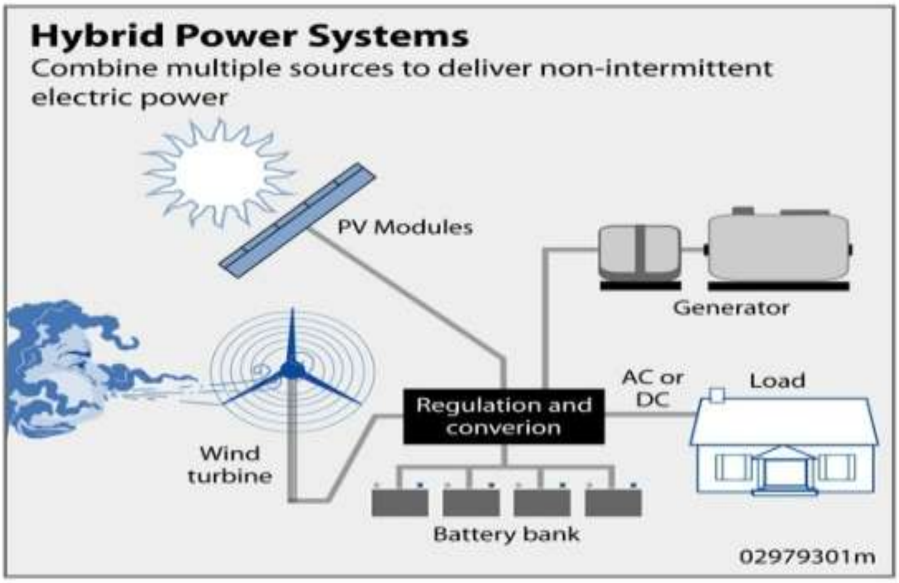

Figure 1: Schematic diagram of hybrid Solar-Wind power generation system

There are many times the decisions are taken while going for the grades of the accessories considering the costand optimising the life of the products. Here the experiment set up is analysed for the following three situations.

Points of differentiation

	Solar	Wind	Hybrid
Operation	Produce electricity directly from insolation	Kinetic energy of wind turbine drives the generator	Combination of both solar and wind
Technical specifications	Rated power 250W	Cut-in speed 5.6m/s	
	No. of solar panel 4	Rated voltage 12V	
	Operating voltage 24V	Wind turbine material-Galvanized Iron	
	Operating Current 5.6A	No. of wings 7	
	Open circuit voltage 37V	Cut-out speed 50m/s Weight 90kg	
	Short circuit current 8.63		
Average life	25 years	15-25 years	Averrage of both
Initial investment	Rs.49500/kW	Rs.90,000/kW	Calculated and given below

The solar wind hybrid systems utilize the combined energy from the solar panel and wind energy unit and generate and supply electrical power to the load continuously. This is the benefit of hybrid system. The power generation by using single source it is not possible to generate and supply power to the load continuously.

4. Life Cycle cost

Since the complete life cycle cost of a solar wind hybrid system is the aggregate cost of the capital investment, operational costs, maintenance costs and battery replacement costs.

Foe a residential two bedroom flat, usually, it will have fluorescent lamp or LED, 1 TV, 1 computer, 4 fans, 1 washing machine, 1 AC, 1 refrigerator, 1 gyser and 1hp as the typical connected load. The total power consumption of the flat in a day can be calculated around 4kWh or 4unit/day.

For an approximate power consumption of 4units/day in areas without grid connected power, the cost assumed to be around Rs.21/unit.

