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Modeling and Analysis of Smart Grid for Energy Balance

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Abstract: Non-renewable energy resources are limited and they contribute to environmental pollution, so the need of the hour is to switch on to renewable energy sources for generation of electric energy. There are various renewable energy sources like solar, wind and biogas, etc. Every renewable resource has its own pros and cons. The modern electric power systems are going through a revolutionary change because of increasing demand of electric power worldwide.

In this paper a model for energy management system has been propose which is responsible for the power balancing for selecting the cheapest energy source available on that time. The system maintains the balance between the demand and generation of electric power. The main objective is energy management and the load priority and shifting for demand side management. A significant improvement in the reliability of energy, reduction in cost has been witnessed by the proposed system thereby improving the quality of life.

INTRODUCTION

Smart grid is an efficient digital technology that provides better control of appliances by accelerating energy saving thereby attaining reduction in cost and improved reliability. The intelligence of smart grid enables effective management of random behavior of loadand at the same time ensures that the delivery of power is economical and meets the demand of industry and consumer. A grid is defined as an electrical system that carries out generation, control, transmission and distribution of electricity [1][Xi Fang et al.].

DEMAND SIDE MANAGEMENT

The management of energy in smart grid is influenced by Demand Side Management which enables functionalities such as control of market of electricity and management. The proposed objective is the development of a Demand Side Management (DSM) algorithm to achieve reduction in the consumption of peak electricity in consumer’s side and the management of operation of appliances according to utility controls and preference of consumers to improvise the profile of demand load. The customer’s power consumption is altered by Demand side management. For the production of desired changes in the power distribution. Demand side management focuses on utilizing power saving technology.

METHODOLOGY

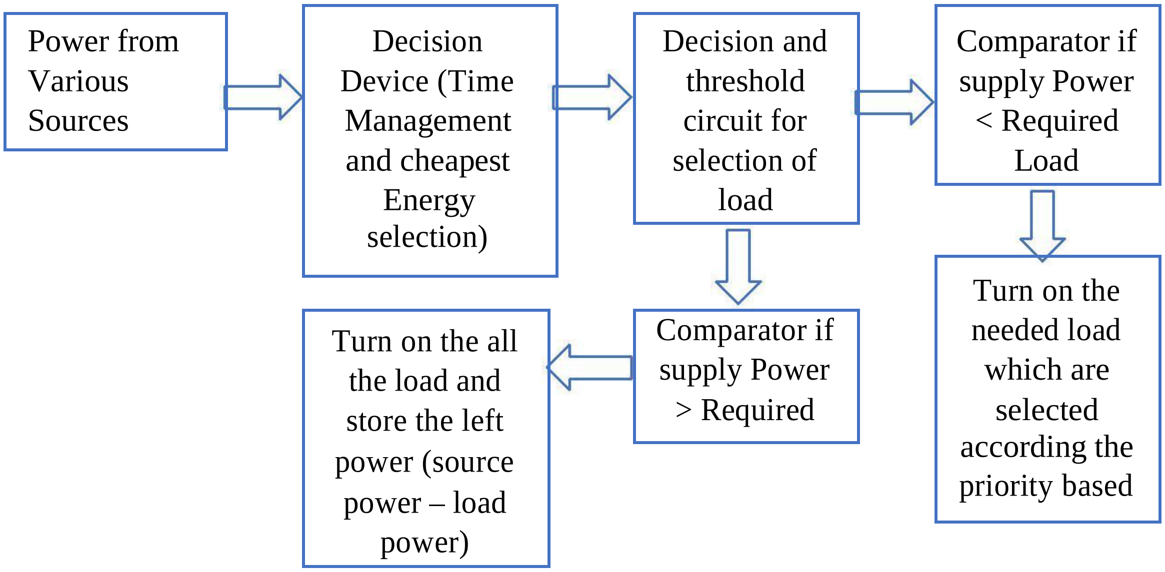

Fig. 1 Proposed block diagram

The power from various sources such as solar, wind, grid, fossil fuels and battery is obtained. The decision device for management of energy is used to decide which source must be employed at what time of the day to ensure reliable supply of power to the load. The threshold circuit compares the supplied power with the load power. If the input power exceeds the threshold then the load is driven by the power from the selected source and extra power is stored in battery ban k. If the power is below threshold then the load is powered by the power stored in the batteries. The load is driven as per selection of priority.

SIMULINK MODEL

The substation block is used for supplying the electric power from various sources of energy such as renewable energy sources namely solar and wind energy and fossil fuels. The three phasemeter is used for displaying and monitoring the power supply to effectively measure the availability of power to ensure proper supply of electric energy. The power supplied to the house load is small (upto 12 Kw), The power supplied to small industry is 10Kw TO 50 kW, Heavy load in the range from 50kW to GW ids supplied to heavy industry.

