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Power Generation by Renewable Energy Sources Maintaining Efficiency and Power Quality

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Abstract—*Renewable energy source in one of the prominent source of energy which can increase the livelihood on earth planet comfortably. Renewable energy sources are proved to be the best alternative for the non-renewable sources such as fossil fuels. India has remarkable growth on electric generation through renewable source of energy. Now a days the renewable source of energy are eminent for reducing the consumption of fossil fuels. The ultimate source of energy is the energy form the sun which is in general term know as solar energy. The solar energy is trapped by the use of solar trackers which are the best conductors of heat as the conduction and convection process are generally takes place for the solar energy consumption. The best fact is that the solar energy is used to generate electric energy by the use of this natural ultimate source i.e. Sun. As India has more than 300 clear sunny days in a year. Day to day average solar energy strike rate over India varies from 4 to 7 kWh/m2 with about 1,500–2,000 sunshine hours per year, that is much more than current total energy consumption. The instruments used as solar tracker are solar receptors.*

Wind is the energy generally used as the substitute of the non-renewable source of energy. Turbulent wind is responsible for the generation of wind energy in wind farm. As with the day to day increase in the cost of non-renewable energy sources the best substitute for them is no other than wind farms. India is on fifth position in production of wind energy with the installed capacity of 11087MW. Even though the plant load factor (PLF) in wind power generation is very low. The increase in interest in wind energy is due to tax relaxation, investment subsidies, and government action towards renewable energy played a huge part in nation's energy system.

In the solar power plant also one need to use the thermal energy source to generate the energy, initially, or may need to use any non-renewable source by any means. Thus the whole of this research is about combination of the this two energy sources and get the power plant run fully by the mean of renewable source of energy only i.e. by the mean of solar energy and wind energy. The main concentration of this paper is to work on the efficiency of plant and also on the power quality. The power quality is affect by the voltage flicker and variable frequency.

Keywords: *solar tracker, solar receptors, renewable source of energy, turbulent wind, power quality, voltage flicker.*

1. INTRODUCTION

The cost of providing sufficient storage capacity for such applications can be reduced if the wind-derived power is interconnect with the other sources of power. For instance, since in most locations the wind often blows when the sun is not shining and vice versa , a system using wind energy collectors and sun energy collectors in combination can be expected to require less energy storage capacity than systems that use these type of collectors separately.

A combination of solar and wind systems are being experimented in a number of isolated locations not connected to the grid. Such system is shown in fig.2 depending on the frequency of the wind generator, consumer circuits could be switched on and off through a consumer control device to ensure that the frequency does not fluctuate by more than few percent of its rating. Similarly solar battery and a number of sections kept in operation depends on the charge on the battery and wind speed. Many remote power systems

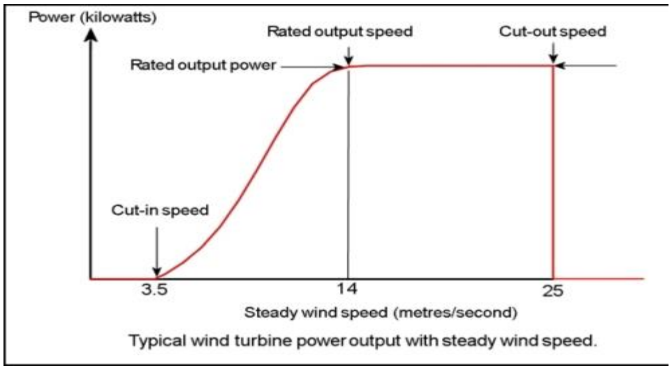
throughout the world rely on diesel generators for the production of electrical power. Such applications include village electrification, irrigation and water pumping. Many of these applications incur high electric energy systems, such as wind and photovoltaic (PV) and batteries by reducing the amount of fossil fuel required.

2. EFFICIENCY OF WIND-MACHINE

Wind Energy Conversion System efficiency is of interest to both aerogenerator designers and system engineers. As WECS is a capital intensive technology, it is desirable for the overall wind electric plant to have the highest efficiency possible, thus optimally utilizing capital resources and minimizing the busbar electric energy cost.

