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Efficiency Analysis of Grid Connected Hybrid Wind-Biodiesel Electric Power Generation System

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Abstract— In this paper renewable energy sources, which are expected to be a promising alternative energy source, which are continually replenished such as sunlight, wind, biodiesel. About 16% of global final energy consumption comes from renewable resources. To have sustainable growth and social progress, it is necessary to meet the energy need by utilizing the renewable energy resources like biofuels, solar, wind, etc. Biodiesel is a renewable fuel, which is an alternative to petroleum-based diesel fuel. Diesel fuel is used for commercial trucks, home and industrial generators, and heating oil, So demand for diesel passenger vehicles grows. The need to integrate the renewable energy like biofuels and wind into power system is to make it possible to minimize the environmental impact on conventional plant. Biodiesel production is the process of producing the biofuel through the chemical reaction called trans-esterification. This involves vegetable or animal fats and neem oil, sunflower oil, pongamia oil, soybean oil, palm oil, mustard oil being reacted with short-chain alcohols (typically methanol or ethanol).The wind power system is well established technologies for renewable energy sources. Each technology has its own individual instrumentation requirements to measure and control system variables. MATLAB software is used to simulate the model. Several endurance will be carried out to investigate wind and diesel- biodiesel blend grid connected generating system. In future work, the MAT Lab will be used to analyze the grid connected hybrid system consisting of wind, biodiesel and energies.

Index Terms— Hybrid energy, Wind energy, Biodiesel, PWM Inverter, Diesel engine.

I. INTRODUCTION

India ranks 5th in wind power generation as on date, with US having the highest installed capacity of over 25GW, with Germany, Spain, China following with 24,17 and 12 GW respectively. In the Indian wind power development, the primary driving factor has been feed in tariffs and accelerated depreciation and other tax incentives for domestic wind systems. Hence most of the investors in Wind Energy, apart from the demonstration projects of State and Central Governments are all from the following table.

There are more than 3500 wind farm having capacities of WEG (Wind Electric Generator) from 225 kW to 2000 kW and most of the owners have bought either from Vendors

TABLE 1 Project in India

State	Energy in MW	Percentage (%)
Tamil Nadu	4305	42.0
Maharashtra	1939	18.9
Gujarat	1567	15.3
Karnataka	1327	13.0
Rajasthan	73.8	7.2
Madhya Pradesh	213	2.1
Andhra Pradesh	123	1.2
Kerala	27	0.3
West Bengal	1	0.0
Total	10242	100.0

(system integrators) or manufacturers having joint ventures or licensing agreement with Foreign collaborators mostly of European origin. India has got an ambitious plan to exploit in full, the wind energy potential in the Country which is estimated to be 48 GW of which only 20% has been

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exploited as on date. However, this amounts to about 3 to 5% of net electricity generated in India.

At present biodiesel is being used as the alternate fuel for a number of vehicles. Biodiesel can be used as the fuel for vehicles in pure form or it can be blended with petroleum diesel in any ratio and be used as the fuel. The blend of 20% of biodiesel and 80% of petroleum diesel is designated as B20, while 100% biodiesel is designated as B100. The B20 can be used in almost all the diesel engines without carrying out any changes in the engine. As the content of biodiesel increases in the biodiesel blend beyond B20 the users must know the issues of potential impact on the engine warranties. You may also have to change the hoses and gaskets for the engine.

The B100 is a pure biodiesel that can also be used as the fuel for the vehicles using petroleum diesel engines with some changes in the hoses and gaskets of the engines. As the proportion of biodiesel increases in the blend a number of concerns need to be addressed. Firstly the energy content of biodiesel is lesser than petroleum diesel so with increasing content of biodiesel the performance of engine is bound to be affected.

