International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 06 Issue: 06 | June - 2022 Impact Factor: 7.185 ISSN: 2582-3930

Operation of Micro-Grid with Domestic and Industrial Load Under Different Scenarios

Lalita Devi[1], Deepak Kumar[2]

[1] Department of Electrical Engineering, Om institute of technology and management, Hisar- 125001, Haryana, India; lalitajangra37@gmail.com.

[2] Department of Electrical Engineering, Om institute of technology and management, Hisar- 125001, Haryana, India; ergargdeepak@gmail.com.

Abstract: This work aims to extract maximum available power from the sun using Photovoltaic cells and wind in wind turbines. Photovoltaic (PV) power system is proving to be a potential alternative to produce electrical power without harming the environment by directly transforming a free inexhaustible source of solar energy into electricity. Enhancement in the technology of the power electronics interface has made it possible to transfer low voltage, low power DC to the useful DC voltage level .The power semiconductor technology using high frequency switching devices has made it possible to generate clean and efficient electrical energy from solar energy using PV cells .

In the recent trends in application of renewable energy sources, integrated solar and wind power plant has been designed with different geometrical parameter for increase the accessibility of solar and wind energy due to increasing the rate of environmental pollution and lake of non- renewable energy resources. A solar and wind power plant not only provide environmental benefits but it also reduces so much of electrical consumption from costly resources. The modelling of the test case system is carried out in MATLAB Simulink. All the resources are designed with a specific rating. The simulations are carried out for 24 hours for all day. The results are discussed in four different cases depending on the participation of resources. Thus, finally a case found that the expense is more when any of the renewable source is not considered. As well as, when both renewable resources are considered, it becomes dominant model for reducing energy consumption

Keywords: wind turbine; Photovoltaic cell; Solar Energy

1.Introduction

Many villages in the world live in isolated areas far from the main public grid[1]. It is really difficult to meet their demands by the conventional sources because of the high cost of transport and the distribution of energy to these remote areas. The concept of using renewable energy sources emerged from the need to search for alternate green sources of energy. In order to curtail the greenhouse effect and to slow the depletion of fossil fuel, the solar energy has been utilized. Photovoltaic power systems are becoming increasingly important in modern electrical grids[2]. Electricity access has also a substantial impact in terms of economic development by increasing productivity and economic growth, as well as local employment The Currently, the electric provisioning of these sectors is done by the hybrid systems of production of electricity[3]. The hybrid systems involve combination of different energy sources with wind, PV, mini hydro, Biomass, fuel cells, diesel generators etc[4]. It was shown that the hybrid systems of energy can in a significant way reduce the total cost of energy produced, while providing a more reliable provisioning of electricity by the combination of Electrical energy plays crucial factor in development of economic and technological of present society [5]. Every year the demand of electrical energy is growing rapidly throughout the world. In India it is very difficult and also uneconomical to transmit power over long distances through transmission lines for special remote villages. Also 70% of its population lives in rural areas [6-7]. Generally the production of electrical energy generally depends on fossil fuels. So the use of standalone Hybrid systems using Renewable energy for production of electricity is more economical in remote areas. There are many renewable energy can be implemented in hybrid systems like solar, wind, hydro, geothermal, biomass etc. Remote rural areas are in great need of affordable and reliable electricity to achieve development[8]. Likewise, an overview through the most important literature on rural electrification proves that renewable energies are one of the most suitable and environmentally friendly solutions to provide electricity within rural areas. Renewable energy resources like hydro, solar, wind, biomass, geothermal, tidal etc. have many advantages over conventional sources[9].

2. Related Works

Some of the recent related works are given below :

D. Saheb-Koussa [10], studied the "Economic and technical study of a hybrid system (wind–photovoltaic–diesel) for rural electrification in Algeria." The reliable dimensions of the system are defined for six locations in Algeria. In this case, a complete optimizing model is developed in MATLAB/Simulink to analyze the sizing of system configuration. It had been concluded by study that the hybrid system is the best option for all the sites considered. Also, it allots higher system performance than photovoltaic or wind alone[11].

Ani Vincent Anayochukwu [12] had studied "Feasibility Assessment of a PV-Diesel Hybrid Power System for an Isolated Of-Grid Catholic Church." showed that establishing a stand-alone hybrid power system is more cost effective and reliable for remote applications instead of running stand-alone diesel generators. Various system configurations have been considered like Diesel generator only; Diesel generator, PV array and inverter (no battery); Diesel generator, PV array, control system, and battery ban and control system for the hybrid PV - diesel energy system is proposed to meet the load demands. It has been observed that hybrid system saves $22,247,359 for the church when compared with the diesel only.

Hongmei Tian, Fernando Mancilla–David*, Kevin Ellis, Eduard Muljadi, Peter Jenkins [13] studied, “A Detailed Performance Model for Photovoltaic Systems.” An equivalent circuit and voltage-current relationship for a single solar cell was derived using the single diode model which include the effects of parallel and series connections in a PV array. This model can be modified to a string of any number of cells in series or parallel and then to PV array. The advantage of this model derives from the fact that it produce all important parameters and V-I and P-V characteristics for arrays of any size[14].
Alias Khamis, Azah Mohamed, Hussain Shareef, Afida Ayob, Mohd Shahrieel Mohd Aras [15], presented paper on“Modelling and Simulation of a Single Phase Grid Connected Using Photovoltaic and Battery Based Power Generation”, this paper has study on the renewable energy used for the distributed generation or microgrid consist of a 3 kW photovoltaic, with 30 panels of 12V for 100Ah battery bank, DC/DC converter, battery charge controller, single phase DC/AC inverter and with various loads

3. Components of Energy Conversion System

Now days, green technologies have been widely used for power generation in the distant regions because of their cost effectiveness and easy implementation characteristics. If such power conversion systems are properly designed then they can be capable of supplying in an unaltered manner for extended hours. The hybrid power system, proposed during study, basically includes the following main elements.

1. Photovoltaic System
2. Battery: Energy storage bank
3. Diesel generator set: Backup energy
4. Power electronic: interfacing elements

4. Hybrid System

A judicious mixing of different technologies with different energy sources provides competitive advantages compared with using a single technology[16]. Hybrid power systems combine two or more energy conversion devices, or two or more fuels that when integrated, overcome limitations inherent in either [17]. The table 4.1 shown below compares the different issues related to renewable energies technologies for the consistent supply. Because of this intermittent nature (solar, wind, hydro, biomass), different technologies are integrated to create a hybrid system to overcome the limitations[18].