Breaker Switch

The breaker switch acts as a decision device to make decision regarding the selection of phase as per the users/customers (House load, Small industry and Heavy load). A comparator is incorporated that compares the available electric power with load power. When the available power exceeds the load power the breaker switch is closed else it acts as open switch. The use of power supplied can be opted as per the customer requirement depending on the type of load namely House load, Small industry or Heavy industry.

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Threshold Circuit

For the determination of power availability from solar power for driving the load. The power generated by solar plant is compared with the threshold power of 2 kW. If the power exceeds the threshold only then it is permitted to operate the load. The comparator circuit compares the solar power with threshold of 2kW. This comparator is connected with grid supply, battery bank, UPS, wind energy.

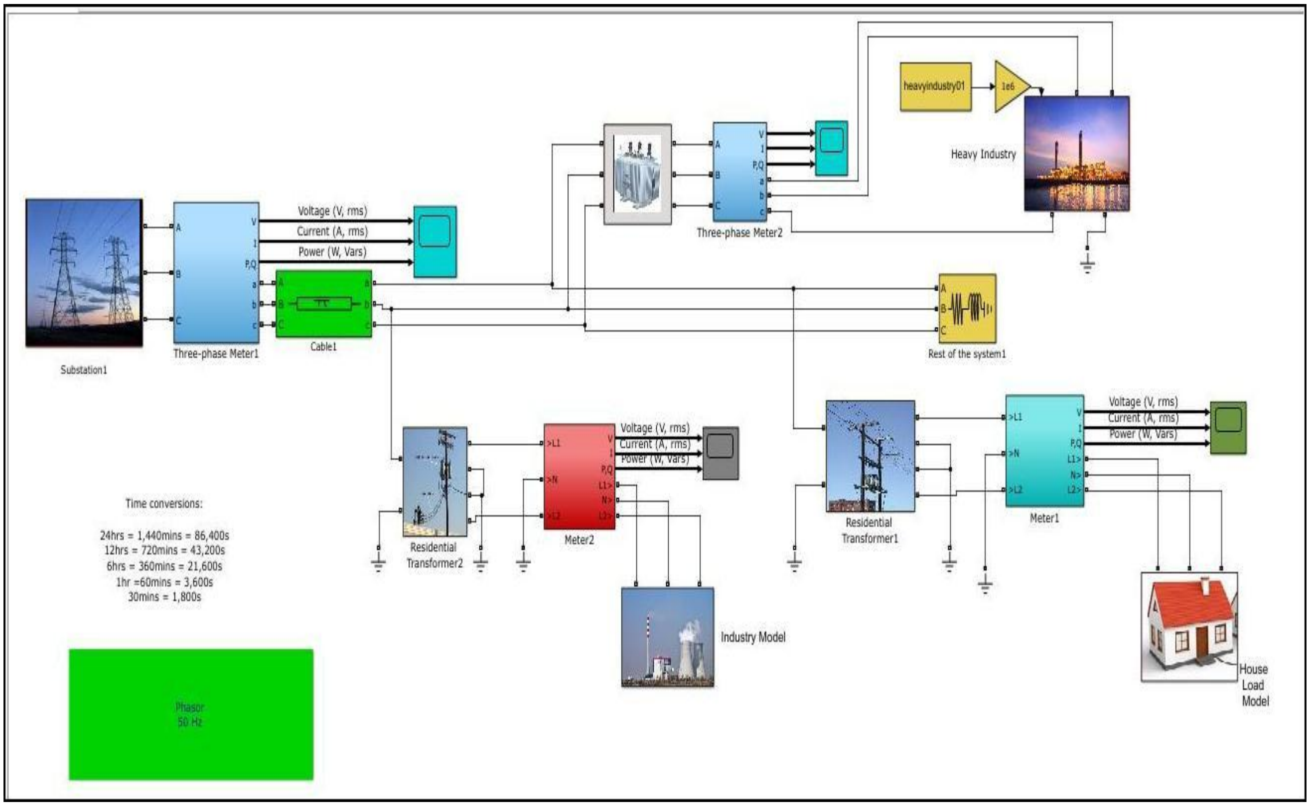

Fig. 2 Simulink Model

The aim of this research is to efficiently manage energy balancing in smart grid and to set the priority of various house loads or industrial loads. Total power is obtained by combining power obtained from solar, wind, grid, battery and fossil fuels. From 12:00 to 6 AM, power is obtained from grid, wind energy and storage battery. After 6 AM the power is obtained from solar panels. If the power from solar panels exceeds 2kW then the energy is supplied to load else power is obtained from grid supply.

