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Distributed Power Generation "The Future for Surplus Power"

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Abstract

The maximum electric power in world is produced by power plants running on fossil fuels and nuclear fuels .But the fossil fuels are present in a limited extent and the use of fossil fuels for power generation also disturbed the environment by polluting the environment with the flue gases. Electricity is also generated by other forms of energy like hydro, solar, wind, tidal, fuel cells, etc., but they are producing power in a small quantity, because of limited environmental conditions on their performance. If we combine the output of the small power generation units like wind, solar, etc. then the high quantity of power is generated from small units. This method of combining the small power generations units with each other for generating high quantity power is known as distributed power generation. According to the high demand of society for electric power, the distributed power generation is a way to supply the surplus power to the society for development and distributed power supply also helps to achieve the goal of smart grid. In this paper the distributed power generation is discussed with combined operation of the wind mill, photovoltaic cell and fuel cell. The three non-conventional energy forms are combined together for the economic operation of energy generation.

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Introduction

In India the electricity supply is lagging in terms of service as well as penetration. The power supply in India is suffers from frequent power cuts and high fluctuations in voltage and frequency due to which the condition of blackouts is formed. Currently in India the demand supply gap is 7.8% of average load and 13 % of peak demand load at current prices, which are heavily subsidized. For minimalizing this gap and maximizing the growth, it is necessary to double the present capacity by installing an additional generation capacity of 100,000 MW. This would require a high investment for generation, transmission& distribution. A major bottleneck in the development of the power sector is the poor financial state of the utilities, which can be attributed to the lack of adequate revenues and state subsidies for supply to the rural subscribers.in rural Indiaonly 31% households have access to electricity.in some states the power is free to agricultural subscribers due to of skewed tariff policy of power, therefore the power supplied to agricultural consumers at the cost of industrial & commercial consumers. This means the electricity supplied to irrigation pumps is not metered, provides for wasteful consumption and thefts. Agricultural consumption, to the extent estimated, is over 30% of total consumption in the country. Transmission and distribution (T&D) losses are over 25%, which are due to both technical losses and theft. A World Bank study on India's power sector describes a "vicious circle" in which the skewed tariff policy and poor financial health of utilities leads to low investments in upgrading power quality, which, in turn, creates opposition for tariff reforms among consumers; which only exacerbates the already poor financial condition of the utilities. Distributed power generation close to the load centers using renewable sources appears to have the potential to address at least some of the problems of electrification.

Distributed Power Generation

Distributed generation (DG) is attracting a lot of attention worldwide. The applications of DG are standby power, peak shaving, grid support and stand-alone power. Widespread use of DG provides alternate system architecture for the generation and delivery of heat and electricity with cost savings.

In the context of rural India, distributed power generation in rural areas can improve voltage profiles, lower distribution losses and supply reactive power locally. The renewable energy sources in rural India is used for the distributed power generation

Renewable energy technologies offer the promise of clean, abundant energy gathered from self-Renewing resources such as the sun, wind, water, earth, and plants. Virtually all regions of the world have renewable resources of one type or another. Renewable energy technologies offer important benefits compared to those of conventional energy sources. Worldwide, 1000 times more energy reaches the surface of the earth from the sun than is released today by all fossil fuels consumed. Photovoltaic and wind generation are also an attractive source of energy because of their benign effect on the environment. Increased population growth and economic development are accelerating the rate at which energy and in particular electrical energy is being demanded. All methods of electricity generation have consequences for the environment, so meeting this growth in demand, while safeguarding the environment poses a growing challenge. Hybrid power systems consist of a combination of renewable energy sources such as: photovoltaic (PV), wind generators, etc., to charge batteries and provide power to meet the energy demand, considering the local geography and other details of the place of installation. These types of systems, which are not connected to the main utility grid, are also used in stand-alone applications and operate independently and reliably. The best applications for these systems are in remote places, such as rural villages, in telecommunications, *etc*.

Hybrid Model of the Wind Mill, Solar Cell and Fuel Cell

The rapid depletion of fossil fuel resources on a world-wide basis has necessitated an urgent search for alternative energy sources to cater to the present day demands. Alternative energy resources such as solar and wind have attracted energy sectors to generate power on a large scale. A drawback, common to wind and solar options, is their unpredictable nature and dependence on weather and climatic changes, and the variations of solar and wind energy may not match with the time distribution of demand.

Fortunately, the problems caused by the variable nature of these resources can be partially overcome by integrating the two resources in proper combination, using the strengths of one source to overcome the weakness of the other. The hybrid systems that combine solar and wind generating units with battery backup can attenuate their individual fluctuations and reduce energy storage requirements significantly. However, some problems stem from the increased complexity of the system in comparison with single energy systems.