II. WIND POWER EQUATION

Although the power equation above gives us the power in the wind, the actual power that we can extract from the wind is significantly less than this figure suggests. The actual power will depend on several factors, such as the type of machine and rotor used the sophistication of blade design, friction losses, and the losses in the pump or other equipment connected to the wind machine. There are also physical limits to the amount of power that can be extracted realistically from the wind.

However, significant areas of the world have mean annual wind speeds of above 4-5 m/s (meters per second) which makes small-scale wind powered electricity generation an attractive option. It is important to obtain accurate wind speed data for the site in mind before any decision can be made as to its suitability. Methods for assessing the mean wind speed are found in the relevant texts (see the References and resources 'section at the end of this fact sheet).

The power in the wind is proportional to

- The area of windmill being swept by the wind
- The cube of the wind speed

The formula used for calculating the power in the wind is shown below:

Power = density of air x swept area x velocity cubed/2

$$P=½.\rho.A.V^3 \qquad (1)$$

Where,

P is power in watts (W)

ρ is the air density in kilograms per cubic metre (kg/m^3)

A is the swept rotor area in square metres (m^2)

V is the wind speed in metres per second (m/s)

The fact that the power is proportional to the cube of the wind speed is very significant. This can be demonstrated by pointing out that if the wind speed doubles then the power in the wind increases by a factor of eight. It is therefore worthwhile finding a site which has a relatively high mean wind speed.

It can been shown theoretically that any windmill can only possibly extract a maximum of 59.3% of the power from the wind (this is known as the Betz limit). In reality, this figure is usually around 45% (maximum) for a large electricity producing turbine and around 30% to 40% for a wind pump, (see the section on coefficient of performance below). So, modifying the formula for Power in the wind we can say that the power which is produced by the wind machine can be given by

$$PM = ½.C_p.\rho\ A.V^3 \qquad (2)$$

Where,

PM is power (in watts) available from the machine

C_p is the coefficient of performance of the wind machine.

It is also worth bearing in mind that a wind machine will only operate at its maximum efficiency for a fraction of the time it is running, due to variations in wind speed. A rough estimate of the output from a wind machine can be obtained using the following equation

$$P_A = 0.2\ A\ V3 \qquad (3)$$

Where,

P_A is the average power output in watts over the year

V is the mean annual wind speed in m/s.

A. Principles of Wind Energy Conversion

There are two primary physical principles by which energy can be extracted from the wind these are through the creation of either lift or drag force. The difference between drag and lift is illustrated by the difference between using a spinnaker sail, which fills like a parachute and pulls a sailing boat with the wind, and a Bermuda rig, the familiar triangular sail which deflects with wind and allows a sailing boat to travel across the wind or slightly into the wind.

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TABLE 2: Types of the wind turbine

Type	Speed	Torque	Cp	Solidity %)	Use
Horizontal Axis					
Multi blade	Low	High	0.25 -0.4	50- 80	Mechanical Power
Three-bladed aerofoil	High	Low	up to 0.45	Less than 5	Electricity Production
Vertical Axis					
Panemone	Low	Medium	less than 0.1	50	Mechanical Power
Darrieus	Moderate	Very low	0.25-0.35	10- 20	Electricity Production

There are various important wind speeds to be considered

• Start-up wind speed - the wind speed that will turn an unloaded rotor

• Cut-in wind speed – the wind speed at which the rotor can be loaded

• Rated wind speed – the wind speed at which the machine is designed to run (this is at optimum tip-speed ratio).

• Furling wind speed – the wind speed at which the machine will be turned out of the wind to prevent damage

• Maximum design wind speed – the wind speed above which damage could occur to the machine.