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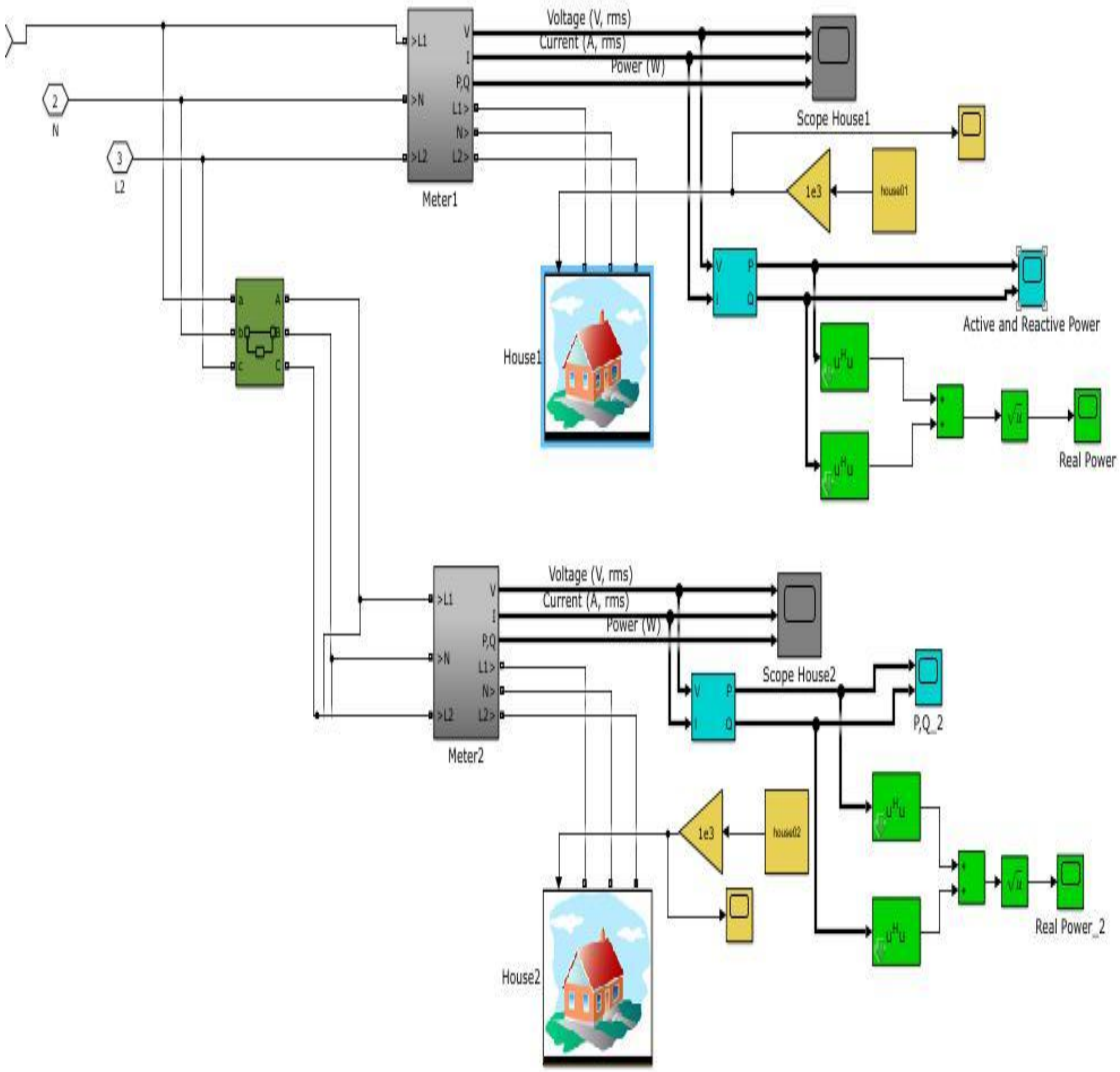

Fig. 3 Internal House Model

Various sources of energy such as solar, wind, grid, fossil fuels, UPS, battery bank etc. are connected to comparators. These power sources act as substation. Here solar power is connected to a breaker switch which is used as a decision device. When the available power exceeds the load power the breaker switch is closed else it acts as open switch.