There are number of benefits of hybrid system which can be outlined as [19]:

- Improved reliability and energy services
- Reduced emissions and noise pollution
- Continuous power can be supplied by incorporating batteries and backup system.
- Increased operational life and reduced cost of maintenance and transportation.
- Efficient use of energy

Table 4.1: comparison between renewable technologies [20]

Comparison between renewable technologies			
	Land condition for power generation	**Power generation stability**	**Issue**
Solar power	Wide open land to secure a large amount of sunlight	Dependent on the amount of sunlight	Power cannot be generated at night
Wind power	Place where strong winds blow constantly	Dependent on the volume of air flow	Low-frequency noise caused by windmills
Hydro power	Place where a dam can be constructed	Influence by the amount of rainfall	Risk of waterside environmental destruction
Geothermal power	Hot springs where vapor can be obtained	Dependent on magma activities and springhead	Locations are limited
Wave power	Coasts where sea routes and fishery industry are not compromised	Dependent on wind and tides	Low diffusion rate- high cost
Tidal power	Coasts where sea routes and fishery industry are not compromised	Relatively stable	Low diffusion rates- high cost
Biomass	Thermal power plant and plantation are needed	Equivalent to thermal power generation	Competition with food, depending on cultivation method

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5.Converters

Converters are the interfacing between source and sink. DC-DC converters convert the unregulated DC input voltage to a controlled DC output voltage at a desire level. It is basically classified as a regulator that is applicable when a specified dc voltage is required at load end but the source is at an unregulated dc value. The DC-DC will affect the overall performance of the power supply system converter as it is considered as the vital part of the power supply [22]. A large number of dc-dc converter circuits are known that can increase or decrease the magnitude of the dc voltage and/or invert its polarity and are classified below. General description of the basic topologies are clearly given with their advantages and disadvantages in the table 3.3 as given below.

Table 3.2: DC-DC converter topologies

S.No.	Topology	/	Advantages	Disadvantages	Applications	Efficiency
1.	**Buck** (step down) Vo<Vin	D	High efficiency, simple, low ripple	No isolation, overvoltage if switch shorts	Small sized embedded system, step down converter	78
2.	**Boost** Vo>Vin	1 − D	High efficiency, input ripple current	No isolation, high output to control short-circuit current	Power factor correction, step	
3.	**Buck-Boost**	/1−D	Simple, high frequency voltage inversion without a transformer	No isolation, hard to ripple output	Power factor correction voltages	80

6. Proposed Model and Results

The micro grid considered for the test case system having renewable resources penetration like solar and wind. The micro grid consists of one conventional source and two non-conventional resources. Industrial and domestic types of loading is considered.

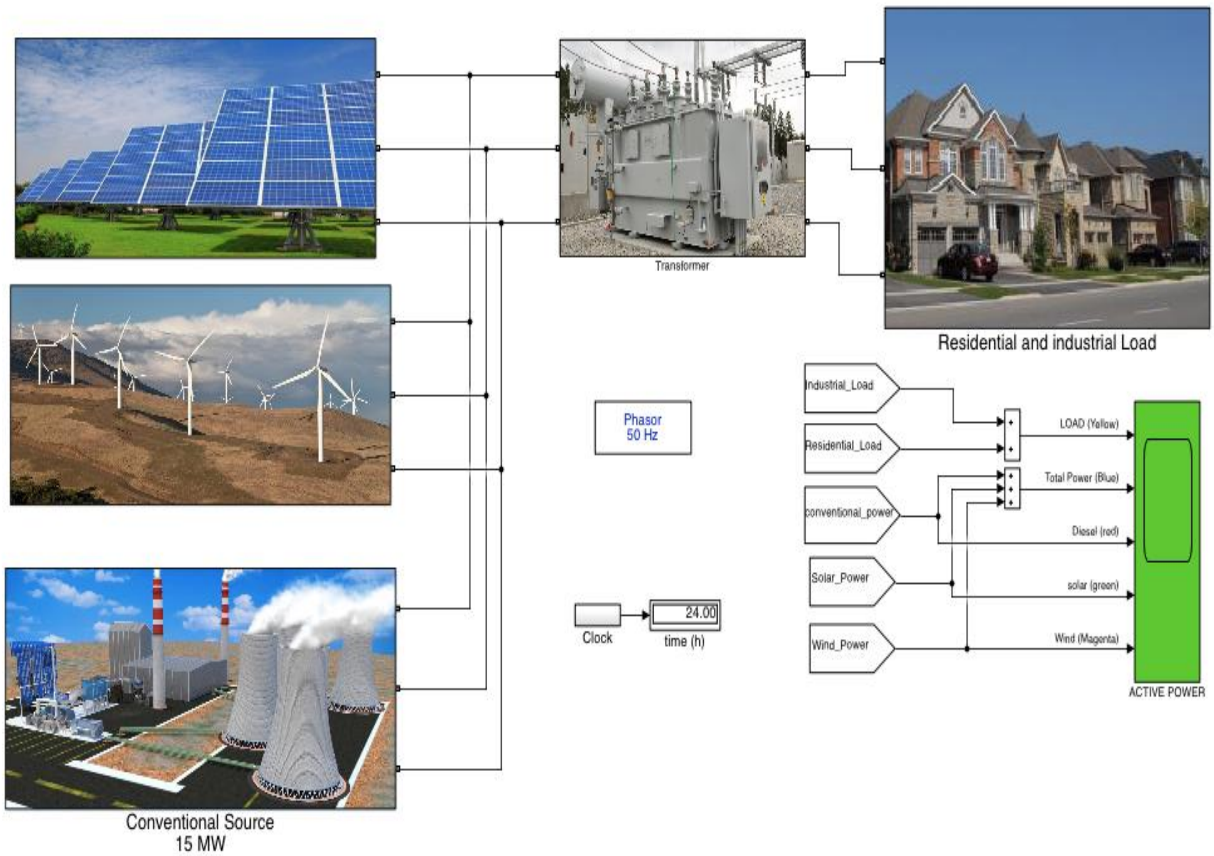

Figure 6.1: Shows the proposed MATLAB SIMULINK model of micro grid

PV farm have capacity of 8 MW and produces energy proportional to three factors: the size of the area covered by the PV farm, the efficiency of the solar panels and the irradiance data.