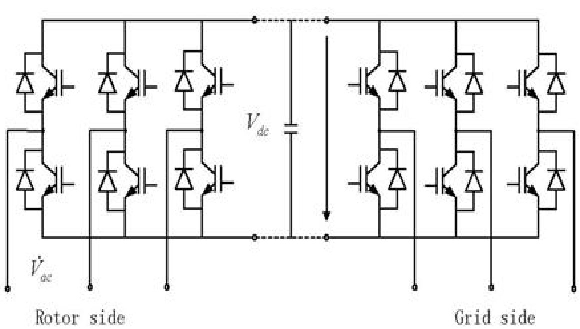

Figure: 1 power converter

*B.*PWM Converter

A device that converts dc power into ac power at desired output voltage and frequency is called an Inverter. Voltage Source Inverter is one in which the dc source has small or negligible impedance. In other words, a Voltage source inverter has a stiff voltage source at its input terminals.PWM control is a method to control the output voltage that is widely in application. In this method, a fixed dc input voltage is given to the inverter and a controlled ac output voltage is obtained by adjusting the on and off periods of the inverter components.

III THE BASIC PROCESS

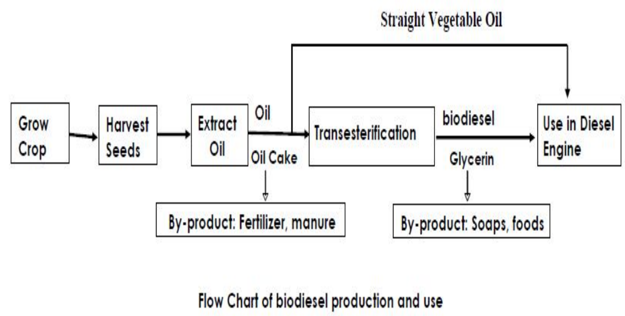

Figure 2:biodiesel production

A. Solvent

Biodiesel is a good solvent. Biodiesel can, if left on a painted surface long enough, dissolve certain types of paints. Therefore it is recommended to wipe any biodiesel or Biodiesel blend spills from painted surfaces immediately.

B. *Performance*

Operationally, biodiesel performs very similar to low sulphur diesel in terms of power, torque, and fuel without major modification of engines or infrastructure. One of the major advantages of biodiesel is the fact that it can be used in existing engines and fuel injection equipment with little impact to operating performance. Biodiesel has a higher cetane number than diesel fuel. In over 15 million miles of in-field demonstrations biodiesel showed similar fuel consumption, horsepower, torque, and haulage rates as conventional diesel fuel.

C. Compatibility Of Biodiesel With Engine Components

In general, biodiesel will soften and degrade certain types of elastomers and natural rubber compounds over time. Using high % blends can impact fuel system components (primarily fuel hoses and fuel pump seals), that contain elastomeric compounds incompatible with biodiesel. Manufacturers recommend that natural or butyl rubbers not be allowed to come in contact with pure biodiesel. Biodiesel will lead to degradation of these materials over time, although the effect is lessened with biodiesel blends. If a fuel system does contain these materials pure biodiesel is being used, replacement with

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compatible elastomers is recommended. The recent switch to low sulphur diesel fuel has caused many OEMs to switch to components suitable for use with biodiesel

.

D. Biodiesel Vs Vegetable Oil Systems For The Farm

For diesel engines, there are two main fuel alternatives to diesel. The first approach is to modify the fuel to run in the vehicle (which is biodiesel) and the second approach is to modify the fuel delivery system to use Straight Vegetable Oil (SVO). With a SVO system it is necessary to reduce the viscosity of the vegetable oil by heating the vegetable oil.

(1).The power equivalent of fuel is:

$$pf = m_f \times c_v \qquad (4)$$

Where,

M_{f} = fuel consumption rate in grams per second

C_{v} = LHV is the lower heating value of the fuel

In MEP [kPa], this becomes:

Fuel MEP=2000*(Pf)/(VN) (5)

Where,

V is the engine displacement in liters

N is the engine speed (rps)

The output of the generator in kWh was divided by the input value of the fuel (power of fuel) used in kWh.