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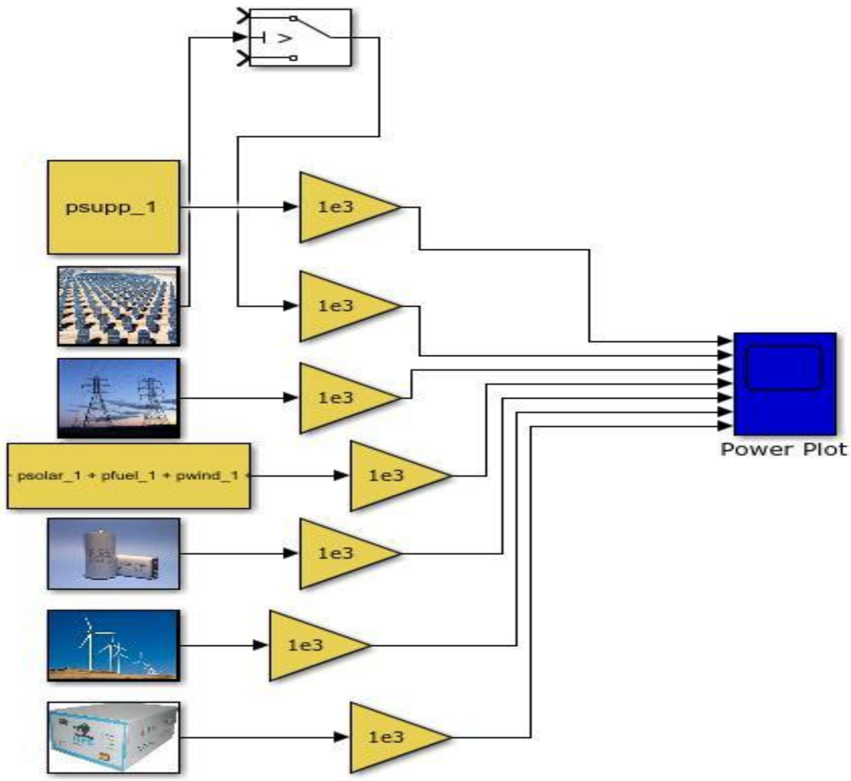

Fig. 4 Substation internal various Electric Sources

ALGORITHM

1. Home consumption data is loaded from .csv files
2. Variables are created for the purposes such as date and time stamp, house power usage(Phouse kW), net power consumption as seen from the grid (Pgrid, kW), power generated by solar panel (Psolar, kW) and power generated from wind turbine.
3. Relation for power balancing is given by:
   House power = grid power + solar power + wind power + fuel cell power + ups power
4. House data is read from .csv files
5. Individual columns are extracted
6. An array of time in seconds is created
7. An array of time in hours is created
8. House data is plotted
9. After clearing the variables, data regarding industrial load is read from the .csv files
10. Steps 5 to 7 are repeated for industrial load and finally the data is plotted.
11. Similarly data regarding heavy industry load is read from .csv files and steps 5 to 7 are repeated for heavy load. This data is plotted.

Flowchart

The data regarding house, industrial and heavy industrial load is saved in workspace so that it can be used by Simulink for simulation. In the flow chart the step two is run in that the condition is come when the load required power is compare with the available source. Here if the Demand

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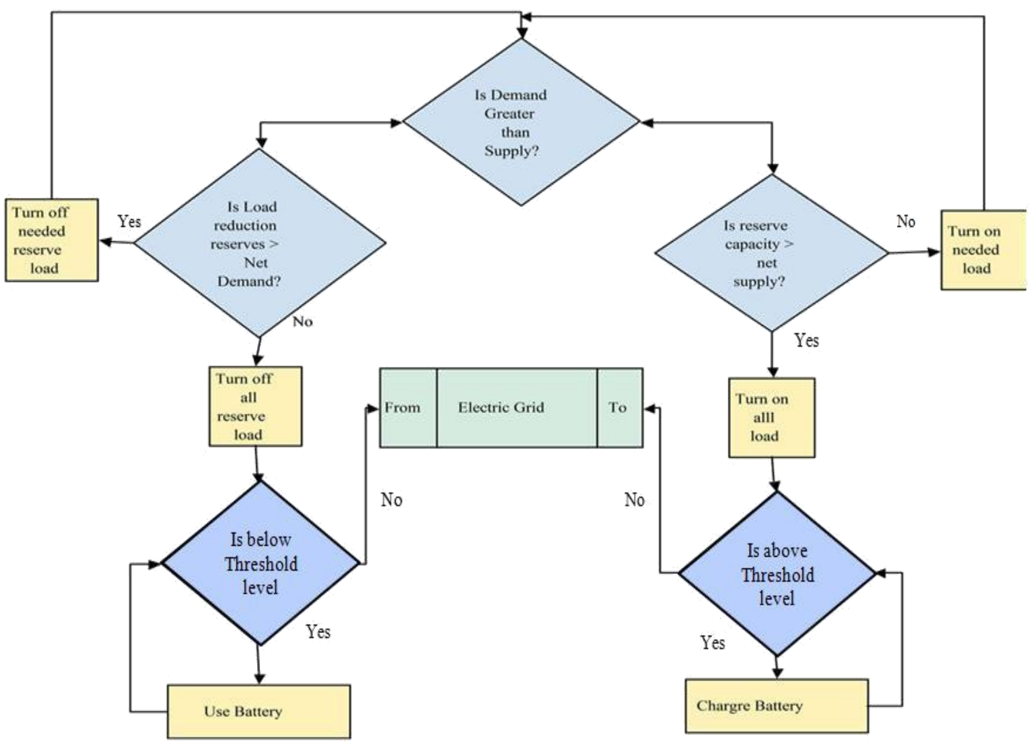
supply is more than the supply then there are two option we turn off the all load and other is turn on the required load which need power less than the available power.If the power is more than the need power then that is store in the battery bank or we can back apply to the Grid. First, the input power supplied is compared with the power requirement of the load. If the supplied power is greater than the power requirement of load the required loads are turned on. If power supply is less than the load power then the load is turned off. If the power supply is quite less to drive any load then all the loads are turned off. If power supply is greater than the the load power requirement of all loads then all the loads are turned off. Now, the supplied power is compared with the threshold power. If the supplied power is less than the threshold then power is obtained from the storage batteries. If the supplied power is greater than the threshold then the power is stored in battery.