Therefore, the monthly cost of energy=4unitsx30daysx Rs.21

=Rs. 2856.00

Now, the annual cost of energy=Rs.2856.0x12

=Rs. 34,272.00

5. Design of Solar Wind Hybrid System

Cost calculation of Solar-Wind Hybrid System	
Capacity of Solar plant	4units of power
Cost of Solar Panel (4kWh)	Rs.1,98,000.00
Capacity of Wind power plant	6 units of power
Cost of Wind system	Rs. 2,97,000.00
Cost of Inverter	Rs. 18500.00
Cost of 8 Lead Acid Batteries	Rs. 72,000.00
MPPT Controller	Rs. 25,000.00
Cost of Installation	Rs. 25,000.00
(Rupees Six Lakh Thirty Five Thousand Five hundred only)	Rs. 6,35,500.00

Payback Period calculation for 4kWh
The cost of the system varies from Rs. 6.5 lakh t0 Rs. 26 lakh for 4kWh depending on the ratio of wind and solar components. The approximate installation cost including works, is about Rs. 52,000.00 and maintenance cost is about Rs. 12000.00 per annum.
The cost of Solar and Wind Hybrid system=Rs.6,35,500.00
Total cost of utility supply+Approximate Annual bil (Calculated above) + INITIAL COST (Substation, transformet and transmission line cost) =Rs. 52,000.00+ Rs. 12,000..00+Rs. 3,60,000.00= Rs.4,24,000.00
So, payback period for the hybrid system will be,
Payback period=Total cost of Soalr and Wind Hybrid system/Total cost of utility supply
=Rs. 6,35,500.00/Rs. 4,24,000.00
=1.4988 yrs= 1.5 years
So, the payback period will be considered as 2 years depending upon the climate variation and other conditions. Hence, the Solar and Wind Hybrid System can be employed efficiently for hilly and remote areas which are not electrified till date.

II. RESULTS AND DISCUSSIONS

Fig. 2 represents the change in Solar power (Ps) with net present value (NPV) for the given range of input. Itshows the change of net present value (NPV) value with respect to the solar power generated.Here the different colours represent the difference in values of NPV for the given input.Similarly this Fig. 3 below represents the change in Wind power (Pw) with net present value (NPV). For thegiven range of input it shows how the NPV value changes for the wind power generated. Since the system is a hybrid system net present value (NPV) changes with both wind and solar, so both the above figures, Fig. 2and Fig. 3 are merged into Fig. 4. Here in Fig.4, the value of power of both the figuresFig. 2 and Fig. 3 are merge, but there are a set of values for NPV for the optimum Power. So now to get an optimum NPV value for the optimum power an need account into the maintenance, lifeof the components and the profit earned in the process.For figure 1 and figure 2 the top, middle and bottom lines of the NPV which are blue, red and yellow lines
respectively.These lines represents:
Blue: Expensive setup using high grade instruments and materials
Red: Moderate cost setup using average grade instruments and materials
Yellow: Cheap setup using low grade instruments and materials
Now considering all the expenses a maintenance figure is plotted