Multiply this figure by 100 to express it as a percent.

$$\text{Energy efficiency} = \frac{\text{Energy output (kWh)}}{\text{Energy input (kWh)}} \times 100\% \qquad (6)$$

The output of the generator could also be determines by the formula of brake thermal efficiency.

IV. SIMMULATION DIAGRAM

A. Wind Simulation Diagram

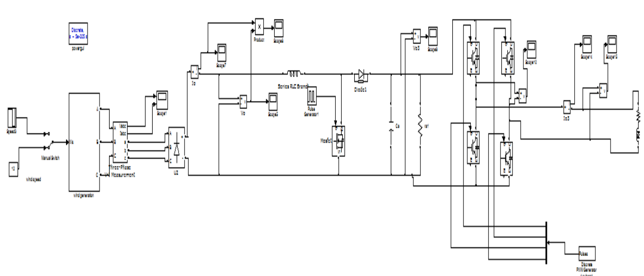

Figure 3: Simulation diagram for wind turbine

The wind energy conversion system operating for the variable speed operation. The tip speed ratio is defined as the ratio of the speed of the extremities of a windmill rotor to the speed of the free wind. Drag devices always have tip-speed ratios less than one and hence turn slowly, whereas lift devices can have high tip-speed ratios and hence turn quickly relative to the wind.The wind energy conversion output efficiency is 40%.So the seasonally time only get the power from wind turbine.

B.Biodiesel Simmualtion Diagram

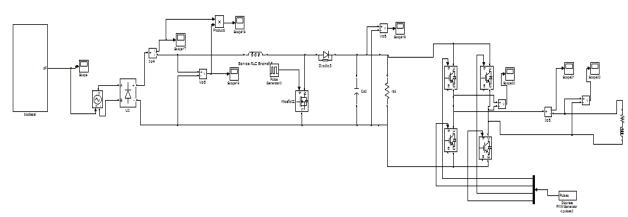

Figure 4: Simulation diagram for biodiesel

Biodiesel is reported to have good lubricating properties which improves engine life and reduces engine component wear.The component of generator that is used

to convert the chemical energy of the biodiesel into mechanical energy is named as engine.The chemical energy of the fuel is firstly changed into mechanical energy by the engine of the generator and then alternator converts this energy in to electrical energy.The diesel generator replaced to waste vegtable oil of biodiesel.So the diesel generator and biodiesel generator efficiency analyzed.

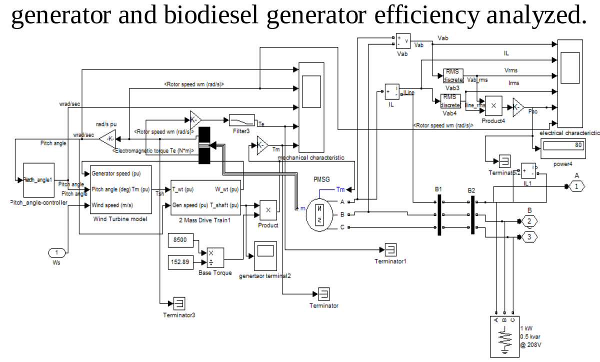

Figure 5: Subsystem for wind turbine

converting the kinetic energy of the turbine rotation into heat. This method is useful if the kinetic load on the generator is suddenly reduced or is too small to keep the turbine speed within its allowed limit. Cyclically braking causes the blades to slow down, which increases the stalling effect, reducing the efficiency of the blades.

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This way, the turbine's rotation can be kept at a safe speed in faster winds while maintaining (nominal) power output. This method is usually not applied on large grid-connected wind turbines.

Windmill can only possibly extract a maximum of 59.3% of the power from the wind . In reality, is usually around 45% (maximum) for a large electricity producing turbine and around 30% to 40% for a wind pump, (see the section on coefficient of performance below).