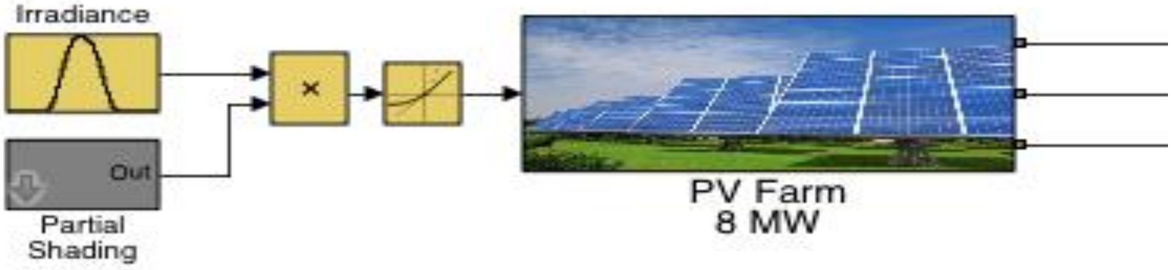

Figure 6.2: Simulink model of proposed PV unit

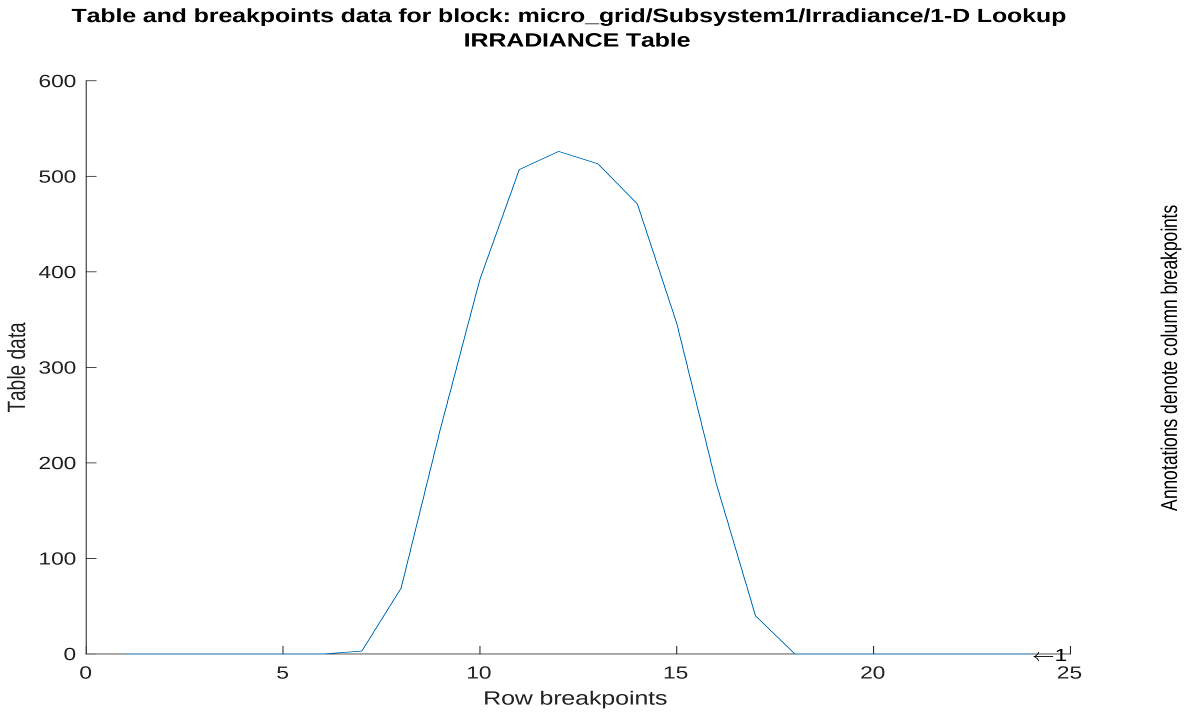

Figure 6.3: Irradiance magnitude throughout the day 24 hours

Wind power plant has 4.5 MW capacity a simplified model of a wind farm produces electrical power following a linear relationship with the wind. When the wind reaches a nominal value, the wind farm produces the nominal power. The wind farm trips from the grid when the wind speed exceeds the maximum wind value, until the wind gets back to its nominal value.

