Solar and Wind Hybrid System for Rural Electrification

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***Abstract*—** Hybrid Solar photovoltaic and battery base energy system here is designed to overcomes the difficulties which are caused in use of conventional energies. Hybrid means combination of two or more energy, solar pv (solar photovoltaic) is a method of generating electrical power by converting solar radiation into direct current using semiconductors that exhibit the photovoltaic effect. Photovoltaic power generation employs solar panels composed of a number of solar cells containing a photovoltaic material. Materials presently used for photovoltaic include mono crystalline silicon, polycrystalline silicon, amorphous silicon, cadmium telluride, and copper indium gallium selenide/sulfide. Due to the increase demand for renewable energy sources, the manufacturing of solar cells and photovoltaic arrays has advanced considerably in recent years.

Keywords- *Solar Photovoltaic, Wind Turbiney, Battery, Nanoconventional, Conventional*

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I. INTRODUCTION

In India, more than 200 million people live in rural areas without access to grid-connected power. Over 80,000 villages remain to be un-electrified, because it is difficult to supply electricity due to inherent problems of location and economy [1].The cost to install and service the distribution lines are considerably high for remote areas. Also there will be a substantial increase in transmission line losses in addition to poor power supply reliability. In most of the remote and non electrified sites, extension of utility grid lines experiences high capital investment, high lead time, low load factor, poor voltage regulation and frequent power supply interruptions. Hence, a convenient, cost-effective and reliable power supply is an essential factor in the development of any rural area.

Thus, to overcome all the disadvantages possessed by the conventional method of electricity generation and transmission distributed energy generation is being preferred and promoted. There are several ways by which electricity can be generated locally using renewable sources such as solar, wind, biogas, etc. [2]. At present, standalone solar photovoltaic and wind systems have been promoted around the globe on a comparatively larger scale [1]. These independent systems cannot provide continuous source of energy, as they are seasonal. Therefore, suitable energy storage systems will be required for these systems in order to satisfy the power demands. Usually storage system is expensive and the size has to be reduced to a minimum possible for the renewable energy system to be cost effective. The cost effective solution would be hybrid power systems which can reduce energy storage requirements. For villages, where we can get abundant source of sun rays and wind blow, we can use a hybrid technique employing solar and wind

Energy. This can release the amount of requirement of the electricity from conventional sources to meet the demand. Lot of research is reported for exploration of renewable sources. It has been established that small photovoltaic systems generators in the capacity range of 200-600 watts can be economically viable in comparison to petrol generators of 500-600 watts [3]. Though the initial investment for solar PV power plants is high, it is economically viable if the life cycle cost approach and environmental benefits are considered. Wind energy systems for irrigation and milling have been in use since ancient times and since the beginning of the 20th century it is being used to generate electric power [4]. Windmills for water pumping have been installed in many countries particularly in the rural areas. Small wind turbines called

Aero-generators can be used to charge large batteries. Typically, winds are stronger during the winter and spring months, then fall off during the summer months. The opposite is true with sunshine, which is strongest in the summer, but affected by more cloudy days during the winter and spring. It doesn't take a lot of clouds to have a significant effect on solar output. A hybrid system can help overcome the seasonal variations of wind and sunlight to give a more balanced output from alternative energy system [5]. This papers presents design and implementation of small solar –wind hybrid system which can feed a rural load without any interruption. A brief review of solar – wind hybrid system is presented in section II. System configuration is explained in section III, while system

sizing and life cycle cost is presented in section IV and section V respectively.

II. SOLAR WIND HYBRID SYSTEM

The estimated potential of various Renewable Energy sources in India by IREDA is shown in table-1. Table.1.Renewable Energy potential in India [6,7].

S. No	Energy source	Potential
1	Solar	20MW/sq.km
2	Wind	20,000 MW
3	Small Hydro	10,000MW
4	Ocean Thermal	50,000MW
5	Tidal	10,000MW
6	Biogas	12 Million plants
7	Biogas based cogeneration	3500MW
8	MSW	1000MW

India is potentially one of the largest markets for solar energy in the world. The estimated potential of power generation through solar photovoltaic system is about 20 MW / Sq.km in India [5]. There is more than enough solar radiation available around the world to satisfy the demand for solar power systems. The proportion of the sun's rays that reaches the earth's surface is enough to provide for global energy consumption 10,000 times over. On average, each square meter of land is exposed to enough sunlight to produce 1,700 kWh of power every year [1]. It is useful for providing grid quality, reliable power in rural areas where the line voltage is low and insufficient to cater to connected load. The Govt. of India is planning to electrify 18,000 villages by year 2012 through renewable energy systems especially by solar PV systems [1]. This offers tremendous growth potential for Indian solar PV industry. The Govt. of India had a target of achieving 150 MW installed capacity in year 2007. It presented a tremendous business opportunity in manufacturing of solar modules and other components.

