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Optimization of Hybrid Renewable Energy Source for Grid Interconnection Remote Area Electrification in India

ShivkumarS.Londhe[1]
Student of MTech
TulsiramjiGaikwad Patil College of Engineering and Technology
Mohagaon, Wardha Road, Nagpur, Maharashtra
Email: shivkumarlondhe@gmail.com

Dr. Harikumar Naidu[2]
HoD, Electrical Engineering Department
TulsiramjiGaikwad Patil College of Engineering and Technology
Mohagaon, Wardha Road, Nagpur, Maharashtra
Email: hod.electrical@tgpcet.com

***Abstract*—Using on grid hybrid renewable energysystems use** for**remote areashas become an attractivesolution.Most of the areas of world Population lives in a that are geographically isolated or grid supply sparely available. Also consumer expects a mobile form of energy. These demands are for professional need or rural electrification. Due to limited reserve of conventional energy sources i.e. fossil fuels and global environment concern. For the use and generation of electric power it is necessary to use Renewable Energy sources (RES). Hybrid renewable energy system (HRES) with conventional energy sources is the ideal system for rural electrification and to provide reliable for of energy to consumer. This paper discussed the HRES for rural electrification & advantages of RES over the Conventional energy sources also control of power flow fed to the load.**

***KeyWords*—- Renewable energy system, Hybrid,Rural electrification, PV, Wind**

I.NTRODUCTION

There are many remote places, especially in developing countries, where grid supply hasnot reached yet but still with more availability of solar-wind hybrid systems. Over and above, The dependence of economy on depleting fossil fuels and the adverse environmentaleffects of conventional power generation systems created renewed interest in renewable energysources toward building a sustainable energy economy. Wind-solar-fuel cell hybrid energy isthe world's fastest growing energy sources, expanding globally at a rate of 25–35% annually over the last decade.

A combination of different renewable energy sources, like wind generator, fuel cell and PV-system,with conventional energy source, like a diesel generator, is known as hybridpower system. Hybrid systems can provide a steady community-level electricity service, suchas village electrification, offering also the possibility to be upgraded through gridconnection in the future.

Solar and wind energy are non-deflectable, site dependent, nonpolluting, and potential sources of alternative energy in meteorological conditionsare important. The performance of solar and wind energy systems are strongly dependent onthe climatic conditions at the location. The power generated by a PV system is highly dependenton weather conditions. For example, during cloudy periods and at night, a PV system wouldnot generate any power. Combined wind and solar systems are becoming more popular forstand–alone power generation applications, due to advances in renewable energy technologiesand subsequent rise in prices of petroleum products. The Economic aspects of thesetechnologies show sufficient promise to include them in developing power generation capacityfor developing countries. Research and development efforts in solar, wind, and other renewableenergy technologies are required to continue improving their performance, establishing techniques for accurately predicting their output and reliably integrating them with otherconventional generating sources.

II.OVERVIEW OF RURAL ELECTRIFICATION

Rural electrification in India has suffered badly over the last decade mainly due to poor operational and financial health of SEB's. Although 86% villages electrified over the years, nearly more than a Lakh of villages are yet in the dream of light; whereas the electrified once is badly suffering heavy power cuts ranging from 10-12 hours a day in needed hours. If we look at present rural electrification status of India given in Table 1.

Variables	Value
Total number of villages	5,87,258
Villages electrified	5,08515
Villages to be electrified	78,743
Total number of households	13,83,71,559
Electrified households	13,83,71,559
Un electrified households	7,40,07,840

Table 1. - Status of rural electrification in India

III.PROPOSED SYSTEM

The proposed system consists of RES connected to the dc link of a grid-interfacing inverter as shown in Figure 1. This configuration is fit for the stand-alone hybrid power system used in remote area. Before reaching towards load centers, the conversion of electricity from wind and solar are carried out. The two energy sources are connected in parallel to a common DC bus line through their individual converters. Then such a DC power is converted back to AC power at fundamental grid frequency of 50 Hz by using multi-level inverter.

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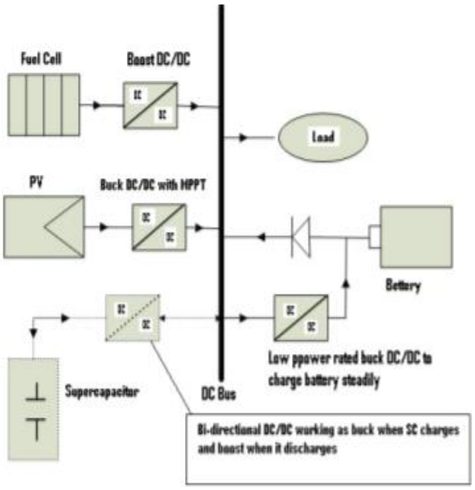

Figure1.Proposed Hybrid System

IV.LOAD ESTIMATION

For load profile estimation for the small village of 20 house, here we consider different cases such as, load by each house of the village, load of school and load of Mosque place.[9]

A. *Electricity demand by each house*

By calculating power consumption by different equipment of house we can calculate power required by the each family.
General Equ^n. = Equip. Rating*Quantity*Hour

1. 2 CFL bulb= 20*2*4
   = 160 W

2. 1 Fan = 60 * 1 * 8
   = 480 W

3. 1 TV = 40 * 1 * 4
   = 160 W

Thus, above discussion peak power consumption of family (W) = 120W and total demand of family per day is = 800 Wh/day.

