MODELING AND SIMULATION OF HYBRID POWER SYSTEM

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Abstract:Energy Generation poses a major challenge for both developing and developed nations. The gap between supply and demand creates issues, as Energy Consumption always exceeds Energy production. Renewable Energy sources now play a crucial role to bridge this gap between energy generation and use. People can now find Photovoltaic Solar panels and wind generators to help save non-renewable resources. The depletion of Non-renewable Energy sources also brings about environmental problems. So, it's time to switch from non-renewable power sources to renewable ones in a way that makes the most of power from renewable resources without hurting the power system. We need a smart power system that can tap into electrical power from renewable resources and uses non-renewable power when renewable power isn't available or can't meet the demand. This forms the main job of a hybrid Power Network. A hybrid power system therefore, is an electrical grid that includes many different operations and energy measures such as smart meters smart appliances renewable energy resources, and energy-efficient resources. This paper links various kinds of energy sources, including non-renewable and renewable ones. It uses the MATLAB Simulink Tool Box to run simulations.

Keywords: Energy Consumption, Renewable Energy, Non-renewable Energy, Power system, MATLAB Simulink Tool Box.

I. INTRODUCTION

Research and development in electrical energy for the future focus on new ways to generate power. These include wind solar-hydraulic, biomass, geothermal thermal storage, diesel, and waste heat recovery. These methods offer solutions to provide power in remote areas where the grid can't reach. They also allow for distributed generation. Combining two or more of these renewable energy sources known as a hybrid system, is gaining traction. These hybrid systems can work together to deliver better quality and more reliable power without relying on the grid. This makes them ideal for bringing electricity to rural areas.

The electrification of rural areas holds special significance, and researchers have examined and discussed various standalone power systems. These include solar setups and hybrid configurations like solar-wind solar-hydro solar-wind-diesel, and solar-wind-diesel-hydro/biogas combinations. The study also looked at and assessed how viable and crucial solar energy is for global electrification. A hybrid power system combines different energy sources to create a dependable, productive, and long-lasting energy supply. These setups blend renewable sources such as wind, hydro, and solar energy with non-renewable options like thermal power.

II LITERATURE REVIEW

Hybrid power systems have caught the eye of many researchers. ASHARI and C. V. NAYAR created a computer program to figure out the best way to use diesel generators. Their goal was to cut down on overall system costs. M. Belhamel, D. Saheb-Koussa and M. Haddadi worked on the perfect design for a hybrid system. They used math models to look at the technical and economic sides of combining wind solar, and diesel power with battery storage. Alalwan, Sami Hamed, and Jonathan W. Kimball took a different approach. They looked at typical weather data using the forever power method. They wanted to find the right size for hybrid micro sources in an islanded MG. Their aim was to keep running costs low. This method helps designers pick the size that best matches what they're looking for in terms of availability environmental benefit, cost, and reliability.