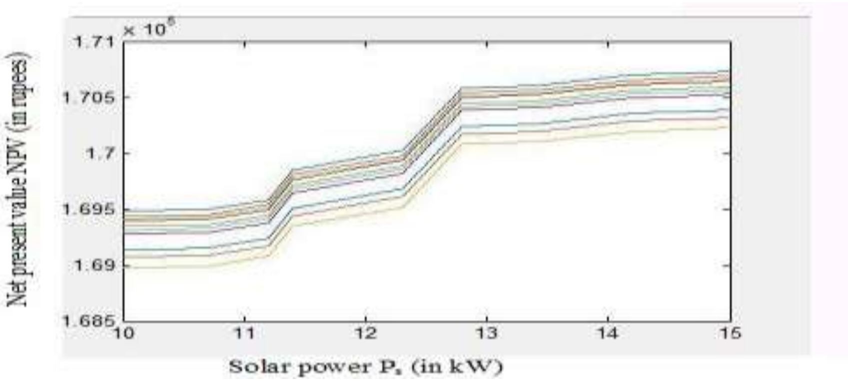

Figure 2: Solar power vs NPV

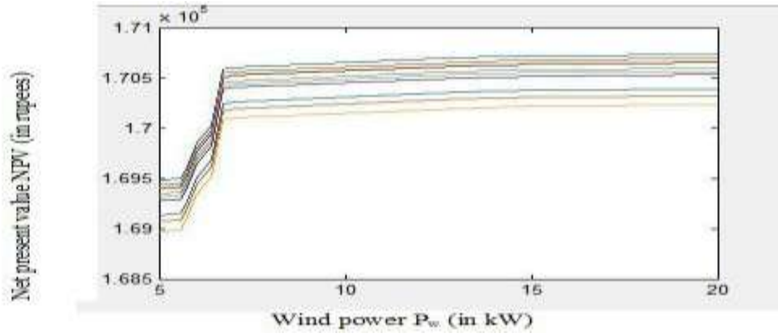

Figure 3: wind power vs NPV

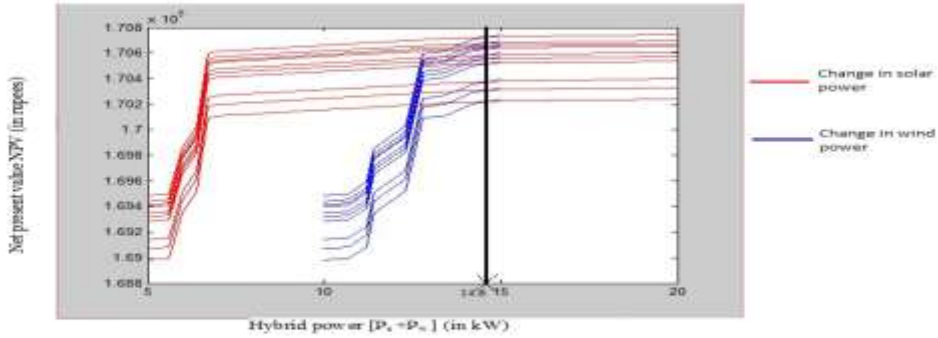

Fig. 4: Hybrid power of solar and wind vs net present value

7. Maintenance Figure

Here, the Maintenance 3 represents the maintenance for the cheap setup (i.e Yellow line)

Maintenance 2 represents the maintenance for the moderate setup (i.e red line) Maintenance 1 represents the maintenance for the expensive setup (i.e blue line) From Fig. 5, if cheap product is selected maintenance is high and it maintenance starts at a early period of time. So, from the Fig. 5 selecting maintenance1 is optimum. Therefore the blue line has been selected next taking the life expectancy of all the component put together. It shows depending on the cost and quality ofthe product, how long it will last.

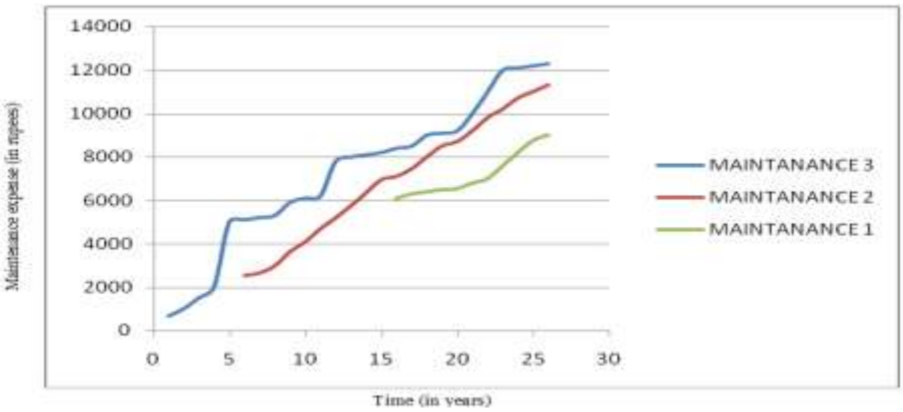

Figure 5: Time vs. maintenance cost

III. CONCLUSIONS

From the above design and developed solar-wind hybrid system, it is clear that the future of the hybrid power is very fruitful for the remote and hilly areas where the difficulties arises in transportation and installation of other type of power plants like thermal power, hydal power etc. Although, the cost of power generation reduced so much due to technological developments in the field of renewable energy systems in recent years, but still they are the expensive source of power. Particularly in India, the development in the field of renewable energy systems in recent year speedup due to full support provided by the state government as well central government too. On the basis of the development in the field of renewable energy, India reaches in near future as "Grid Parity" in solar power generation as well as in wind power generation too.

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