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Dynamic Modelling of Hybrid System for Efficient Power Transfer under Different Condition

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Abstract:

This paper proposed a dynamic modeling of hybrid wind-PV-battery system with investigation of the proposed model under various conditions. In this system three sources are connected through DC-links with different converters such as AC or DC. The aim of this paper is to provides continuous power in different seasonal and in weather conditions and investigation of the dynamic model performance of the system under effect of quality and stability of the system. The dynamic modeled systems were simulink and tested in MATLAB simulink software.

Keywords **— hybrid, dynamic, converter, power quality, power stability.**

. INTRODUCTION

Due to vanishing fuel with large amount of CO_2 production in environment, we have to find an alternative solution with new technologies which provides reliable power with less disadvantages. Renewable sources using in production of power with battery which can't meet only load demand but also reduce generation cost and environment pollution [1]. For generation of power by renewable sources depends on the atmospheric condition, this source can meet sustained load demand, two or more source are required for integration such as wind and solar. Renewable energy source has a numerous advantages over non-renewable sources such as have high efficiency, no emission, no fuel cost, and onsite installation [2]. The operation of hybrid system source requires understanding the dynamic behavior of the hybrid wind-PV-battery system [1]. In this paper presents dynamic modeling of wind-PV-battery system and controlled continuous power supply for load demand. A 4KW hybrid wind-PV-battery dynamic system is modeled and systems were explored in this paper [3]. The hybrid wind-PV-battery system works on the principle of stand-alone micro-grid with autonomous mode operation. The dynamic load connected to the hybrid generation system is 5HP DC motor load. The energy generation from hybrid wind-PV-battery system is useful in providing power in remote areas which are isolated from utility grid and stand-alone operation is best option at that site [4]. The dynamic model of hybrid system is tested in Matlab simulink software and its results shown with different operating conditions.

. SYSTEM CONFIGURATION AND DYNAMIC MODELING

Hybrid system consists of a PV and wind panel system with battery bank and system dynamic model for each component individually shown in figure 1. The system components connected through different-different converters [5].

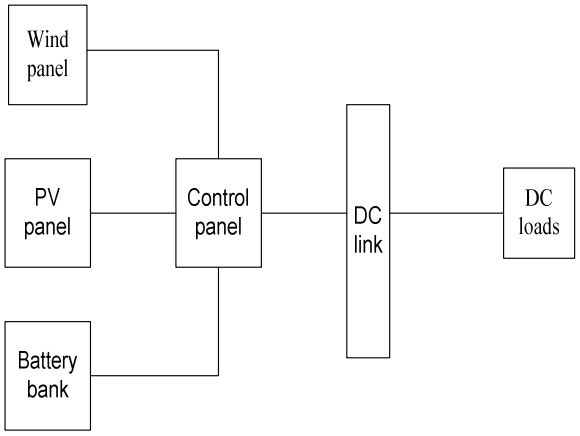


Fig. 1 Hybrid wind-PV-battery system.

A. PV Array

PV array is not a single cell it is a combination of number solar cell in series and parallel connected mode and module is a combination of series and parallel connected cells. Operating point of PV-module

determined by DC voltage of the cell and PV array output depends on isolation level, and affected by the temperature.

B. Wind Turbine

Wind energy conversion system is a two-step conversion required from power to electrical power (1). Wind power is converted from mechanical power, (2). Electrical power is obtained from the permanent magnet synchronous generator that is connected through DC links. The input parameter of wind turbine is wind speed.

C. Battery

Battery system works on the constant voltage and battery connected to the DC link through converter and it works as charging and discharging mode of the battery. Battery voltage set at minimum valve for when it discharge, battery does not damage due to discharging.

□. DYNAMIC SIMULATION AND RESULTS

Figure 2 shows that dynamic simulink model of hybrid wind-PV-battery system and this configuration is used for testing efficient, reliable and continuous power under various variable input cases. The system mainly operates in two modes (1). When nature of source various, (2). When load power varies.