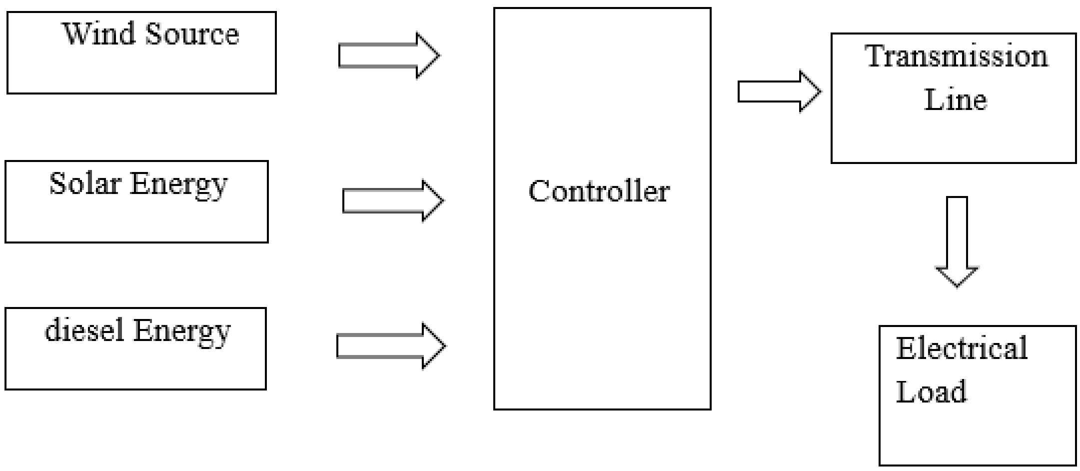

Figure 1: Basic block Diagram

The diagram shows a basic idea of a hybrid energy system combining different energy sources to give a steady and lasting power supply. Though it's a simple picture, it points out the main parts and how they work together. To make and use these systems has a big impact on moving to a cleaner and stronger energy future. How well the system works depends a lot on how smart the controller is and how well it uses energy storage to deal with the ups and downs of renewable energy. This tech can do a lot for both on-grid and off-grid uses helping with energy safety and being good for the environment.

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III MATLABSIMULINK

MATLAB Simulink is a robust visual programming platform created by MathWorks. Rather than typing traditional code, you create models by dragging and dropping blocks and linking them together. These blocks stand for different math functions, systems, and parts. Simulink has been designed to model, simulate, and analyze dynamic systems across multiple domains. This means it can handle setups that involve various aspects such as electrical, mechanical, and control systems.

A. SIMULATION DESIGN

1. **PV Farm (8 MW)**

- A time-varying irradiance input (including partial shading effects) has an influence on the farm to produce electrical power.

- A 25 kV/600 V transformer steps up the output (or steps it down, depending on how the system is designed).

2. **Wind Farm (4.5 MW)**

- A wind profile input changes its power output throughout the day.
- The farm feeds the generated power into the same bus or distribution system as the PV.

3. **Diesel Generator (15 MW)**

- Serves as a dispatchable source or backup to keep the system stable and fill any gaps when renewable can't meet demand. It can adjust its output up or down based on net load needs and control settings.

4. **Loads**

- **Residential Load**: 10 MW, with a power factor of 0.15 (showing it uses some reactive power).
- **Industrial Load**: 0.16 MVA also using reactive power. •Both loads connect to the same bus or feeder downstream from the transformer.

5. **Measurement & Display**

- Sections labelled "Residential Load," "Industrial Load," "Diesel Power," "Solar Power," and "Wind Power" feed into a display or scope that shows:

▪ **Total Power** (blue trace),

▪ **Diesel** (red),

▪ **Solar** (green),

▪ **Wind** (magenta),

▪ **Load** (yellow).

This helps you monitor each source's input and the system's overall demand.

6. **Power Gui & Clock**

- Simulink's "power Gui" serves as a specialized solver for power systems (phasor or discrete modes).
- The "Clock" shows a 24 hour simulation timeframe.

Overall, the diagram shows how solar, wind, and diesel generation supply a combined residential and industrial load modeling the dynamic power flows and control interactions in a hybrid power system over a 24-hour period.