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RESULTS

From the substation the input power is applied and that are distributed in different location according the load capacity for house load for industry load for heavy industry load.

Here in the house 1 output there are energy source are the solar wind and the grid and here wind energy are 1 kw all the 24 hours and the solar is available day time and grid is saved here. And load is more at the 8 to 9 pm at night and for selecting the solar power we use here threshold ckt when that is more than the 2 kw then on it can be apply to the load

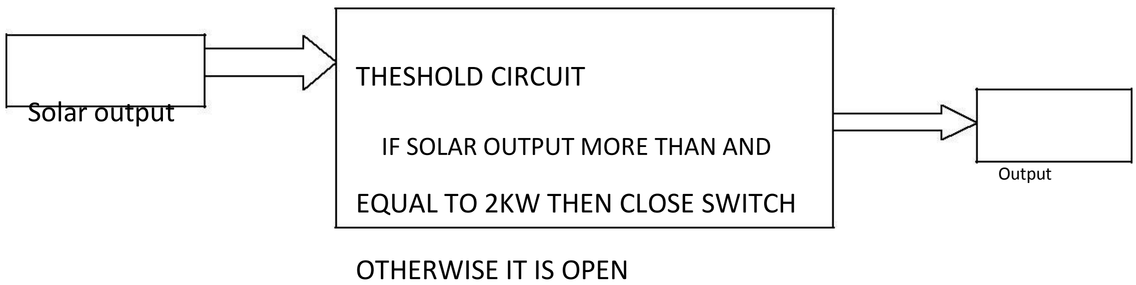

Fig. 5 Threshold circuit

Table 1.Properties of the Different House are shown in the Table here in the Table

House No	Used Power by Load	Generate Power	Grid Power	Solar Power	Wind or other Source Power
01	1 to 6 KW	1 to 6 KW	-2.5 to 6 KW	0 to 4 KW	0 KW
02	.5 to 12 KW	.5 to 12 KW	-3 to 12 KW	0 to 4 KW	1 KW
03	0.5 to 10 KW	0.5 to 10 KW	-2.5 to 12KW	0 to 5 KW	1 KW
04	0.6 to 7 KW	.6 to 07 KW	0 to 7 KW	0 to 5.25 KW	1 KW
05	.5 to 8.5 KW	.5 to 8.5KW	-4 to 6 KW	0 to 4 KW	1.5 KW

Properties of the all the houses are given in the table according to that the house output in shown in the figure

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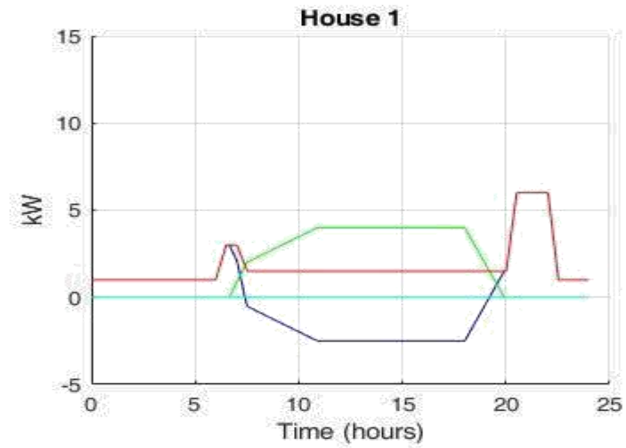