B. *Electricity demand by school*

1. 2 CFL bulb= 20*4*4
   = 320 W

2. 1 Fan = 60 * 2 * 4
   = 480W

Peak demand of school = 200 W
Total demand of school per day = 800 Wh/day

B. *Electricity demand by Temple*

1. 2 CFL bulb= 20*2*4
   = 160 W
2. 1 Fan = 60 * 1 * 2
   = 240 W

Peak demand of school = 200 W
Total demand of school per day = 800 Wh/day
Thus, from above discussion;
Maximum demand of Power = (140 * 20) +100+200
= 3100 W= 4.5 W
Max. Power demand per day= (800*20) +400+800
= 17200 Wh/day = 32.3 kWh/day

Below graph shows daily load profile for Small villages of 20 houses;

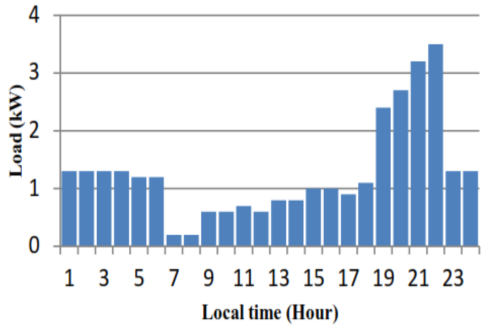

Figure.2.Lad Duration Graph

V.COMPONENT OF HYBRID POWER SYSTEM

A PV–Wind power system, which is a combination of a photovoltaic array integrated with a wind generator. The system consists different component such as, PV array, wind generator, a battery bank, a charge controller and a DC/AC or AC/DC converter. Depending upon requirement it can be used.

A.PV System

Sizing of PV system can be depending on different factors these are;

1. Solar radiation of the site.
2. The daily power consumption (Wh) and types of the electric loads
3. The storage system to contribute to the system's energy independence for a certain period of time.

The PV generator is oversized it will have a big impact in the final cost and the price of the powerproduced and in the other hand, the PV-generator isundersized, problems might occur in meeting thepower demand at any time.

B. Wind Energy

Wind energy sources have the potential to significantly reduce fuel costs, greenhouse gas emissions, and natural habitat disturbances associated with conventional energy generation. Wind turbine generators are an ideal choice in developing countries where the most urgent need is to supply basic electricity in rural or isolated areas without any power infrastructure. Wind energy has become competitive with conventional forms of energy. Wind energy is a potential choice for smaller energy producers due to relatively short installation times, easy operating procedures, and different available incentives for investment in wind energy.

C.Storage Bank

Batteries are the basic component of an energy storage system. Which is used as a back for the power supply for the system.

D.Power Electronic Devices

Different power electronic devices are used in this system as per the requirement such as AC-DC or DDC-AC converter, DC-DC converter.

VI.MATLAB SIMULATION MODEL OF PV &WIND SYSTEM

A. Modelling of Solar (PV) System

A PV generator consists of an assembly of solar cells, connections, protective parts, supports etc. Solar cells are made of semiconductor materials (usually silicon), which are specially treated to form an electric field, positive on one side and negative on the other. Then solar energy hits the solar cell, electrons are knocked loose from the atoms in the semiconductor material, creating electron-hole pairs. If electrical conductors are then attacked to the positive and negative sides, forming an electrical circuit, the electrons are captured in the form of electric current.[1]

Below diagram shows the Equivalent circuit diagram of a solar cell

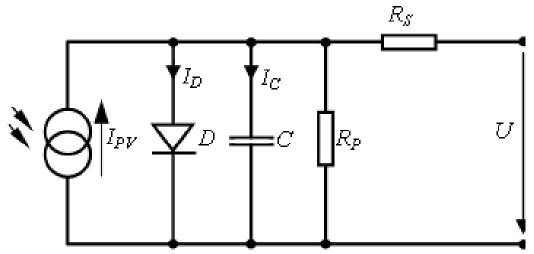

Figure 3. Equivalent circuit diagram of a solar cell

The basic Equation from the theory of semiconductors that mathematically describes I-V characteristics of PV cell is;

$$I = I_{pv.cell} - I_D$$

Where $I_{pv.cell}$is the current generated by incident light and I_D is the diode current.

The equation for saturation current I_0 given below;

$$\frac{Iscn + KI\Delta T}{\exp(Voc + Kv\Delta T)/aVt) - 1}$$

Equation for photovoltaic panel $I_{pv}$is given below;

$$I_{pv}=(Ipvn+ K_I\Delta T)G/Gn \qquad (3)$$

Figure-4 shows the mathematical model for current I_m shown in the following equation

$$I_m= I_{pv}- I_0[\exp (V+IRs/aVt) - 1] \qquad (4)$$

Where:

k - Boltzmann constant (1.3806 10^{-23} J/K);

T - Reference temperature of solar cell;

q - Elementary charge (1.6021 10^{-19}As);

V - Solar cell voltage (V);

I0 - saturation current of the diode (A);

I_{pv}- Photovoltaic current (A).