Wind energy is the kinetic energy associated with the movement of atmospheric air. It has been used for hundreds of years for sailing, grinding grain, and for irrigation. Wind energy systems convert this kinetic energy to more useful forms of power. Wind energy systems for irrigation and milling have been in use since ancient times and since the beginning of the 20^{th} century it is being used to generate electric power [4]. Windmills for water pumping have been installed in many countries particularly in the rural areas. Pros include clean power generation, cheaper than solar generation and there should be no shortage of wind, especially in coastal areas. Cons include visual impact considerations. During periods of low winds or calm, wind turbine can produce only limited power. On cloudy days, solar system is likewise limited in its ability to produce power. Seasonal variations of sun and wind is shown in fig.1.Seasonal variation in wind and sun means there are periods where system may be limited in how much power it can produce. So there is need to find a way to offset the dog days of summer and the rainy days of winter.

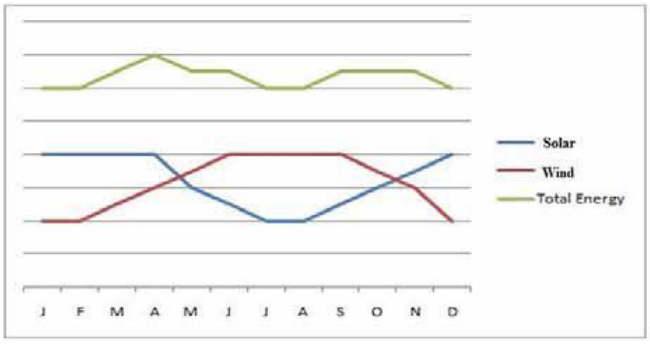

Fig.1 Seasonal Variation of sun and wind

Fortunately, one can utilize a hybrid system of wind and solar to capture the strengths of each system,
while at the same time overcoming the weaknesses of each system, to create a balanced approach to producing energy. And as a bonus, for those days where both wind and sun are available, there is increase in production over what a single system could provide. This type of installation is particularly applicable for rural areas where there are hilly areas from which wind and solar energy is available in abundant respects. Thus the plant integrates benefits of PV and wind energy. The project can also be applied in urban area but the overall cost for this project would be more than the mains power supply installation. Therefore the methodology is particularly applicable in rural areas only.

III. SYSTEM CONFIGURATION

Solar-Wind hybrid power plant consists of mainly the solar cells and an alternative for solar i.e. wind mills. The energy is being produced from the two with a combination. Further the energy is fed to the hybrid controller. The energy from the battery is fed to the load via inverter as per the requirement. The functional block diagram of solar-wind hybrid power plant is shown in fig.2.

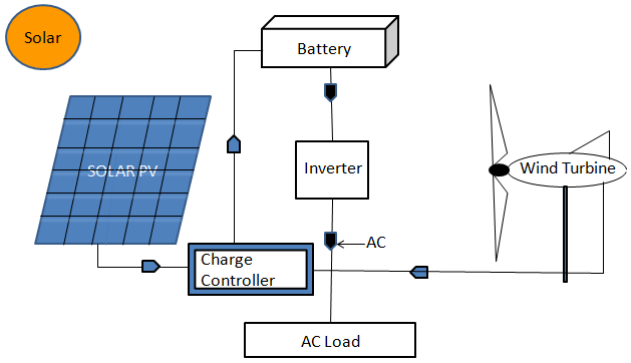

Fig.2. Block diagram of Solar-Wind Hybrid Power System

IV. SYSTEM SIZING

In order to optimize system efficiency, it is required to go for proper sizing of system. A simple algorithm is developed for system sizing. The flow chart of algorithm is as shown in fig.3.