More over the low efficiency of this hybrid model is another big disadvantage, on the part of energy production. The above hybrid model use batteries as its storage system, which cannot be discharge beyond 30% from the point of view of life cycle of the batteries. So taking view of above difficulties of the solar/wind hybrid model, we are introducing Fuel cells as another generating resource accompany with the above two resources. The fuel cell can generate electricity at any climate conditions which can increase the overall production of the system and decrease the demand of batteries for this system. The individual efficiency of the fuel cell is very high which can improve the efficiency of whole new hybrid model. The efficiency of hydrogen fuel cell operating at 25°C has a maximum theoretical efficiency of 83%.

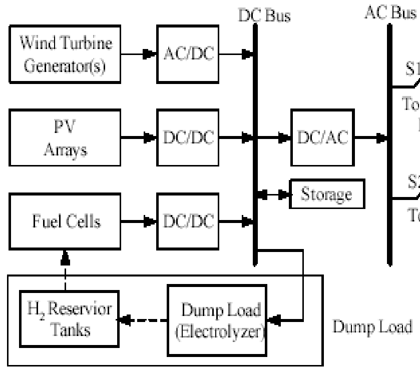

Fig-1 a Simple Model of PV /Wind/ Fuel cell system

Power output from hybrid system using simulation tool MATLAB

A. Solar photovoltaic cell

The solar cell is the basic building of the PV power system it produces about 1 W of power. To obtain high power, numerous such cell are connected in series and parallel circuits on a panel (module), the solar array or panel is a group of a several modules electrically connected in series parallel combination to generate the required current and voltage. The electrical characteristics of the PV module are generally represented by the current vs. voltage (I-V) and the current vs. power (P-V) curves. Figs. and show the (IV) and (P-V) characteristics of the used photovoltaic module at different solar illumination intensities.

The V–I characteristic of the PV module are

I = IL - I0 (e^q(V +IRS)/nkT _ 1) (1)

Where IL = photo current

I0 = diode saturation current

RS = series current

q = charge of electron

k = constant

T = temperature

N = number of PV module

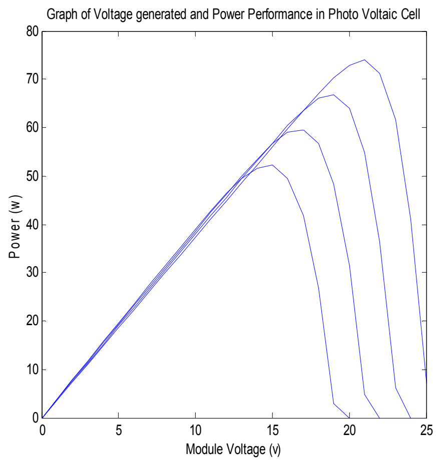

Fig. 2: Power delivers by a PV module for different valves of V

B. Wind energy system

The wind turbine captures the wind's kinetic energy in a rotor consisting of two or more blades mechanically coupled to an electrical to be used for system control. The fundamental equation governing the mechanical power capture of the wind turbine rotor blades, which drives the electrical generator, is given by:

Pwin(t)=1/2*ℓ*A*V(t)^3*Cp*Effad(2)

Where ℓ = air density (kg/m^3)

A = area swept of rotor (m^2)

V = wind speed (m/s)

Effad =efficiency of the AC/DC Converter

The theoretical maximum value of the power coefficient Cpis 0.59 and it is often expressed as function of the rotor tip-speed to wind-speed ratio (TSR). TSR is defined as the linear speed of the rotor to the wind speed.

TSR =ω□R/V (3)

Where R and ω□are the turbine radius and the angular speed, respectively. Whatever maximum value is attainable with a given wind turbine, it must be maintained constant at that value for the efficient capture of maximum wind power.

Power is directly proportional to wind speed, as the wind speed increases the power delivered by a wind turbine also increases. If wind speed is between the rated wind speed and the furling speed of the wind turbine, the power output will be equal to the rated power of the turbine. Finally, if the wind speed is less than the cut-in speed or greater than the furling speed there will be no output power from the turbine.

The graph for power generated by a wind turbine for different value of Cp is shown below.