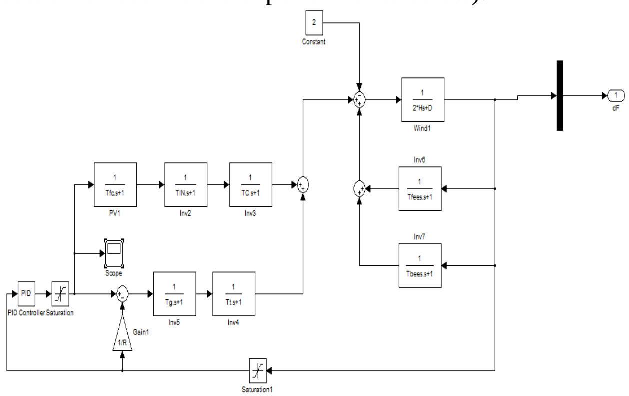

Figure 6: Subsystem for biodiesel engine

The diesel generator replaced to biodiesel oil .So the biodiesel output overall efficiency is 40%.In diesel generator output overall efficiency is 33%.So the waste vegtable oil is good efficiency and good lubricant oil.The environmental pollution is reduce.

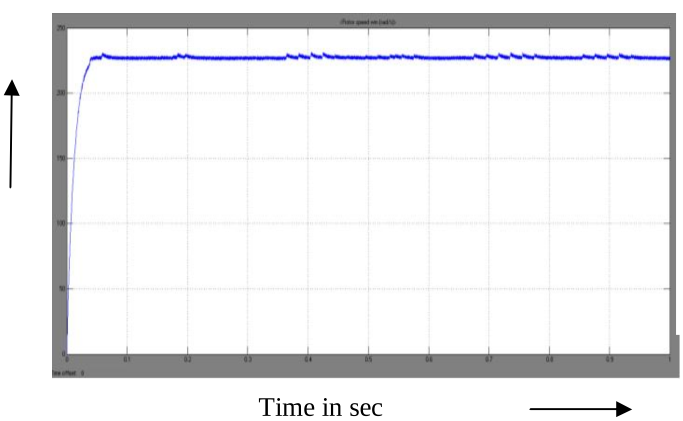

Figure 7: Wind speed

The wind energy conversion speed is gradually increasing for the variable speed operation .Then wind speed operation certain period condition saturated shown in below figure. The cut-in velocity (v cut-in) is defined as the wind speed at which the turbine starts to generate the power.

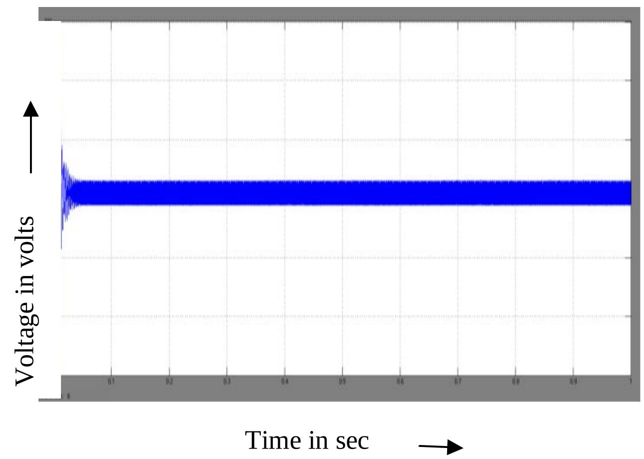

Figure 8: Wind energy Converter output

The wind turbine is an energy converter device that captures energy from the wind and converts it into useful work. Almost all of the wind energy conversion systems are connected to the grid of electric power networks.

