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A Novel Concept of Hybrid Renewable Generation for Power Supply at Remote Area

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Abstract:

The beginning of the 21st century has brought about a change in energy demands where the consumer expects a more mobile form of energy. These energy demands can be for professional needs (electrical equipment), for remote locations (lack of existing infrastructures) and for leisure purposes. Each end-user wants a self-contained energy source adapted for the use and generation of electric power it is necessary to use Renewable Energy sources (RES). Hybrid renewable energy system (HRES) which contain PV cell and wind combined system is interconnected with grid which gives continuity of the supply and provides better quality of power to the consumer. This paper discussed the HRES for rural electrification and load estimation in rural area, component of hybrid system.

Keywords — **Renewable energy system, Hybrid, Rural electrification, PV, Wind**

1.Introduction

There are many remote places, especially in developing countries, where grid supply has not reached yet but still with more availability of solar-wind hybrid systems. In India there are many places where the grid supply is not available due to geographical restriction. The large amount of dependence of economy on depleting fossil fuels and the adverse environmental effects of conventional power generation systems created renewed interest in renewable energy sources toward building a sustainable energy economy.

Solar and wind energy are non-deflectable, site dependent, non-polluting, and potential sources of alternative energy options. For both systems, variations in meteorological conditions are important. The performance of solar and wind energy systems are strongly dependent on the climatic conditions at the location. The power generated by a PV system is highly dependent on weather conditions. For example, during cloudy periods and at night, a PV system would not generate any power. Combined wind and solar systems are becoming more popular for stand–alone power generation applications, due to advances in renewable energy technologies and subsequent rise in prices of petroleum products. The Economic aspects of these technologies show sufficient promise to include them in developing power generation capacity for developing countries. Research and development efforts in solar, wind, and other renewable energy technologies are required to continue improving their performance, establishing techniques for accurately predicting their output and reliably integrating them withother conventional generating sources

2. Summary of Indian Village/Remote Area Electrification

Availability of electricity in Remote area which is adversely affected since last some year especially due to poor operational and financial health of SEB's (State Board of Electricity)Although more than 85% of villages electrified over the years, nearly more than 18452 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.

Table 1- Status of rural electrification in India

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

3. Load Estimation

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

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 Equation (1).

Equipment Rating*Quantity*Hour(1)

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

C.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;

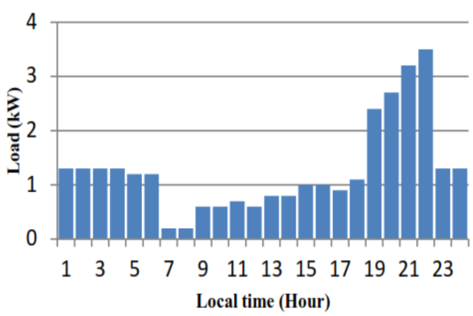

Figure1-Load Duration Graph

4. Existing System

The existing 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.

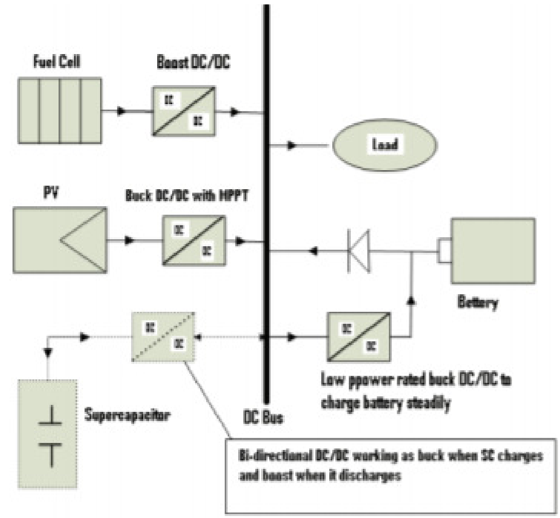

Figure 2-Existing Hybrid System

5. Proposed Solar –Wind Hybrid Power System

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

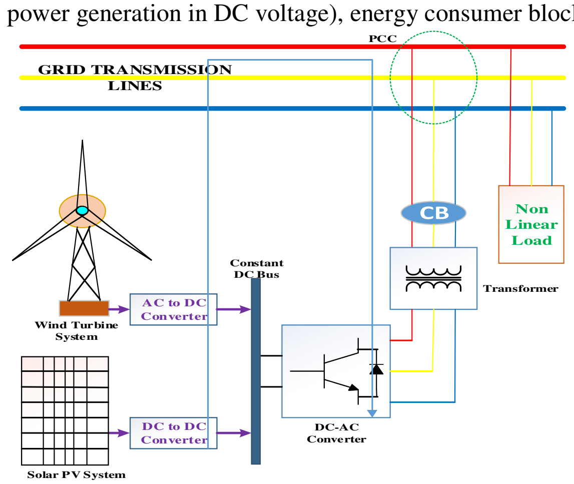

Figure3-solar-wind Hybrid power generation system

6. 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 power produced and in the other hand, the PV-generator is undersized, problems might occur in meeting the power demand at any time.

B. Wind Energy

*E*nergy 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

7. PV & WIND SYSTEM

A. 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.

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

$I = I_{pv.cell} - I_D$(2)

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

The equation.3 for saturation current I_0 given below;

$$\frac{\mathrm{Iscn} + \mathrm{KI}\Delta\mathrm{T}}{\exp(\mathrm{Voc} + \mathrm{Kv}\Delta\mathrm{T})\,/\mathrm{aVt}) - 1} \qquad (3)$$

Equation. 4 for photovoltaic panel $I_{pv}$is given below;

$I_{pv}= (I_{pvn}+ K_I\Delta T)\, G/G_n$ (4)

The current I_m shown in the following equation

$I_m= I_{pv}- I_0[\exp (V+IRs/aVt) - 1]$ (5)

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).

B. Wind Power System

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

$$E_b = \frac{1}{2}\, mv^2 \ (6)$$

Where ρ is the density of air (kg/m^3).

Based on the above two equations, the wind power

$P = \frac{1}{2}\varrho A v^3$ (7)

$P = \frac{1}{2}\varrho A v^3 C_p$ (8)

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

8. 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 electrificationand control of power flow to the load. It's going to increase the per capita consumption of electricity of India.

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