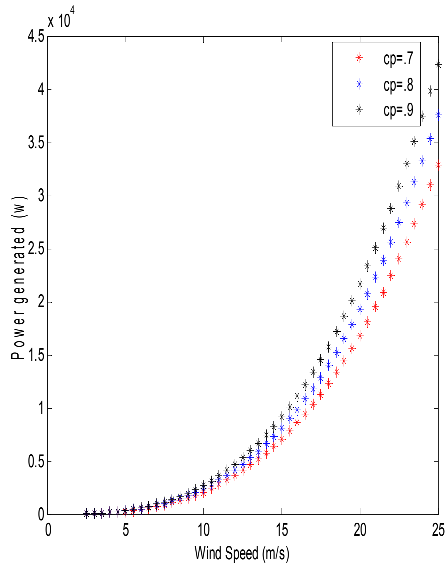

Fig. 3: The power generated by a wind turbine for different value of Cp

C. Power output of the fuel cell

The power output of the fuel cell is shown in the graph. The fuel cell used in the present SOFC (solid oxide fuel cell), the following fuel cell is used because of it following advantages:-

1. Operate at higher temperature, which reduces the need for expensive precious metals (such as platinum) to increase their electrical efficiency.
2. Can operate on a number of different hydrocarbon fuels,
3. Better start up time.
4. High electrical efficiency (70%)
5. Near zero emission and quite operation with little maintenance cost.

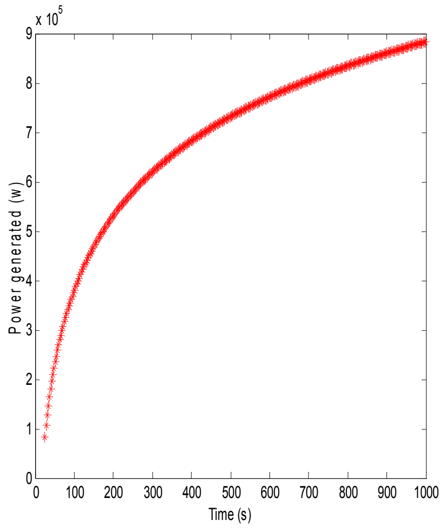

Fig. 4: Graph shows the Power response of the FC

The graph shows the voltage response of the FC, initially voltage is low until the current reaches a relative high level, the voltage reaches the peak just pass 1000s, and then starts to drop, and this is typical of FCs and has to do with irreversibility when current reaches certain level.

Neglecting the ohmic losses the total power generated by the FC (Pfc) is

Pfc =NoVI (4)

Were no = number of fuel cell

V = stack voltage

I = stack current

The total output power delivered can be increased by increasing the number of fuel cell; the power delivered by each fuel cell is different as the chemical reaction which makes chemical energy of fuel into electrical energy is different in each fuel cell.

Combine power output

A. Combine power output power from a Wind and a PV module

The total wind- and PV-generated power during each hour is first computed as follows:

$$P_{Gen}(t) = P_{Wind}(t) + N_{PV} \times P_{PV}(t)$$

Where NPVis the number of PV panels, and PWind(t) is the power from the wind at time T[6][7].

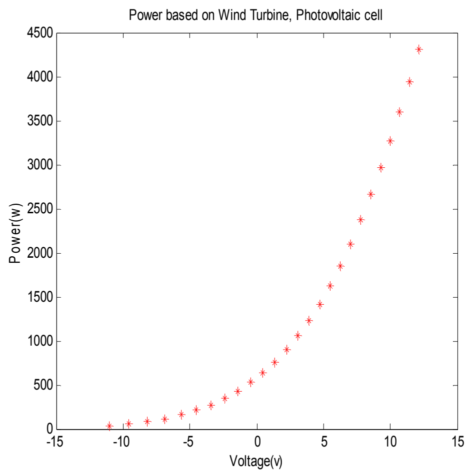

Fig. 5: Power based on wind turbine, photovoltaic cell

Combine power output power from a Wind /PV module/fuel cell

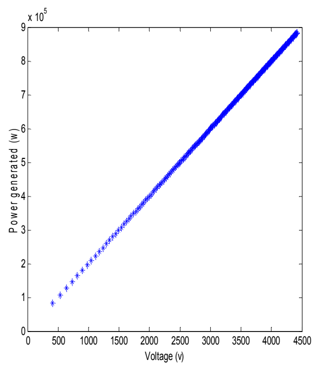

Fig. 6: Power based on Photovoltaic cell, Wind Turbine, Fuel cell

The graph here shows a linear variation which means the power delivered by the system increases as we increase the voltage to the system, more over its easy to find out the power delivered by the system to a particular voltage as the graph here is a linear one.

Conclusion

In this paper the hybrid model of wind/pv solar cell/fuel cell is used for distribution power generation in rural area. The combined operation of all the three power generating non-conventional energy sources improves the efficiency of the output

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