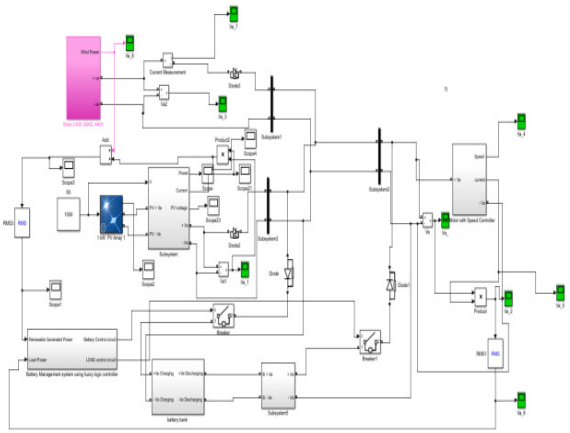


Fig. 2 Dynamic simulink model.

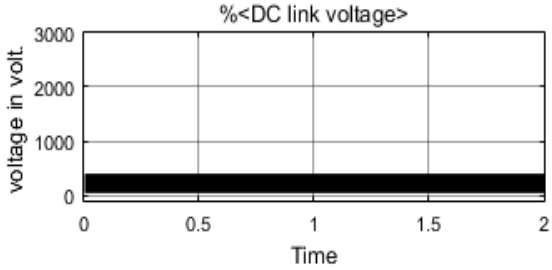
Modes of operating condition

In this condition system input conditions was changed according to the weather and environmental conditions. Investigate model on weather conditions such as summer, winter and rainy season and environmental conditions as day and night. In different season wind and sun nature was also changed with time but in rainy season sun may not be produce power or in night environment and wind also produce power merely depends on the wind speed conditions at that time. Solar can generates power only for few hours in a day because sun has a six hour for show their higher intensity. Solar produces variable power due to the variable solar irradiation in morning 8-11 low, 12-1 high, mid day 1-4 very high, 4-5 low and late day 5-7 very low according to solar irradiation temperature is also affect the power generation this data is only used in summer season, in winter season morning 8-10 very low, 10-12 high, mid day 1-4 very high, 4-5 very low and late day 5-7 extreme low solar irradiation.

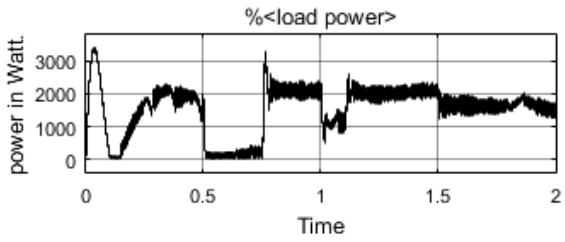
As same as rainy, winter season temperature was low. In rainy season we was unknown from that day may be sunny day or may be cloudy day. Wind source is also variable source, day will be windy or not depends on their wind characteristics of that place and it may be very high or low we unknown from it. In this paper seven cases are studied in simulation for nature of source varies, for all these cases battery was initially charged and load was constant. In second mode load varies from low to high and battery bank was in charging state.

(1). Nature of source varies

In this condition it has seven mode of operation for hybrid power generation system with different weather conditions in addition with charging and discharging modes of a battery. Battery stored energy when both source generates sufficient power to supply load demand and excess energy will be stored in the battery otherwise if battery is fully charged than battery discharges for a load when source generates insufficient power for supplying load demand. The nature of source will be varies according to day, night and for weather condition. The power sources are varies from high to low both at same time or varies with different-different time. PV panel has solar irradiance and wind has speed for variable inputs. Battery charge and discharge depends on the output power of the sources. The DC links require constant voltage, in this case 240V and it may be fulfill through sources (PV or wind) or through battery. Both these waveforms are same for first modes for all seven cases. From figure 3(a) shows that dc link voltage which is constant at 240V, figure 3(b) shows that load power in watt and it must be continuously supplied for reliable operation of a hybrid configuration.



(a) DC link voltage.

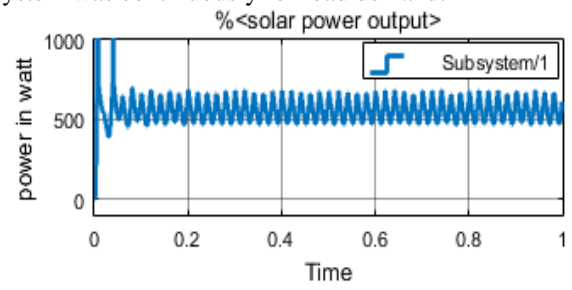


(b) Load power in watt.