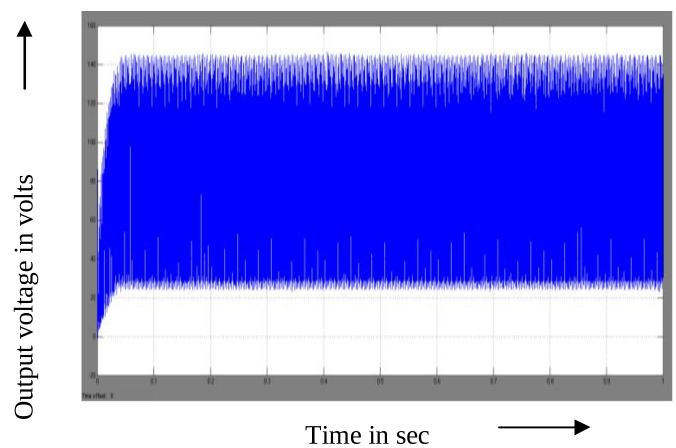

Figure 9: Wind system output voltage

The wind energy conversion system output voltage is also increasing to initial condition and certain period saturated the waveform.So the wind energy is depending upon the speed and time. The variable speed operation only geting the more amount of output.The wind speed is increasing at the same time power also increasing.So the wind speed characteristics waveform speed is gradually increasing and saturated the curve.

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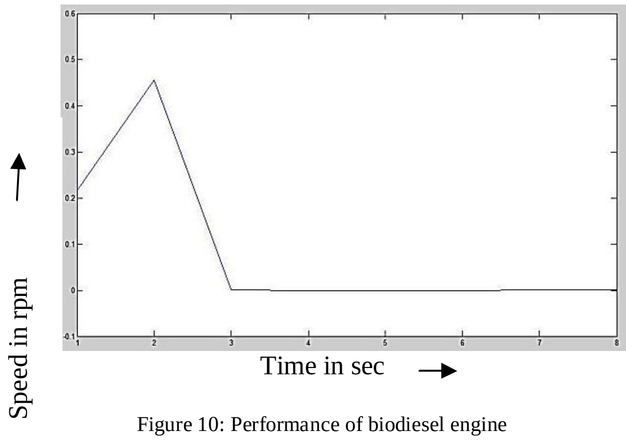

Figure 10: Performance of biodiesel engine

The diesel engine replace to run the biodiesel engine.so the engine running speed initially high.The speed will decrease and constant speed run engine.So the efficiency is high and fast compare to diesel engine performance.

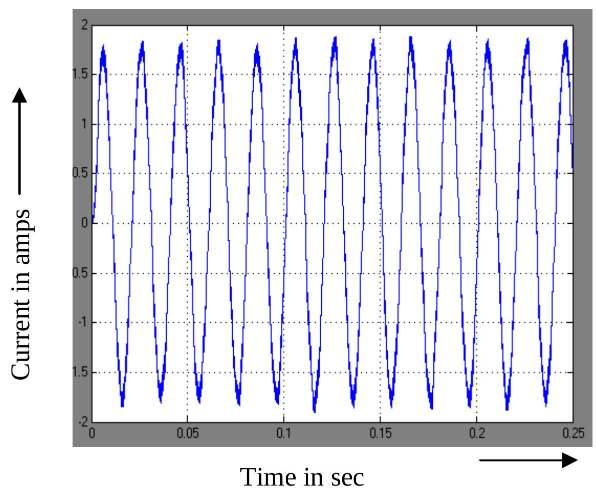

Figure 11: Biodiesel output current

From that biodiesel output curent is 2amps get the output side.So the converter and inverter device will be used to get the output power.Converter of the device is voltage fluctuation will be reduced and output ac current is getting the inverter side.