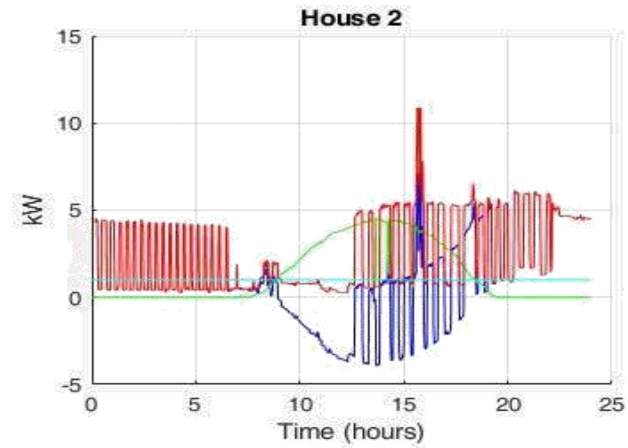

Fig 6 Result of House 1Fig 4.3 Result of House 2

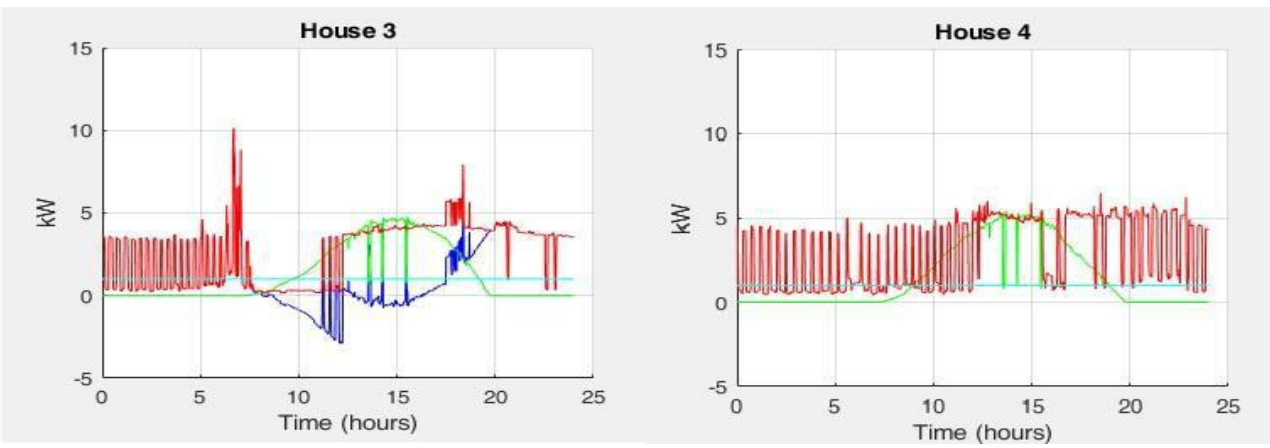

Fig. 7 Result of House 3 and 4

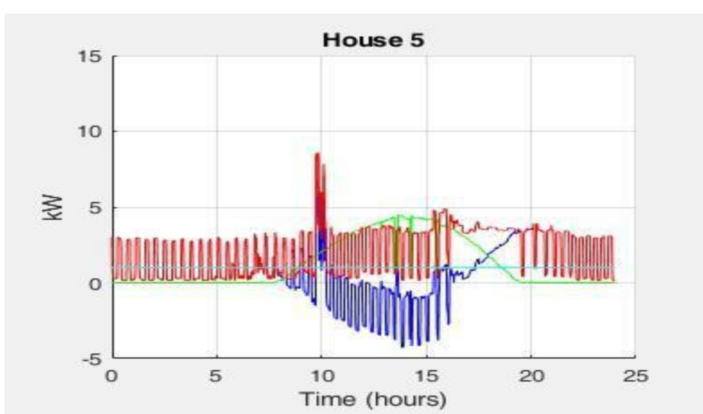

Fig 8 Power consumption of House 5

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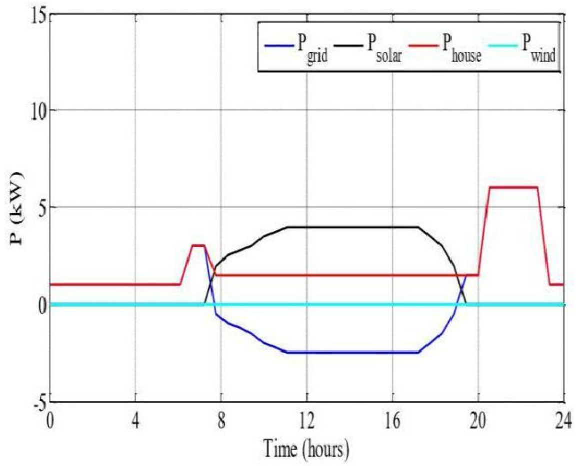
The Generate Power = Sum of all the Power from Different Sources like in the house first the generate power is the sum of the load use power and the solar power

The Grid Power here is the Difference of the load power and solar/ wind source power here in this its negative term show the power is saved and stored in the battery bank or send back to the grid. All above output of different houses are after the energy balancing and selecting the cheapest energy source. If the power is more the required load next problem is come if the load power is more compare to the power source