Figure 6.4: Proposed model of Wind farm

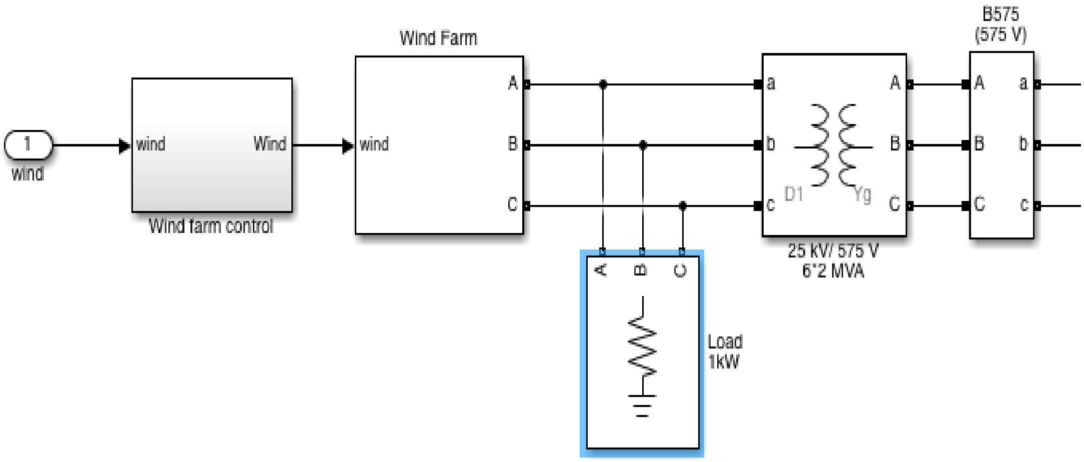

Figure 6.5: Equivalent diagram of MATLAB SIMULINK model of wind farm

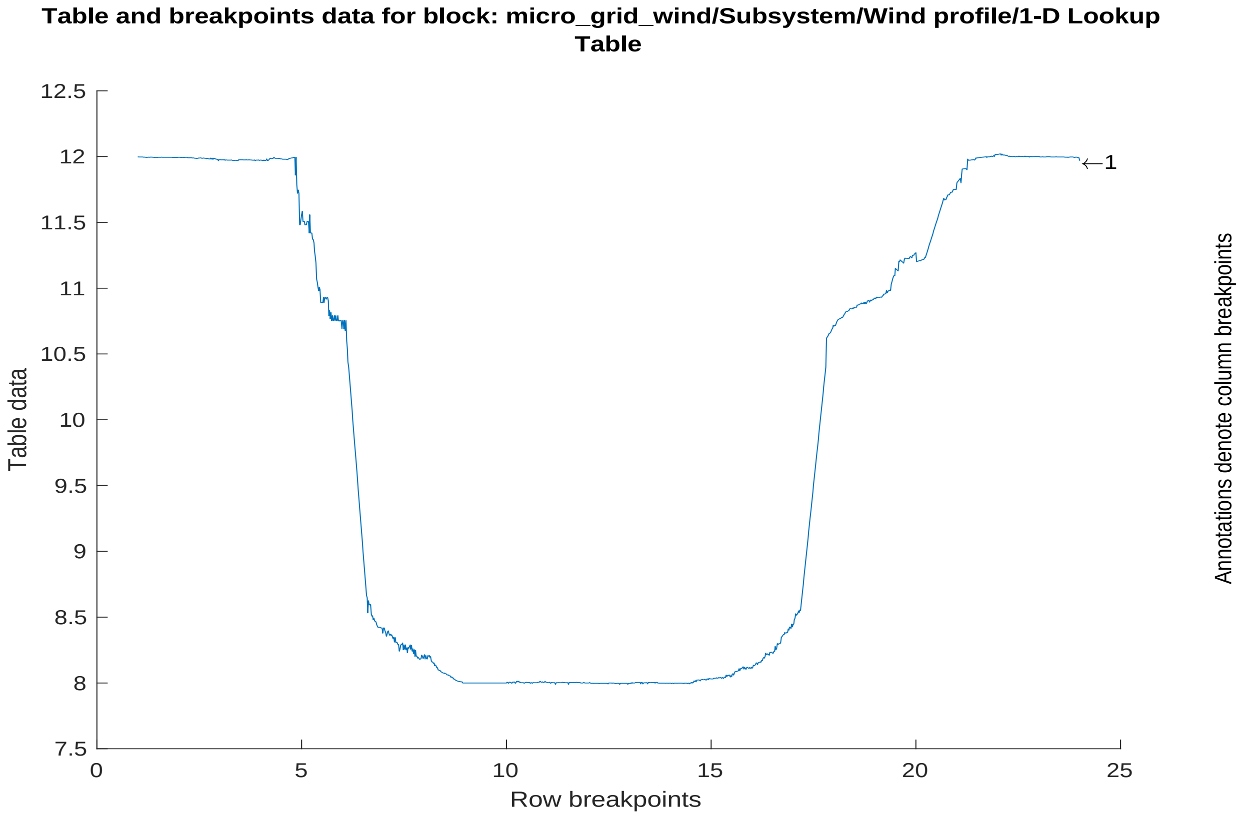

Figure 6.6: Waveform of power taken from wind unit

The load is composed of residential load and an asynchronous machine that is used to represents the impact of an industrial inductive load (like a ventilation system) on the micro-grid. The residential load follows a consumption profile with a given power factor. The asynchronous machine is controlled by a square relation between the rotor speed and the mechanical torque.

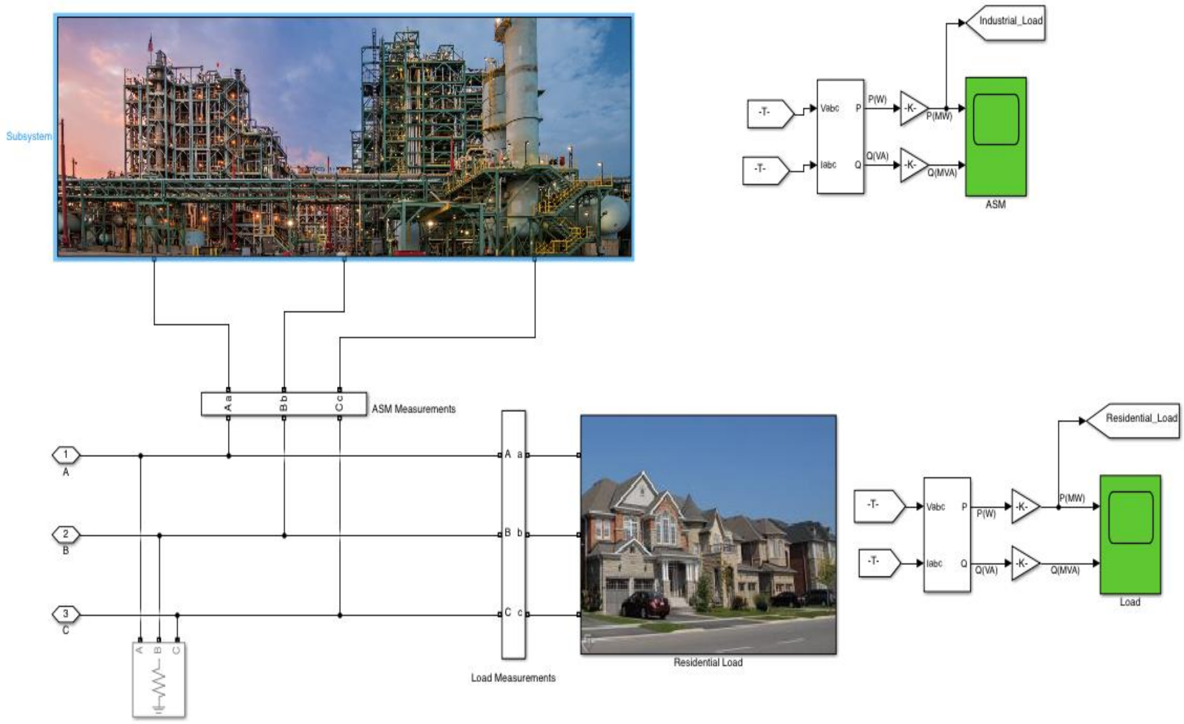

Figure 6.7: SIMULINK model industrial and domestic load of micro grid

The simulation lasts 24 hours. The solar intensity follows a normal distribution where the highest intensity is reached at midday. The wind varies greatly during the day and has multiple peaks and lows. The residential load follows a typical pattern similar to a normal household consumption. The consumption is low during the day and increases to a peak during the evening, and slowly decreases during the night. Three events will affect the grid frequency during the day:

- The kick-off of the asynchronous machine early at the third hour
- A partial shading at noon affecting the production of solar power
- A wind farm trip at 22h when the wind exceeds the maximum wind power allowed

The simulations are carried out in four cases which are given as follows:

Case 1: With wind and conventional source

In this case the participation of solar resources are neglected and found the total expenses through the power supplied by conventional resources.