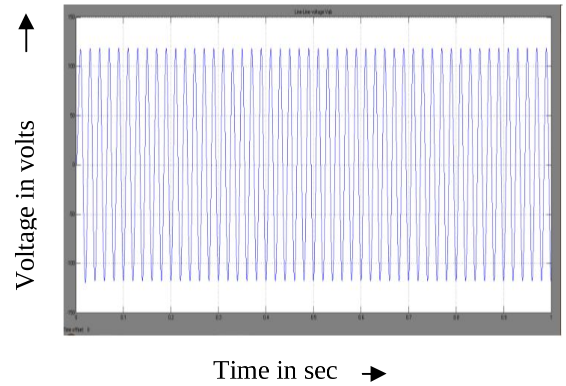

Figure12: Output ac voltage waveform

The AC/DC/AC converter is divided into two components.The Voltage-Sourced Converters that use forced-commutated power electronic devices (IGBTs) to synthesize an AC voltage from a DC voltage source. A capacitor connected on the DC side acts as the DC voltage source. The power captured by the wind turbine is converted into electrical power by the induction generator and it is transmitted to the grid by the stator and the rotor windings.So the wind turbine ac output voltage is connected to grid.

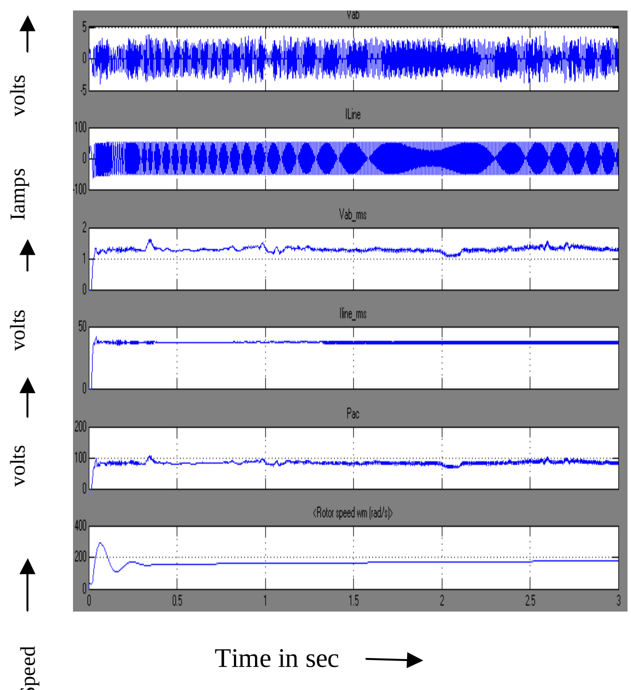

Figure13:Mechanical characteristics

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The PMSG technology allows extracting maximum energy from the wind for low wind speeds by optimizing the turbine speed, while minimizing mechanical stresses on the turbine during gusts of wind. The optimum turbine speed producing maximum mechanical energy for a given wind speed is proportional to the wind speed .Another advantage of the PMSG technology is the ability for power electronic converters to generate or Turbine.In this waveform line current and voltage value Shown in figure.

V. SIMMULATION RESULT

Efficiency analysis:
Power= voltage x current.
Wind energy efficiency

$$\text{Efficiency} = \frac{182}{600} \times 100\%$$
$$=30.33\%$$

Biodiesel energy efficiency

$$\text{Efficiency} = \frac{480}{1175} \times 100\%$$
$$=40.85\%.$$

VI. CONCLUSION

The wind energy conversion system output is simulated using MATLAB. The behavior of converters and the output of wind energy conversion system at variable speed of wind generator are analyzed in this paper. When the wind power is increased, the efficiency of the output is also increased. The converter system can regulate the dc bus voltage with nearly sinusoidal line side current and low harmonics distortion. The system can track the maximum output power by various wind speeds. The wind energy conversion system obtains the power only at the time of season. But the biodiesel system obtains the power continuously. The biodiesel is reported to have good lubricating properties which improve engine life. Simulation result shown that biodiesel electric power generation system achieves superior capability of efficiency. The efficiency of Wind power generation system is 30% at a wind velocity of 9 meters per second (about 20 mph) and biodiesel efficiency is 40%.These plants ensure a continuous power output and keeping fuel costs down due to the CO_2 emissions. By combining the wind turbines with biodiesel engines, the efficiency of the biodiesel is high, so these plants ensure a continuous power output.

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BIOGRAPHY

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