The overall conversion efficiency, $\dot{\eta}_o$ of an aerogenerator of the general type is :-

$\dot{\eta}_o$ = useful output power ÷ wind power input speed ratio in the range a roughly 6 to 10.(Figure1)



It has also been observed that the convertible power of energy is proportional to the cube of the wind speed. Thus if the wind speed decreased by 20%, the power output is reduced by almost 50%. The wind speed may be considerable from day to day and from season to season. The efficiency of a wind generator depends first and foremost on the blade tip speed to wind speed V_T/V if n is the rotation frequency, i.e. rotations per second, if a rotor of diameter D meters, the tip speed is π n D m/sec.

where

$= \dot{\eta}_A . \dot{\eta}_G . \dot{\eta}_C . \dot{\eta}_{Gen}$

Fig. 1

$\dot{\eta}_A$ = Efficiency of the aeroturbine
$\dot{\eta}_G$ = Efficiency of the gearing
$\dot{\eta}_C$ = Efficiency of the mechanical coupling
$\dot{\eta}_{Gen}$ = Efficiency of the generator

By the cascaded energy conversion, form which overall efficiency will be strongly determined by the

Golding has derived the expression for aeroturbine efficiency as :-

$$\dot{\eta}_A = = C_P \frac{1-k\,(V_T/V)}{1+k\,(V_T/V)}$$

lowest efficiency converter in the cascade. The efficiency of the remaining three element is quite high bu less than 100%.

Consider an arbitrary aeroturbine of cross- sectional area A driven by the wind. Its efficiency

Where

where

$$k = \frac{F_D}{F_L} = \frac{\text{drag}}{\text{lift}} \text{ ratio}$$

would be:

$\dot{\eta}_A$ = useful shaft power output ÷ wind power input
= C_p
= Coefficient of performance

The theoretical maximum value of C_p is 0.593.

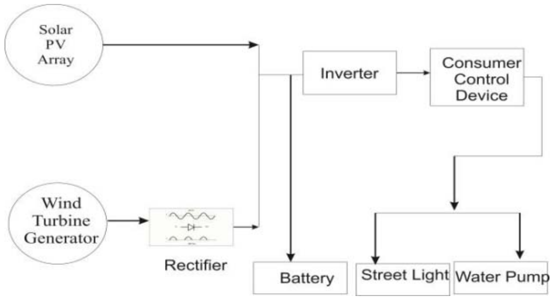


Fig. 2

In the practice two-blade propeller type of rotor can a maximum power coefficient of 0,4 to 0.45 at a tip
V_T = wind velocity of blade element in plane of rotation due to blade turning. V = impinging wind velocity.

The Betz limit on wind turbine efficiency. There is a theoretical limit on the amount of power that can be extracted by a wind turbine from an airstream. It is called the Betz limit. The limit is

$\dot{\eta} = 16/27 \approx 59\%$

3. CHARACTERISTIC SHOWN BY THE WIND GENERATOR

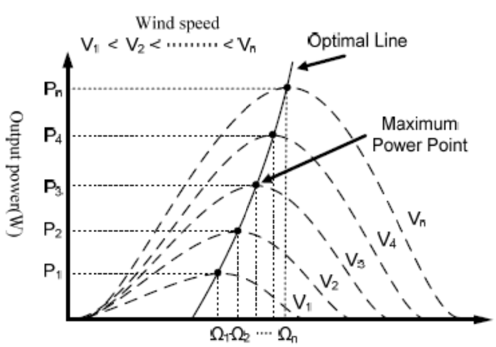
The maximum power of a machine corresponds to value of TSR at various wind speeds.

Thus, when the wind speed will be fixed, then a non- linear relationship between the machine (generator) output power and the rotor speed. A variable-speed operation of the wind generators to enables the system to effectively reduce the mechanical stress on the generator blades and gears. The design of the system structure as well as control strategy has a gentle influence on the system performance and the power output of generator.

Maximum Power Point Tracking is an electronic system which operates the Photovoltaic (PV) modules in a manner that allows the modules to produce all the power. Maximum Power Point Tracking (MPPT) is not a mechanical tracking system that —physically moves the modules to direct them to point more directly at the sun. MPPT is a completely an electronic system that varies the electrical operating point of the modules so that the modules are able to deliver maximum available power. The extra power harvested from the modules is then provided as increased battery charge current. MPPT is to be used in conjunction with a mechanical tracking system, whereas the two systems are completely different.

The wind generation power coefficient is maximized for a tip-speed ratio value λopt when the blades pitch angle is β = 0◦. The wind generation power curves for various wind speeds are shown in Fig. 3. It is observed that, for each wind speed, there exists a specific point in the wind generation output power versus rotating- speed characteristic where the output power is maximized. The control of the wind generation load results in a variable-speed wind generation operation, such that maximum power is extracted continuously from the wind. The value of the tip-speed ratio is constant for all maximum power points , while the wind generation speed of rotation is related to the wind speed as follows:

$$\Omega_n = \lambda_{opt} \frac{V_n}{R}$$



Rotor speed (in m/s) Fig. 3

Table 1. The Classification System For Wind

Turbines. Source: Spera, 1994 And Gipe, 1999

4. VOLTAGE FLICKER IN WIND POWER GENERATION

Voltage flicker is a visible variation in brightness of lamp due to rapid fluctuations in the voltage on the power supply. Over the source impedance of grid , the voltage drop is generated by changing the load current of an equipment . Such fluctuations in time generate flicker. Flicker generally affect the sensitive electronic equipment such as TV receivers or industrial processes relying on constant electrical power.