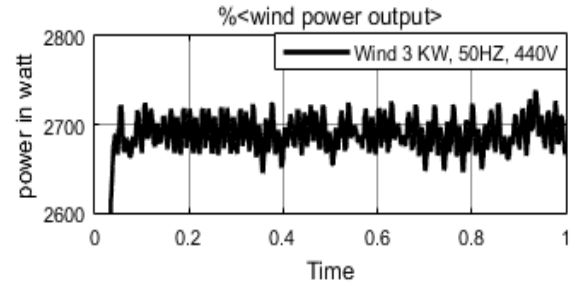
Fig. 3 waveform of DC link voltage and load power.

Case □: Solar irradiation at 1000W/m^2 and 13m/s wind speed

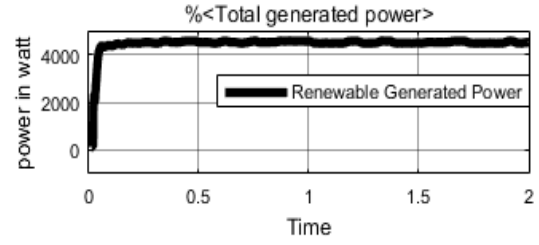
In this case solar panel was operates on condition at 1000W/m^2 with 25^{0}C temperature solar irradiation and wind panel was operates on the 13m/s wind speed with battery storage in between $SOC_{min} \leq SOC \leq SOC_{max}$ and battery was nearly full charged condition. Solar generated power was insufficient for supply load demand as shown in figure 4(a), wind panel generated power was sufficient for supplying load demand as shown in figure 4(b), load was in variable nature it was high or low depends on that time of load shown in figure 3(b). As shown from figure 4(c), total generated power was very high as compared to load demand and extra generated power stored in the battery and hybrid system was continuously for load demand.



(a) Solar generated power



(b) Wind generated power

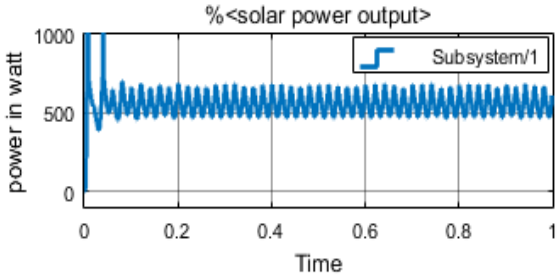


(c) Total generated power

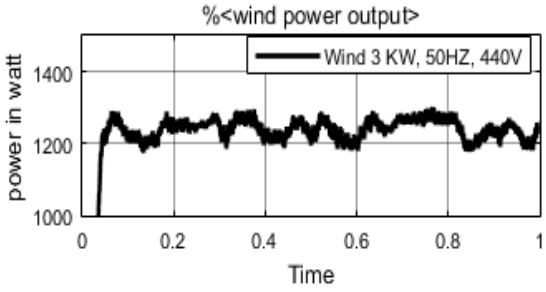
Fig. 4 waveform of solar generated power, wind generated power, total generated power.

Case □: 1000W/m^2 solar irradiation and 10m/s wind speed

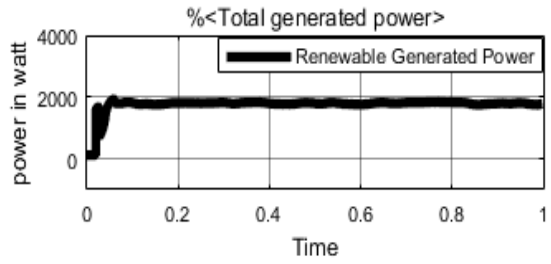
In this case the hybrid system operated on 1000W/m^2 with 25^{0}C temperature solar irradiation and 10m/s wind speed with battery charged mode condition. Wind generated power was low as compare to previous case due to low wind speed and solar generated power was same as previous case. Solar generated power is insufficient to supply load demand then wind panel combines with PV for supply continuous load demand, as shown from figure 5(c) total generated power from both source was insufficient to supply load demand, at starting of simulation, battery back-up was supplied extra load required power. This condition arises from few second to several minute.