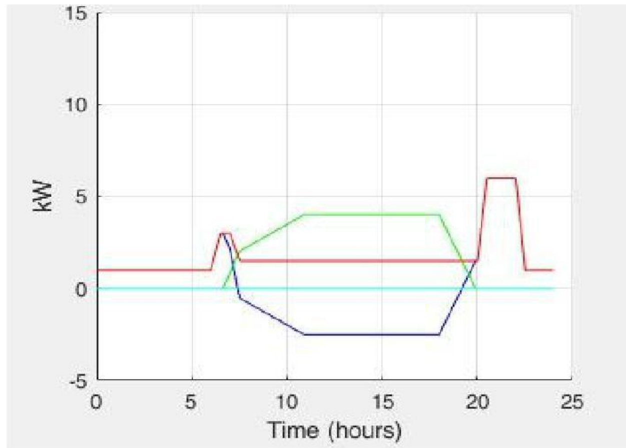


Fig 9 Result [1]

Fig 10 Result of simulation

Table Characteristics of heavy load

Industry	LOAD	POWER	Solar Power	Grid Power
HEAVY	0.6 TO 10MW	Solar, Grid and Battery Bank	0 TO 5MW	up to 10 MW

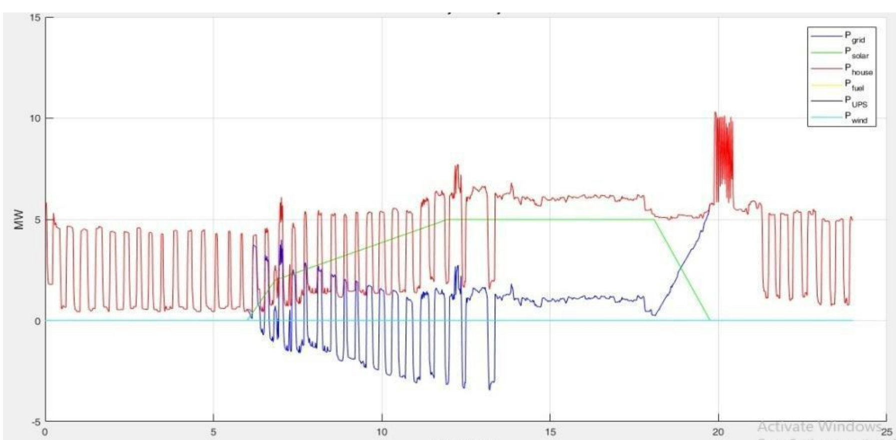


Fig 11 Heavy Industry

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In the above figure the Heavy Industry output is shown and here after 6:30am the solar power is capable to run the load and if load increase then Grid supply is combined with that otherwise we save the grid supply and also the solar power is more than the load the is also stored in the battery bank as well as after that send back to the grid.

Table Comparison of proposed system with the Ali Mekkaoui et al. [4]

Result	Energy Source	Stored	Complexity
Simulated Fig 1	Grid and Solar	Directly stored in Battery	Less
Base Paper Fig 2	Grid and Wind	Firstly cover in Dc then Store	More

Fig shows the graph of power (in kW) versus time (in hours) where solar power is indicated by green line, grid power is plotted by dark blue line, Wind power is plotted by sky blue line, and the load power is indicated by red line.

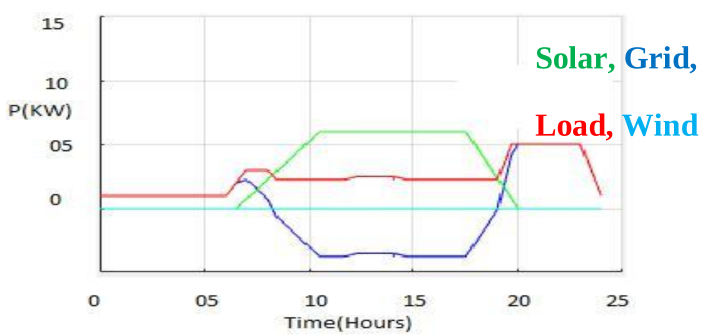

Fig 12 Result from proposed work

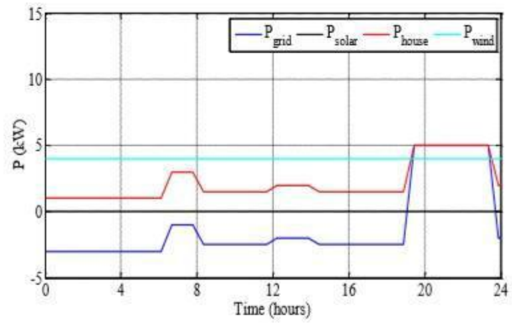

Fig 13 House simulation results [1]

Breaker Circuit
It is a logic switch which used to cut the load if the load is more than the available power here the result is shown this circuit help to set the required load.