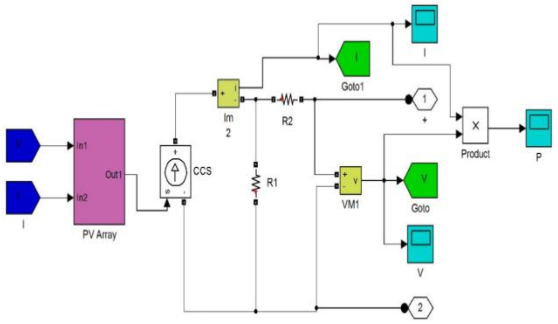

Figure 4. The MATLAB Simulink modelof PV array

B. Modelling of Wind Power System

Modeling the wind energy converter is made considering the following assumptions

- Friction is neglected;
- Stationary wind flow;
- Rotation-free flow;
- Free wind flow around the wind energy converter

Wind energy systems harness the kinetic energy of wind and convert it into electrical energy or use it to do other work, such as pump water, grind grains, etc. The kinetic energy of air of mass m moving at speed v can be expressed as

$$E_b = \frac{1}{2} mv^2 \qquad (5)$$

Where ρ is the density of air (kg/m3).

Based on the above two equations, the wind power

$$P = \frac{1}{2}\varrho Av^3 (6)$$

We have;

$$P = \frac{1}{2}\varrho Av^3C_p \qquad (7)$$

Cp is called the power coefficient of the rotor or the rotor efficiency. It is the fraction of the upstream wind power, which is captured by the rotor blades and has a theoretical maximum value of 0.59. In practical designs, maximum achievable Cp is between 0.4 and 0.5 for high-speed, two blade turbines and between 0.2 and 0.4 for low-speed turbines with more blades.

A MATLAB Simulink model based on the equations mentioned above, was developed for the wind generator module. This model is shown in below figure.6.[5]

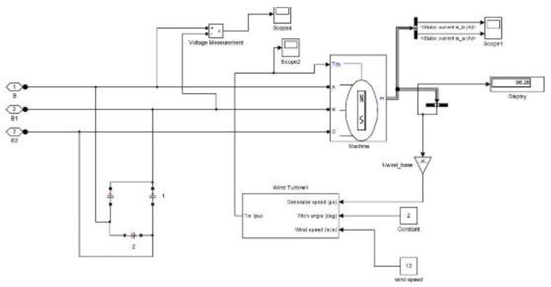

Figure 5.wind turbine Induction generator module

Elements	Installed Capacity/Demand
Solar	3000 W
Wind	2000 W
Battery Bank	5000 W
Village peak Load	5980 W

Table.2- Modeling parameters

In this hybrid system Solar PV system gives a power output of 3000 W at voltage 220V, Wind energy System gives power

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output 2000 W at 250 V and battery bank capacity is 5000 W. The voltage at the common dc bus is maintained at V. A multilevel inverter is used to get a supply voltage at 240 V 50 Hz with a power capacity of 6500 W.

We are managing the non-linear village load with the combination of any two of the three systems such as solar-wind, solar-battery and wind-battery for non-grid supply. With Gridsupply available a combination of gird plus hybrid power system is used to supply the village load

VII.SOLAR –WIND HYBRID POWER SYSTEM

Using the RegenSim. Library a renewable energy hybrid system shown in Fig.6.Had developed. As shown, the simulation system contains power generation blocks from renewable energy sources such as sun, wind, battery blocks (providing the energy storage), measurements blocks for electrical parameters (voltage, current etc.), inverter blocks (for power generation in DC voltage), energy consumer block

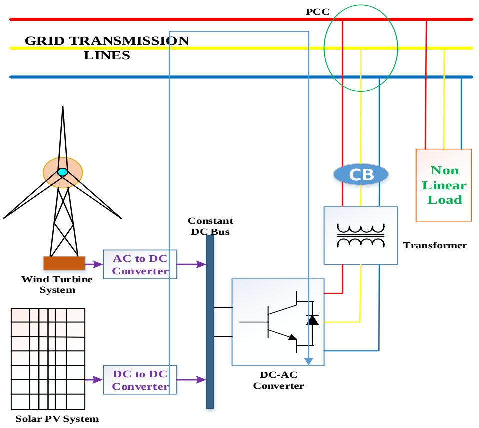

Figure.6- The MATLAB Simulink model of the solar-wind Hybrid power generation system.

CONCLUSION

Hybrid renewable energy system provide better environment for rural electrification in India. The hybrid renewable energy system provide mobile form of energy to consumer And relief the grid to some extend during peak load. A two system condition with grid supply and without grid supply is discussed. It gives a promising environment for rural electrification and control of power flow to the load. It's going to increase the per capita consumption of electricity of India

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