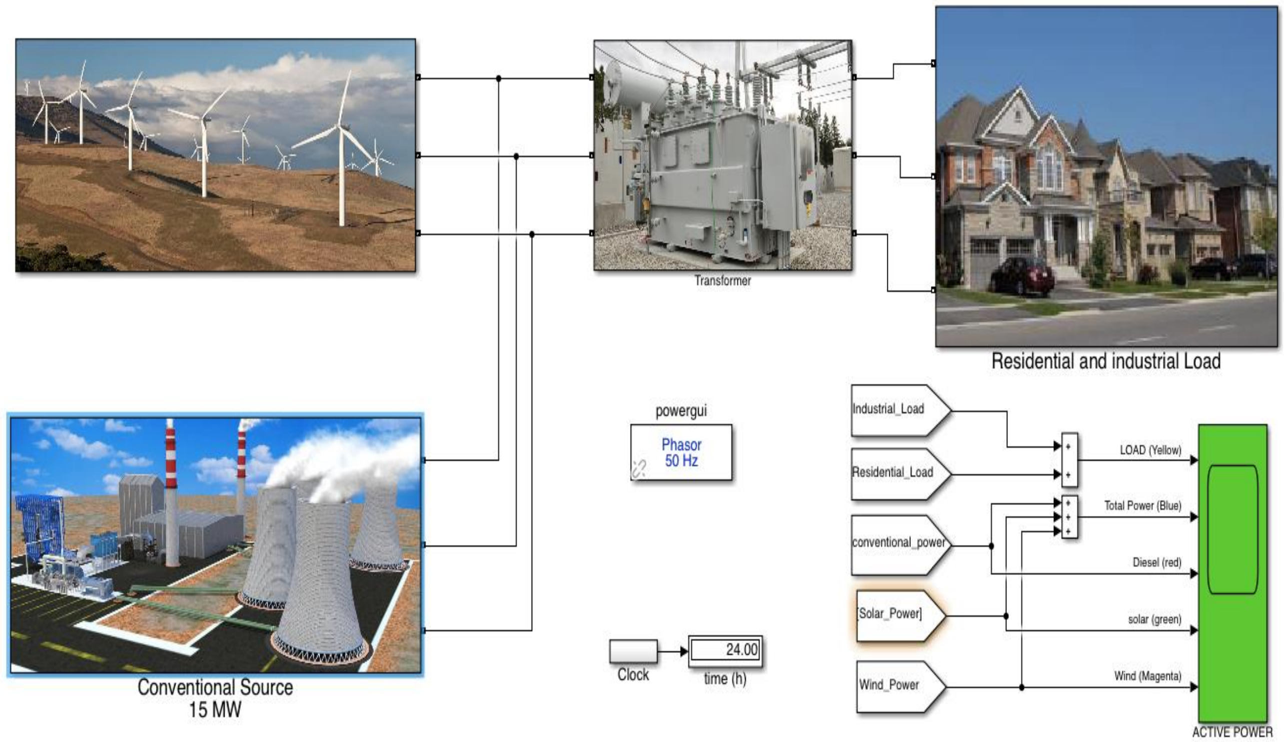

Figure 6.8: MATLAB SIMULINK model of micro grid with wind and conventional sources

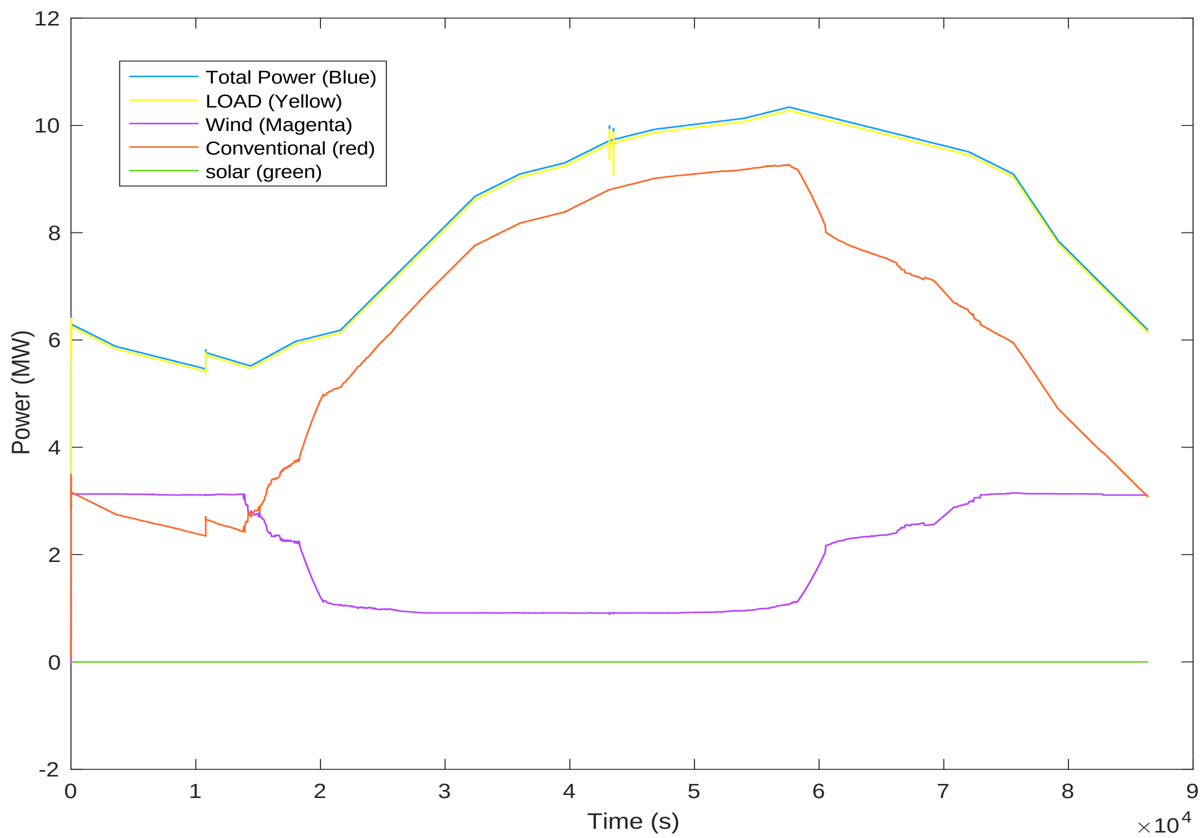

Figure 6.9: Power flow output for 24 hours with participation of wind and conventional source

Case 2: Solar and conventional resources:

International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 06 Issue: 06 | June - 2022 Impact Factor: 7.185 ISSN: 2582-3930

In this case wind power plant is neglected and observe the power demand from conventional resources.

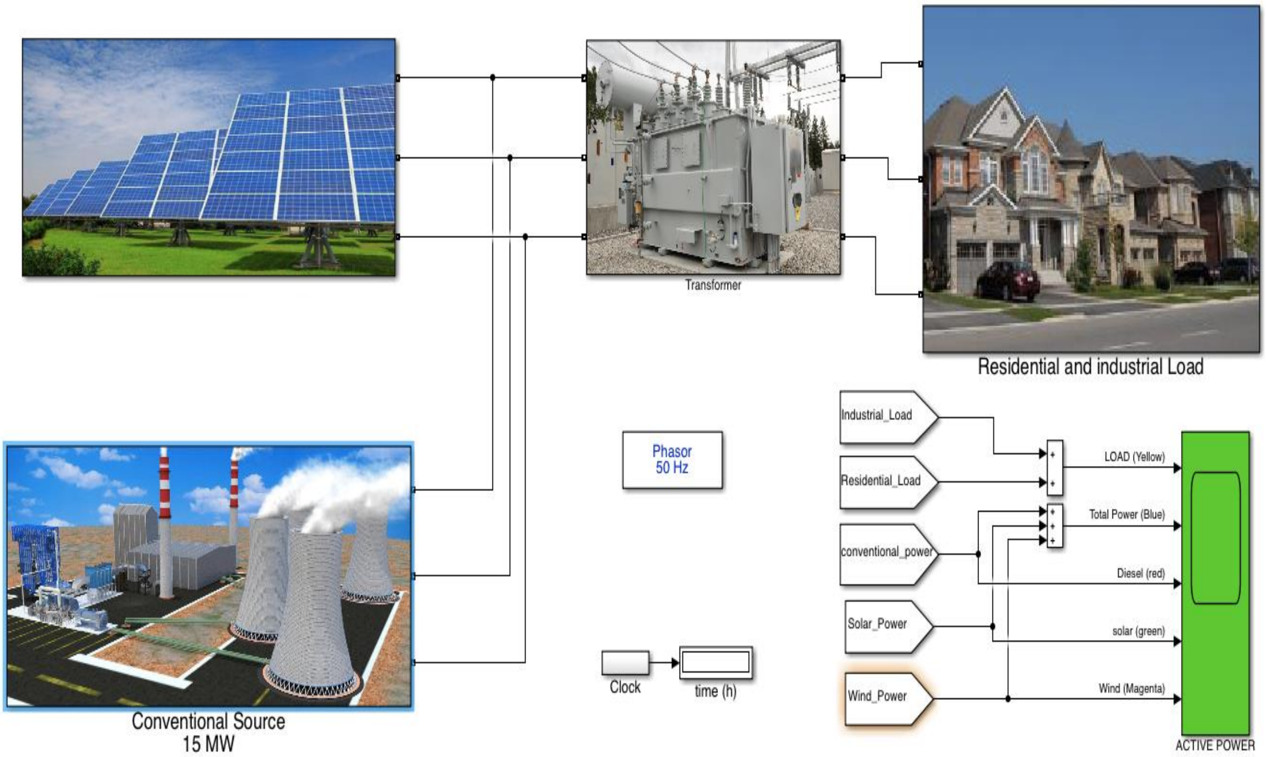

Figure 6.10 MATLAB SIMULINK model of micro grid with solar plant and conventional source