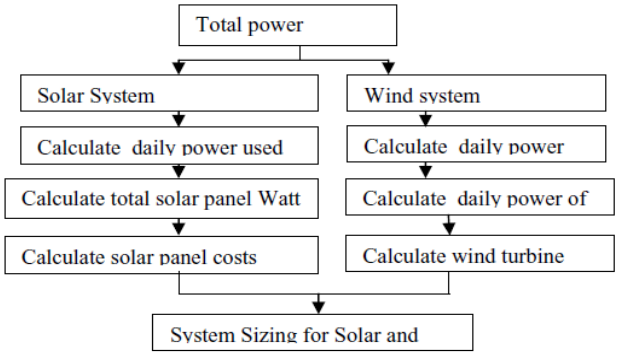

Fig.3 Flow Chart of system sizing

V. LIFE CYCLE COST

Life Cycle Cost (LCC) of a hybrid system consists of initial capital investment, the present value of operation and maintenance cost and the battery replacement cost. Life cycle cost analysis is a tool used to compare the ultimate delivered costs of technologies with different cost structures.

Example:- Consider, house consist of three rooms with 1 Tube, 3 CFL, 2 Fan & 1 T.V. as connected load.

Table No. 3 Total Consumption of House

Connected Load	Watt	Hours	Watt-hours
1 Tube	40	4	160
3 CFL	45	4	180
2 Fan	80	6	480
1 T.V.	150	6	900
Total load	315		

Maximum Demand= It is greatest demand of load on the house during a given period.

Diversity Factor= sum of individual max. Demand / Max. Demand of house

Total Consumption= 1620wh

Approximate consumption= 1.8kwh or 1.8units/day

Consumption per month= 1.8 x 30= 56units/month

Monthly bill=56 x 4=Rs.224/-

Annual bill=224 x 12=Rs.2688/-

Approximate annual bill=Rs.2800/- per annum

For solar panel:-

Solar panel watt capacity= 1.8kwh/7hours x 1.25=0.32142kw or 321.42watts per day

Solar panel cost= 321.42 x 150=Rs.48, 213/- (as per table given below)

For wind generation:-

For 800 w generation of electricity considering value from table,

Wind System Cost=0.8 x 45,000= Rs. 36,000/-

Total cost of solar and wind hybrid system= Rs 48213 + 36,000 + 8000 + 8000 = Rs. 1, 00,213/-

Table No. 2 Cost values of the economic parameters and components for the base case

S. No	Parameters	Cost
1	Silicon type PV module cost	Rs.150-200 /Wp
2	Lead acid battery cost	Rs.4000 /kWh
3	Cost of battery charge controller	Rs.2000 /kWh
4	Wind system cost	Rs.45,000 /kW
5	Economic evaluation period	20-30 years
6	Lead acid battery average life	4-5 years
7	Life period of wind machine	10 years
8	Life period of SPV system	25 years
9	Silicon type module efficiency	8-14%

VI. COSTING:

The cost of the system varies from Rs 2.50 lacs to Rs 3.50 lacs per kW depending on the ratio of wind and solar components. The approximate cost of installation, including civil works, is about Rs 10,000 per kW. Repair and maintenance cost is about Rs 3000 per kW per annum [1].

Payback Period calculation:-

Total Cost of Solar and wind hybrid system=Rs. 1, 00,213/-

= Rs. 1, 03,000/-

So, payback period for hybrid system will be,

Payback Period= Total cost of solar and wind hybrid system

Total cost of utility supply

Payback Period= 1, 00,213/1, 03,000= 0.97 years

= 1 year (approximately)

So, Solar and Wind Hybrid System is more efficient for rural areas which are not yet electrified.

VII. CONCLUSION

Under current acute power shortage scenario with increasing cost of natural gas, coal and turbine fuel and due to their impact on environment, there is a very urgent and great need of finding alternate source of energy to generate electricity. There are several ways by which electricity can be generated using renewable sources such as solar, wind, biogas, etc. Individual generation of solar and wind energy is costlier.

Solar and wind energy integrated technologies have great potential to benefit our nation. They can diversify our energy supply, reduce our dependence on imported fuels, improve the quality of the air we breathe, offset greenhouse gas emissions, and stimulate our economy by creating jobs in the manufacturing and installation of solar and wind energy systems. By using solar and wind integrated system we can electrify remote area also it is applicable for metro cities in future to avoid unwanted load shedding.

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