(a) Solar generated power



(b) Wind generated power



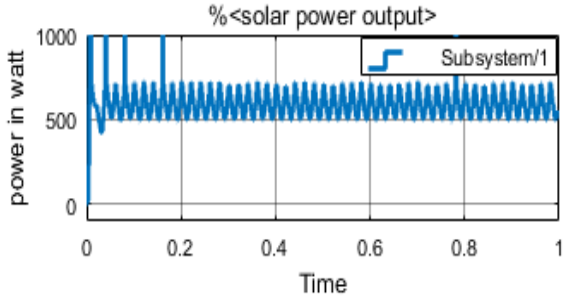
(c) Total generated power

Fig. 5 Waveform of solar generated power, wind generated power, total generated power.

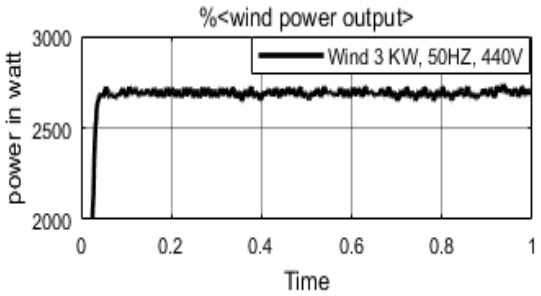
Case □: Solar irradiation at 1600W/m^2 and wind speed same 12m/s

In this case solar irradiation was 1600W/m^2 (especially in summer season) and wind speed was 12m/s and battery storage was charged mode. Solar panel generated more power than previous case but it was insufficient to supply load demand shown in figure

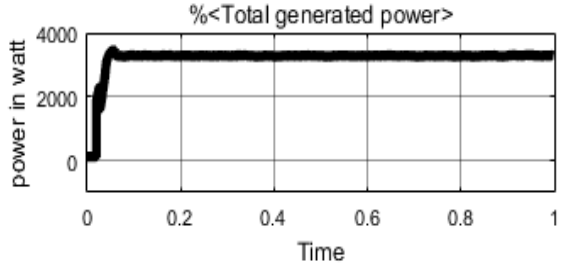
6(a), wind generated power is also unable to supply load demand as shown in figure 6(b), combination of wind-PV used for supply load demand. The total generated power is sufficient for supply load demand as shown in figure 6(c). Load was in variable nature it was high at the starting of the simulation and after some time load power was zero and passing half time it was constant. Battery is in between SOC min to max value and extra generated power was stored in the battery.



(a) Solar generated power



(b) Wind generated power

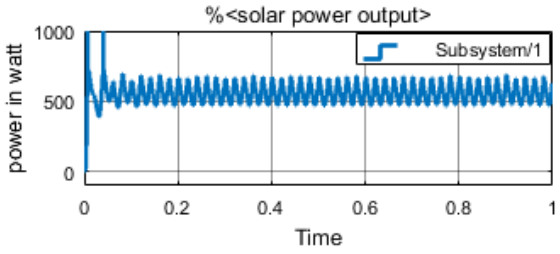


(c) Total generated power

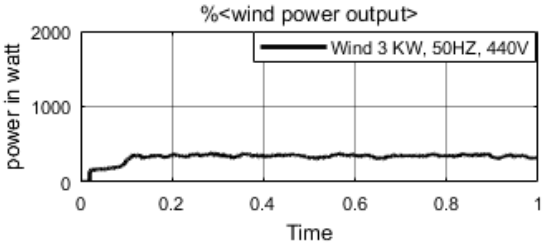
Fig. 6 Waveform of solar generated power, wind generated power and total generated power.