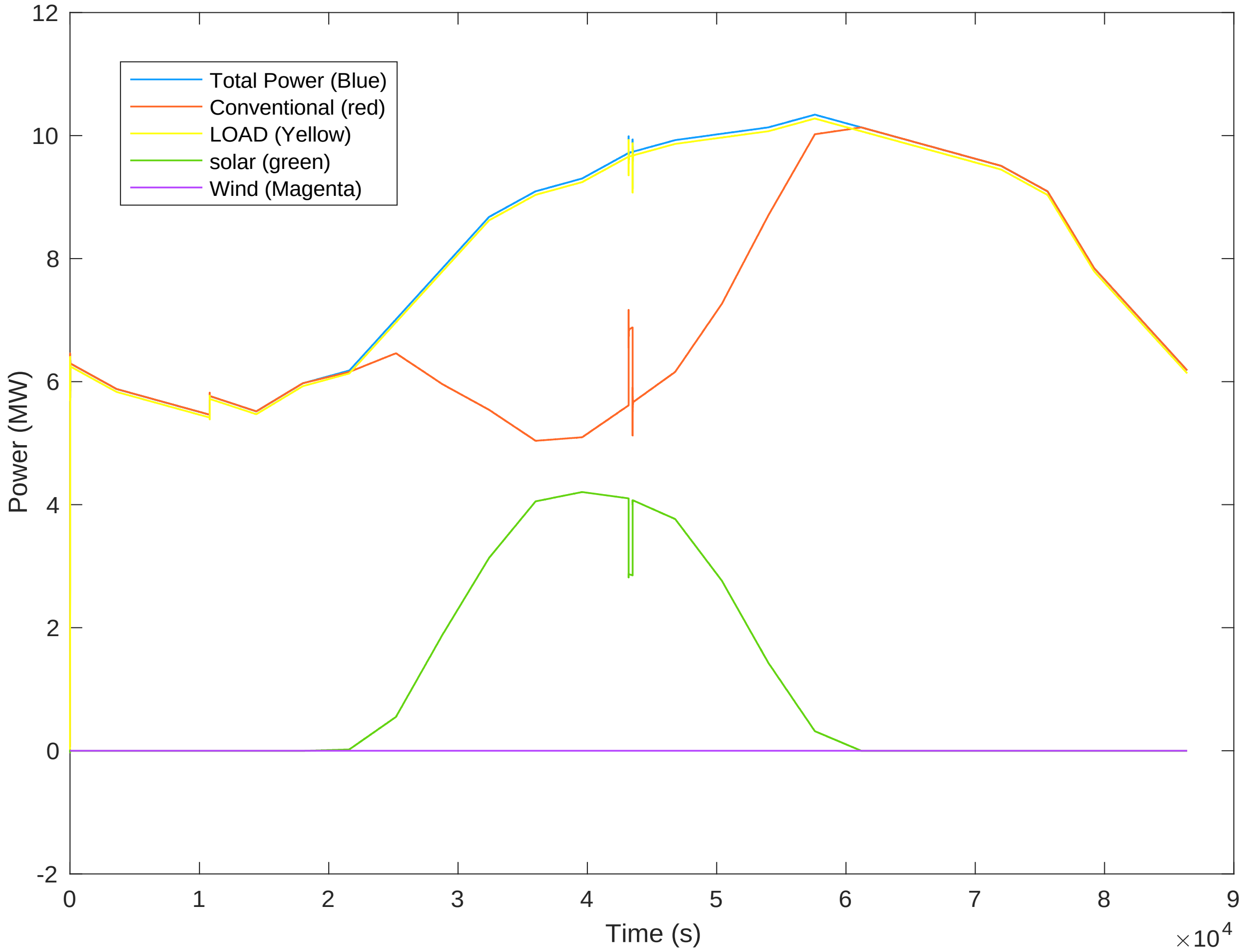

Figure 6.11: Power flow output for 24 hours with participation of wind and conventional source

Case 3: Conventional source only

In this case both renewable resources are ignored for find out the power consumption from conventional sources. This case has more expenses of electricity consumption because total power is supplied by conventional sources only.