A flickermeter device is used for the measurement of instantaneous flicker sensation on terminal voltage of a STATCOM unit. The flickermeter model is designed according to functional specifications of the international standard IEC 6100-4-15. The flickermeter is a standardized instrument for measuring the flicker obtained by simulation and by statistical analysis of the response of the lamp-eye- brain chain to the input voltage fluctuations. (Fig. 6).

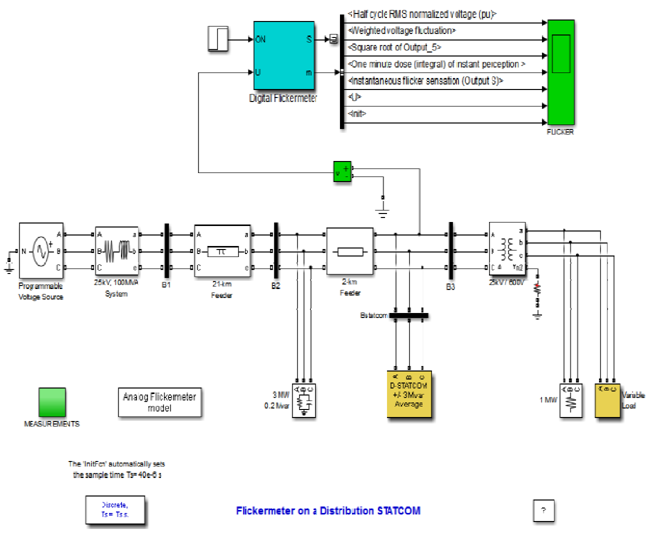


Fig. 4

In order to minimize the initial transient response, certain initial conditions need to defined for the different transfer functions. A fixed initialization period (Tin = 0.3 s) is required between the instant the model is enabled (input ON = 1) and the computation of the results. Fig. 4.

Measurement	Rotor diameter	Power rating
Micro	Less than 30 mm	0.05 kW to 2 kW
Small	30 mm to 120 mm	2 kW to 40 kW
Medium	120 mm to 450 mm	40 kW to 999 kW
Large	460 mm and Larger	More than 1.0 MW

5. RESULT

The flicker generated on the model above as shown in the graph developed on the scope:

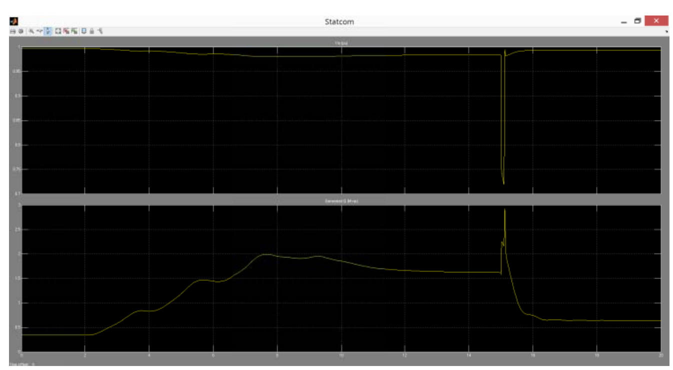


Fig. 5

6. CONCLUSION

The wind power generate the voltage at the very drastic level by the mean of the wind as the fuel as the renewable source. The efficiency of the wind turbine taking the reference of Betz limit then it will be only

59%. The flicker may also generate at the mid of the generation which is controlled by the STATCOM. The flicker meter is used for the detection of such flicker and the STATCOM is the device which is used for its rectification. The speed range 3.5 to 4.0 rev/s produced a higher power coefficient at a higher tip speed ratio than the other speeds. Considering that these tests are performed on a wind turbine which was operated below par, the output seems to indicate that it is operating more efficiently in the middle speed range i.e. from 3.5 to 4.0 rev/s.

7. FUTURE SCOPE

The paper just revels about the efficiency of the wind power plant and also emphasis on to the maintenance of the power quality by equalizing or rectification of the flicker by the FACTS like STATCOM. The future work on the paper will be on increasing the efficiency of the hybrid plant which will be cumulative of the solar and wind power generating station.

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