Case □:- When solar panel at 1000W/m^2 irradiation and wind speed at 5m/s

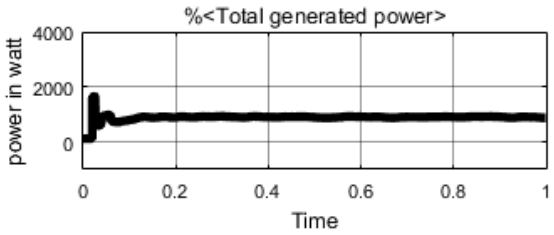
In this condition solar irradiation was standard at 1000W/m^2 but wind speed was low at 5m/s, battery states was charged mode (SOC at SOC_{max}). Wind generated power was very less as shown from figure 7(b) and also solar generated power was also very less and they singly unable to supply load demand. The combination of wind-PV provides total generated power was also less compared with load demand as shown in figure 7(c). Load demand power was more than generated power then extra load required power supplied by the battery and fulfill load demand with continuously supplied load. This condition was arises from few second to several minute due load was in variable nature and source was also variable then load demand was meet after some time by only from source.



(a) Solar generated power



(b) Wind generated power

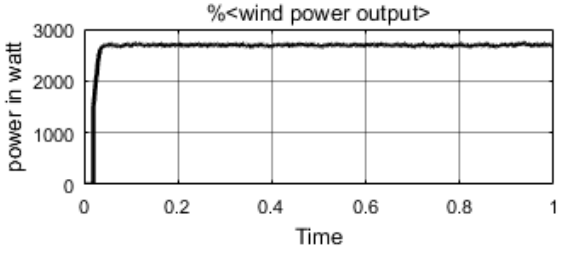


(c) Total generated power

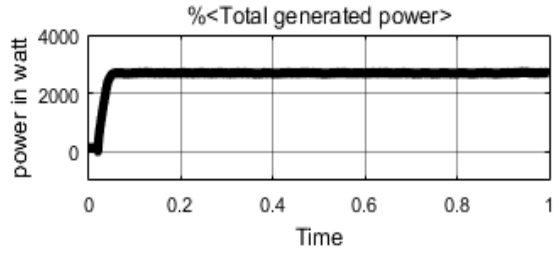
Fig. 7 Waveform of solar generated power, wind generated power and total power.

Case □: Solar irradiation at zero W/m^2 and wind speed at 12m/s

In this case solar irradiation was zero (night or cloudy day) and zero power generated from solar panel (especially in night time) but wind speed was at 12m/s and battery charge states was maximum. Wind generated power was very low at the staring of the simulation as shown in figure 8(a) but at the same time load power was increasing as shown in figure 3(b) this power was supplied by the battery bank, after some time wind generated power was sufficient for continuous supply load demand and extra generated power was stored in the battery bank. Load was in variable nature with source then power was supplied by wind source and by battery.



(a) Wind generated power

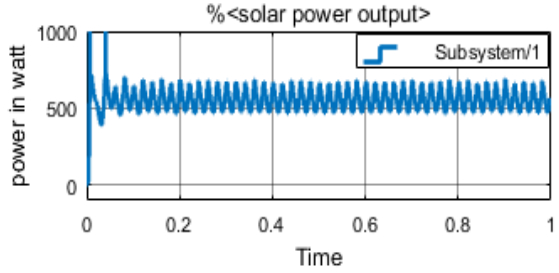


(b) Total generated power

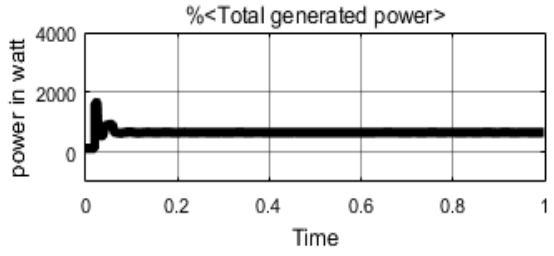
Fig. 8 Waveform of wind generated power and total generated power.

Case □: Solar irradiation at 1000W/m^2 and wind speed at zero m/s

In this case solar irradiation was at the 1000W/m^2 (day time) and wind speed was zero m/s and zero power generated from wind source (especially in winter day season) and battery states is fully charged. Solar generated power was insufficient for continuous supply load demand as shown from figure 9(a) and total generated power from both source shown in figure 9(b). Wind generated power was zero so only solution in this condition was that total extra required power was supplied by battery bank for the load demand and continuous power supplied for the load. This condition was arises from few second to several minute, load and source was variable in nature. Battery stored power was major source in this condition.