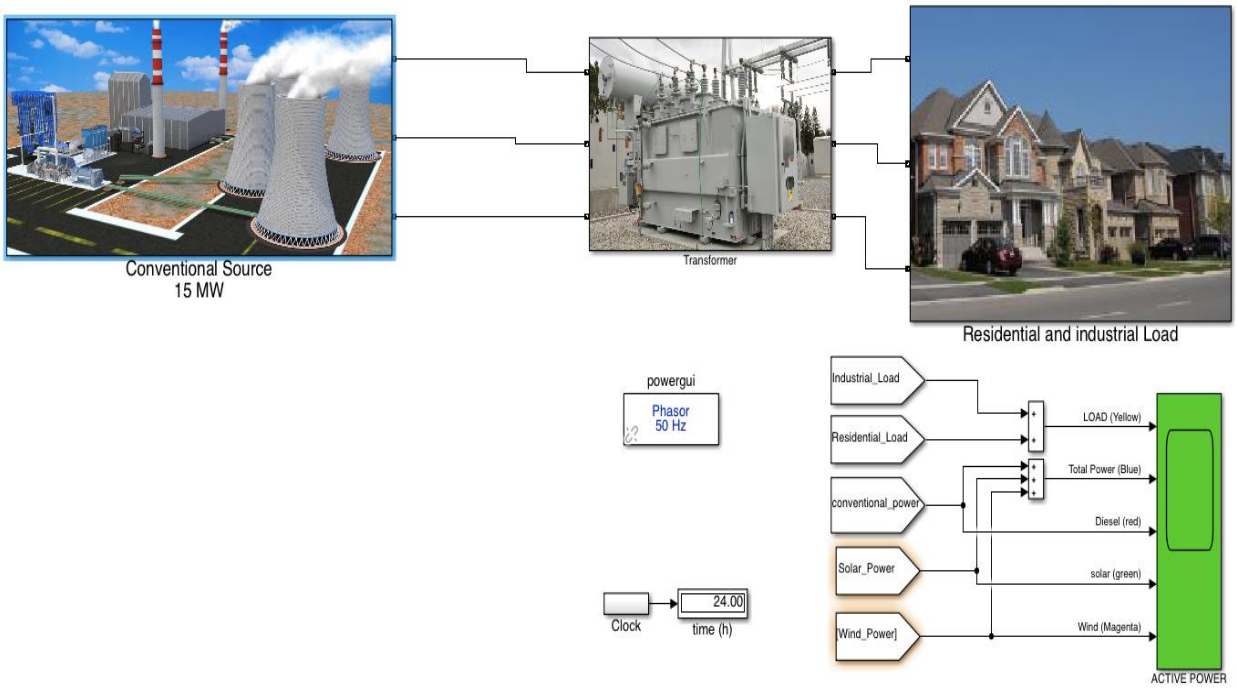

Figure 6.12 MATLAB SIMULINK model of micro grid only with conventional source

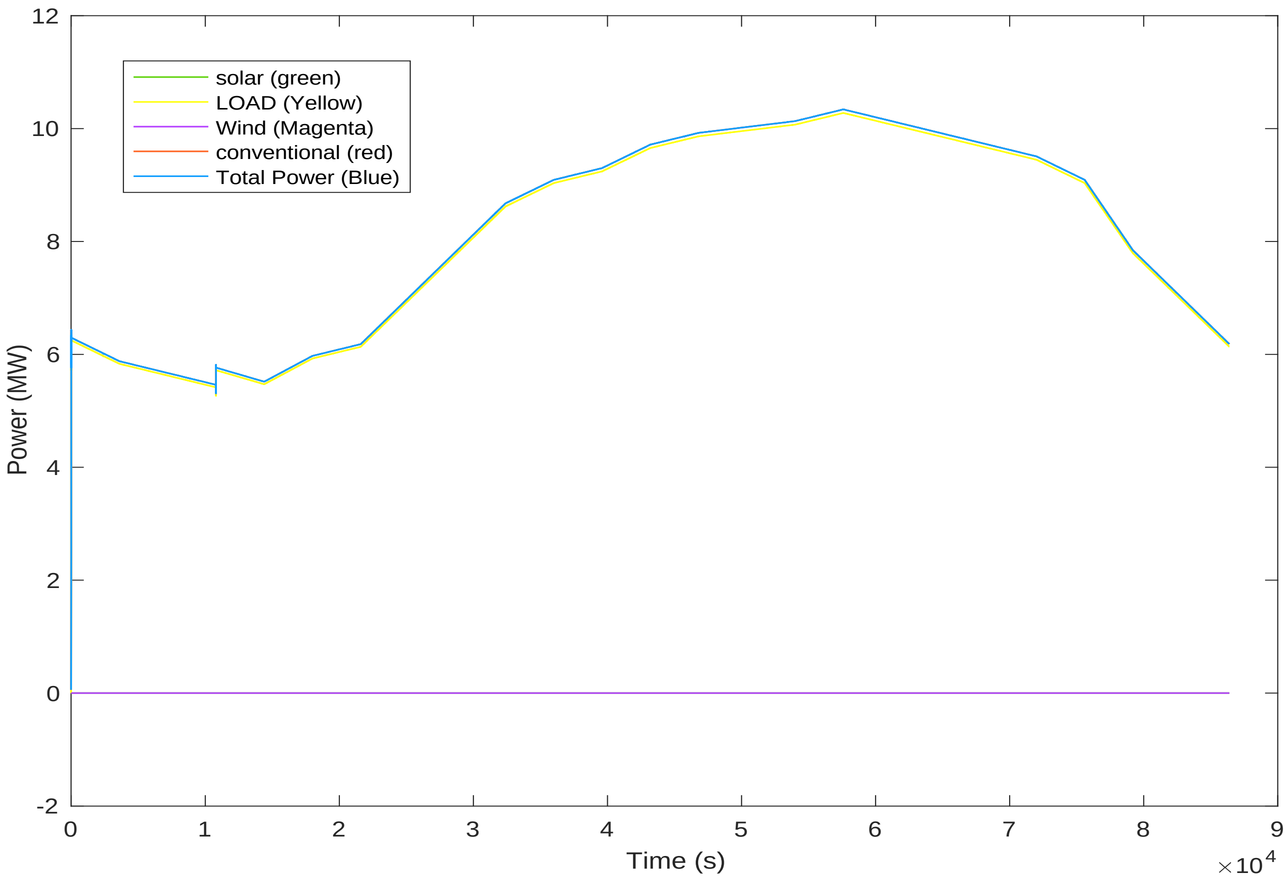

Figure 6.13: Power flow output for 24 hours with participation of only conventional source

Case 4: Solar wind and conventional resources:

This case has effective energy management in a micro grid due to integration of renewable resources. Wind power plant has effective output in night time whereas solar has dominant power at day time. So throughout 24-hour cycle micro grid aid by renewable resources. In this method need of conventional energy resources is low as compared to other methods.

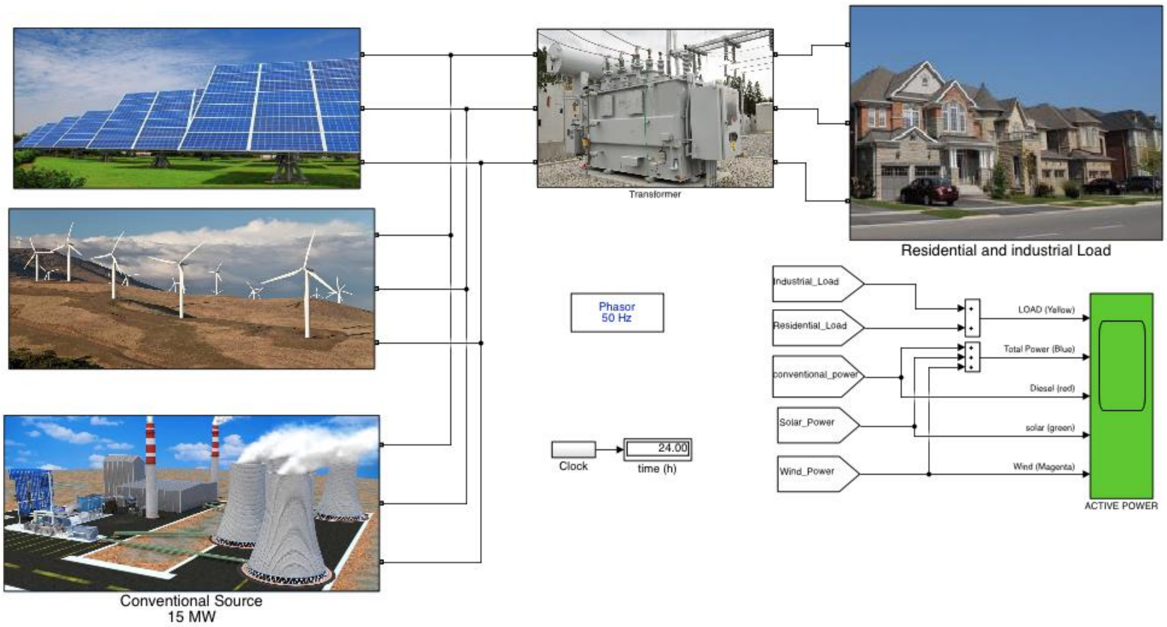

Figure 6.14: MATLAB SIMULINK model of micro grid with conventional source and both renewable resources i.e. solar and wind