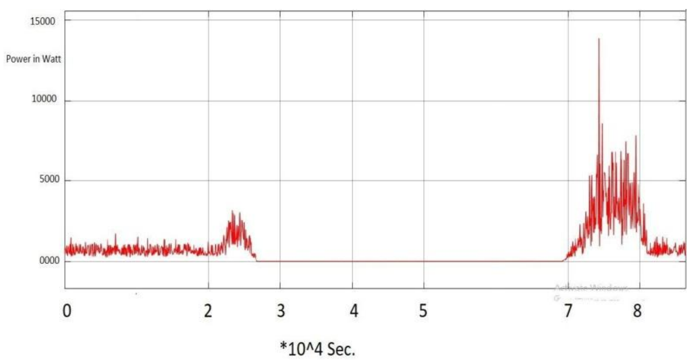

Fig 14 shows the Output power available with house load when the circuit breaker switch is closed

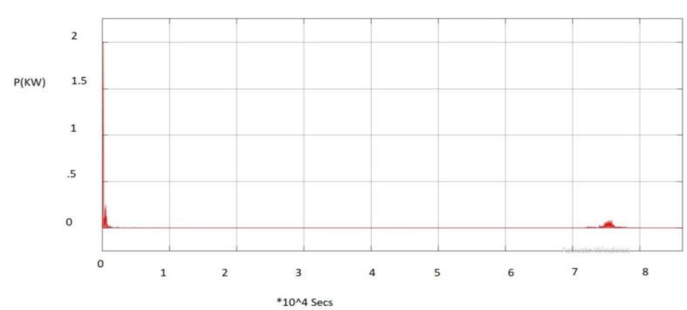

Fig 15 Output power available with house load when the circuit breaker switch is open

Fig Output power available with house load when the circuit breaker switch is open. Fig shows the Output power available with house load when the circuit breaker switch is closed

Fig 16 Output power available with house load when the circuit breaker switch is open

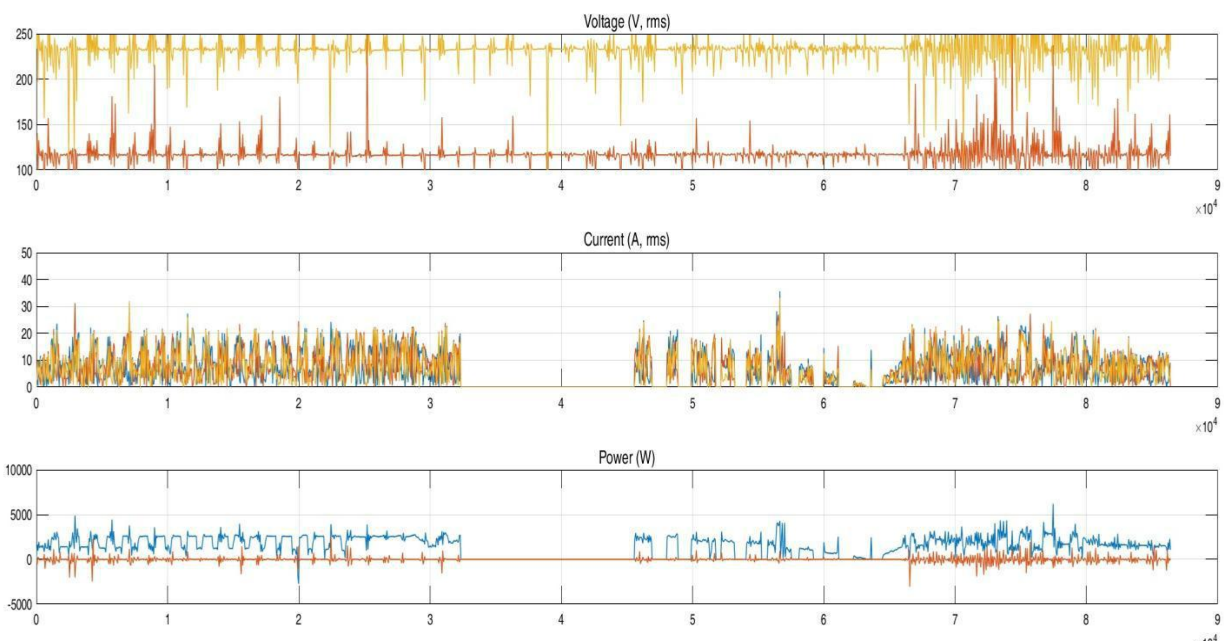

Fig 17 Output power available with house load when the circuit breaker switch is close

Conclusion

The proposed model involves different types of renewable energy like solar, wind and biogas energy as well as non-renewable energy under normal operating conditions and explains the energy exchange between consumers and GEN. The exchange of the energy is time dependent and on the load priority based. The cost of electricity is not taken into consideration, but the different consumers can choose the cheapest energy.

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