(a) Solar generated power



(b) Total generated power

Fig. 9 Waveform of solar generated power and total generated power.

Case □: Solar irradiation at zero W/m^2 and wind speed zero m/s

In this case both source input condition was zero or both source was fails to operate then battery provides whole load power demand. Total generated power from both sources was zero and load power was continuously supplied by the battery bank. This condition also arises from few second to several minute. Load was in variable nature than load demand goes to zero than no source or battery was supplied power.

(2). When load changes

In this condition system was have a two more cases in which load change from zero to maximum value. The DC link voltage would be same at 240V and power generation was continuous, battery states in charged mode. Figure 10 shows that the waveform of DC link voltage.

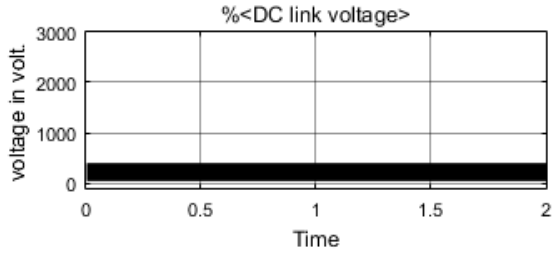
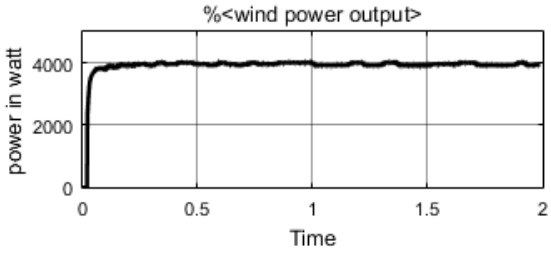


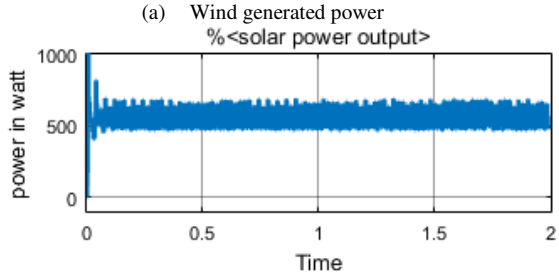
Fig. 10 Waveform DC link voltage in volt.

Case □:- Load is zero and generated power is continuous

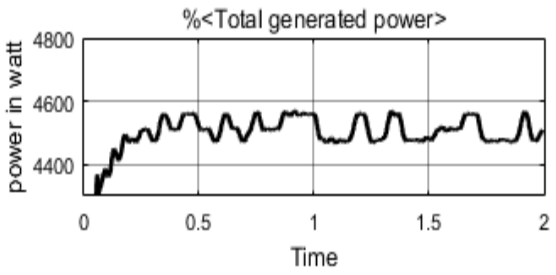
In this case load was zero and power generated continuously in 24 hour, several hour considered to be no load condition. It may be in day or may be in night time no load or less load conditions, generated power will be stored and battery was been charged for its higher SOC_{max}. Wind generated power was very high and sufficient for supply load as shown from figure 11(a) and extra power generated from wind panel stored in battery bank. Solar panel also generated power, this PV power and extra wind power was stored in the battery bank, as shown from figure 11(a) wind generated power, 11(b) PV generated power, 11(c) total power generated from both source and 11(d) battery stored power status. As shown from figure 11(e) load was in variable nature, from figure shows that at the starting of simulation load was high and passing sometime of simulation load was zero.