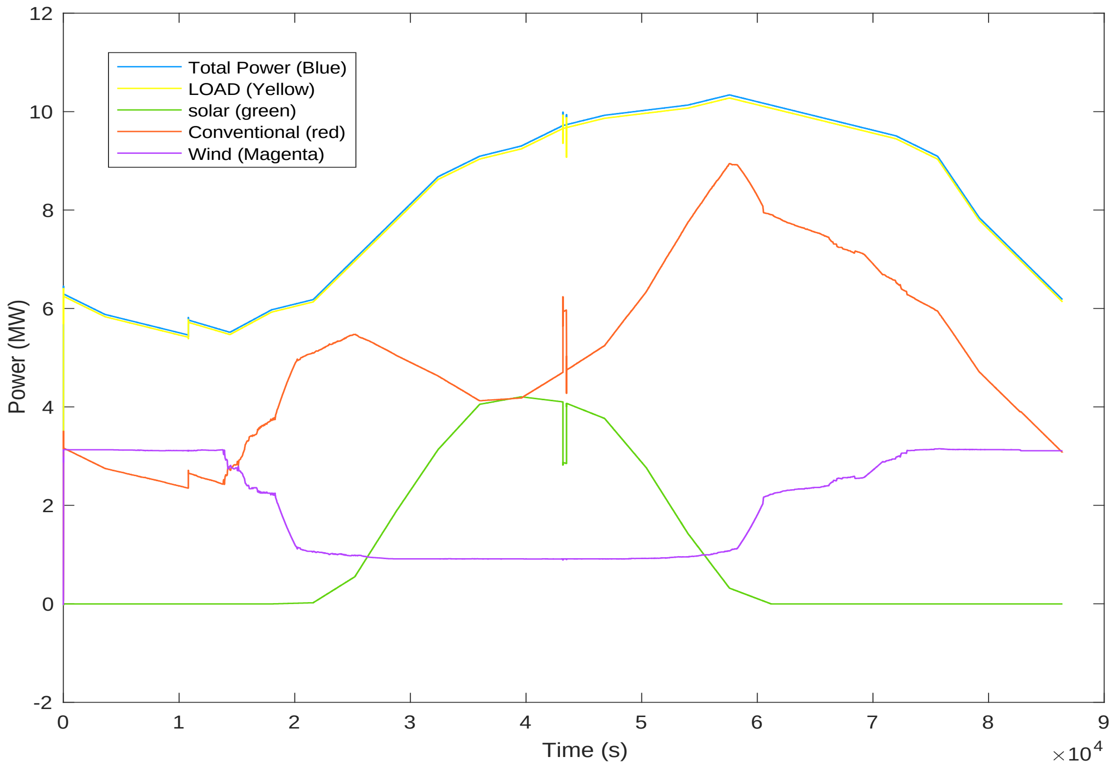

Figure 6.15: Power flow output for 24 hours with participation of solar, wind and conventional source

There is only case 4 in which cost of conventional fuel (coal, nuclear, diesel) is lesser in comparison with other 3 cases. So, this is more efficient in comparison with other cases. While focusing on third case where both renewable resources are removed from the grid, it is more costly and less efficient. The only way to save conventional sources, is to maximum use of renewable energy.

References

[1] Lasseter. R," Microgrid:A Conceptual Solution," PESC'04 Aachen, Germany 20-25 June 2004.
[2] R.H.Lasseter,"Microgrids," IEEE PES Winter Meeting, January 2002.
[3] Nikos Hatziargyriou,"Microgrids,the key to unlock distributed energy resources?,"IEEE PES May/June 2008.
[4] Johan Driesen And Farid Katiraei, "Design for Distributed Energy Resources," IEEE PES May/June 2008.
[5] Benjamin Kroposki, Robert Lasseter, Toshifumi Ise, Satoshi Morozumi,Stavros Papathanassiou, And Nikos Hatziargyrious,"Making Micro grid Work," IEEE PESMay/June 2008.

[6] Zhe Zhang, Gengyin Li and Ming Zhou,” Application of Microgrid in Distributed Generation Together with the Benefit Research,” IEEE 2010.
[7] H.S.V.S. Kumar Nunna and Ashok S, “Optimal Management of Microgrids,”IEEE 2010.
[8] Giri Venkataramanan and Chris Marnay,” A large Role for Microgrids,” IEEE PES May/June 2008.
[9] Hans, S. and Ghosh, S.(2020), "Position analysis of brushless direct current motor using robust fixed order H-infinity controller", Assembly Automation, Vol. 40 No. 2, pp. 211-218.
[10] S. Hans,S. Gupta Algorithm for Signature Verification Systems National conference on Signal & Image Processing(NCSIP-2012), Sri sai Aditya Institute Of Science & Technology.
[11] S. Hans, S. Gupta Preprocessing Algorithm for Offline signature System" National Conference on Recent Trends in Engineering & science (NCRTES- 2012), Prestige Institute of Engineering & science, Indore.
[12] S. Hans, An Algorithm for Speed Calculation of a Moving Object For visual Servoing Systems International Conference on VLSI, Communication and Networks (VCAN-2011), Institute of Engineering & Technology Alwar-2011.
[13] S. Hans & SG Ganguli (2012) Optimal adaptive Visual Servoing of Robot Manipulators
[14] S. Katyal, S. Raina and S. Hans. "A Energy Audit on Gujarat Solar Plant Charanka." International Journal for Scientific Research and Development 5.4 (2017): 2133- 2138.
[15] S. Hans (2018) A Review of Solar Energy And Energy Audit on Harsha Abacus Solar Plant: A Energy Audit on Gujarat Solar Plant Charanka.
[16] S. Hans, R. Walia ,Thapar Institute of Engineering and Technology, Patiala. "Optimal MPPT Control using Boost Converter for Power Management in PV- Diesel Remote Area ." Global Research and Development Journal For Engineering 45 2019: 24 - 31.
[17] S.Katyal, S.Raina and S. Hans. "A Brief Comparative Study of Solar Energy." International Journal for Scientific Research and Development 5.4 (2017): 2126-2132.
[18] S. Hans and S. Ghosh, "H-infinity controller based disturbance rejection in continuous stirred-tank reactor," Intelligent Automation & Soft Computing, vol. 31, no.1, pp. 29–41, 2022.
[19] S. Hans, S. Ghosh, S. Bhullar, A. Kataria, V. Karar et al., "Hybrid energy storage to control and optimize electric propulsion systems," Computers, Materials & Continua, vol. 71, no.3, pp. 6183–6200, 2022
[20] S. Hans, S. Ghosh, A. Kataria, V. Karar and S. Sharma, "Controller placement in software defined internet of things using optimization algorithm," Computers, Materials & Continua, vol. 70, no.3, pp. 5073–5089, 2022