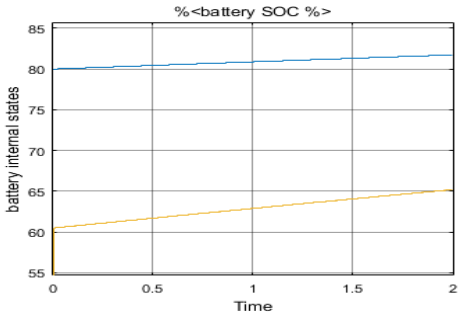
(a) Wind generated power



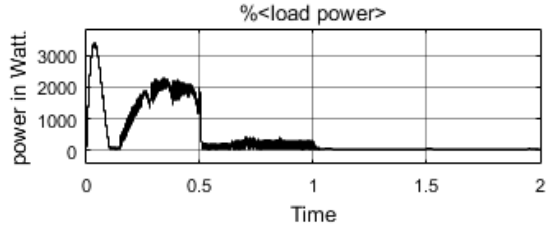
(b) PV generated power



(c) Total generated power from both source



(d) Battery charging state

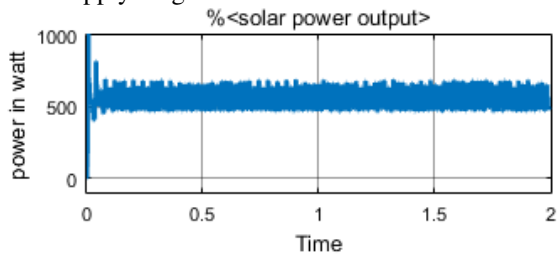


(e) Load power in watt.

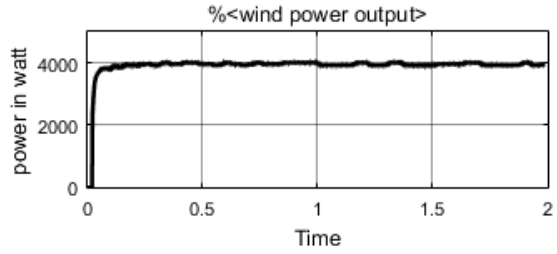
Fig. 11 Waveform of generated power, PV generated power, total generated power, battery charge mode and load power.

Case □:- When load goes to minimum value to very high value:

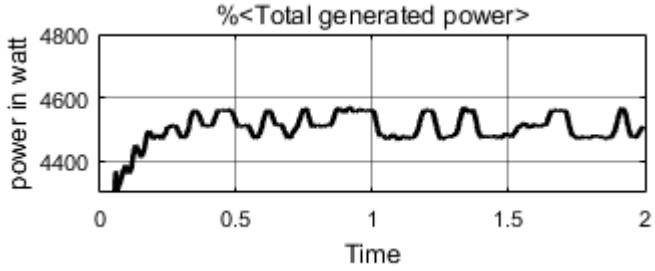
In this case load was very high and both sources are unable to supply load demand, all three PV, wind and battery works as a source of power. This condition will be happens for one second to several hour and load may be goes to minimum to very high value. In this case battery bank was discharge and also contribute in supply load demand. If battery was fully discharged then one source goes in off-MPPT mode and supplied for battery charging. Due to very high load demand, system may go under load shedding situation and system stops for few second to several minute and system will resupply load when load come in generated power supply range area.



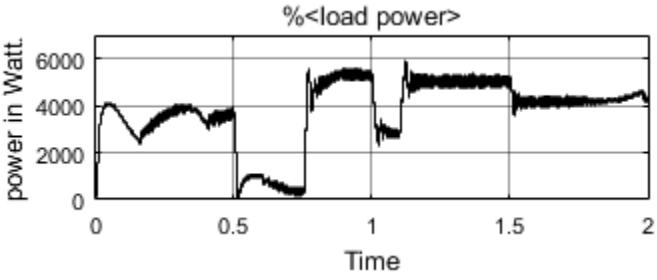
(a) Solar generated power



(b) Wind generated power



(c) Total generated power



(d) Load power

Fig. 12 Waveform solar generated power, wind generated power, total generated power and load power.

□. CONCLUSION

The above result shows that hybrid wind-PV-battery system provides efficient, stable, reliable and continuous power operation in isolated mode. This isolated system load may be residential, industrial, agricultural and motor or electric vehicle load but in this case system provides residential load for home appliances. This system works on different weather and environmental conditions and result provides a efficient power transfer from source to load through different components. The above results show the developed control strategy is able to distribute the load demand among different individual sources effectively. The power transfer in different components is automatically handled by fuzzy logic ruleviewer.

ACKNOWLEDGMENT

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