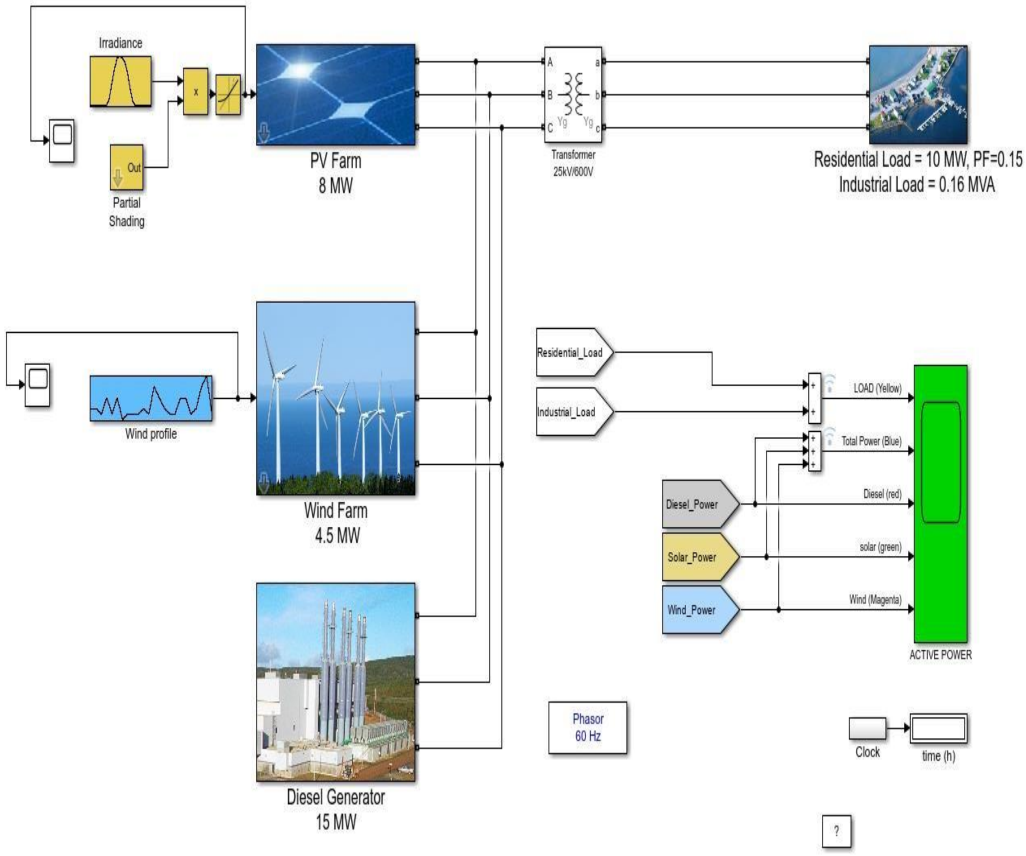

Figure 2:Modelling and Simulation of Hybrid Power System

B. METHADOLOGY

The picture we've shown you displays a Simulink model of a hybrid microgrid system. People use this to simulate and analyze power flow and control strategies.

The picture uses Simulink's block diagram approach. It shows each part of the microgrid (PV farm, wind farm, diesel generator, loads, transformer) as separate blocks. This makes it easy to change things and understand how the system is put together.

Simulink is built to simulate dynamic systems. This model helps to analyze how the system behaves over time showing the effects of changing solar light, wind speed, and power needs. To sum up, the diagram shows a Simulink-based method to model, simulate, and analyze a hybrid microgrid. It lets researchers study how the system changes, check how well it works, and create control plans for smooth and reliable operation.

IV RESULT ACHIEVED

Figures 4 to Figures 11 show various waveform of hybrid power system with different renewable and non-renewable sources.

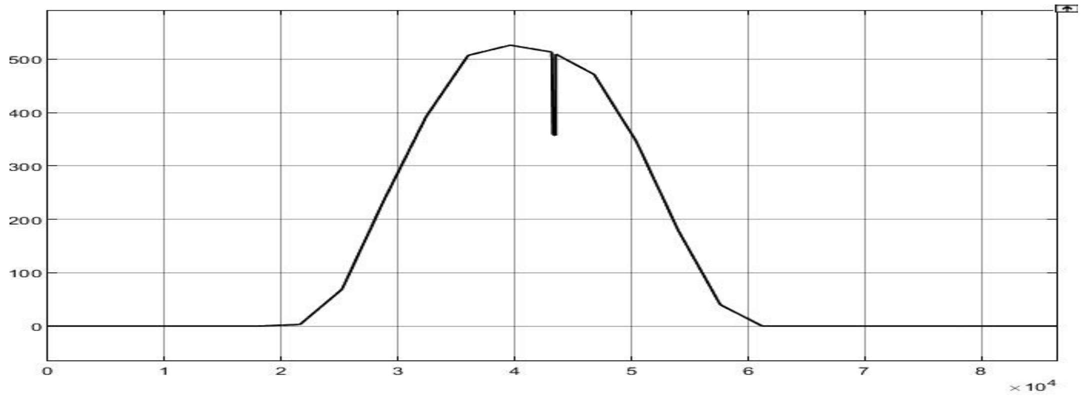

Figure 3 :Graphical representation of Irradiance of PV Farm

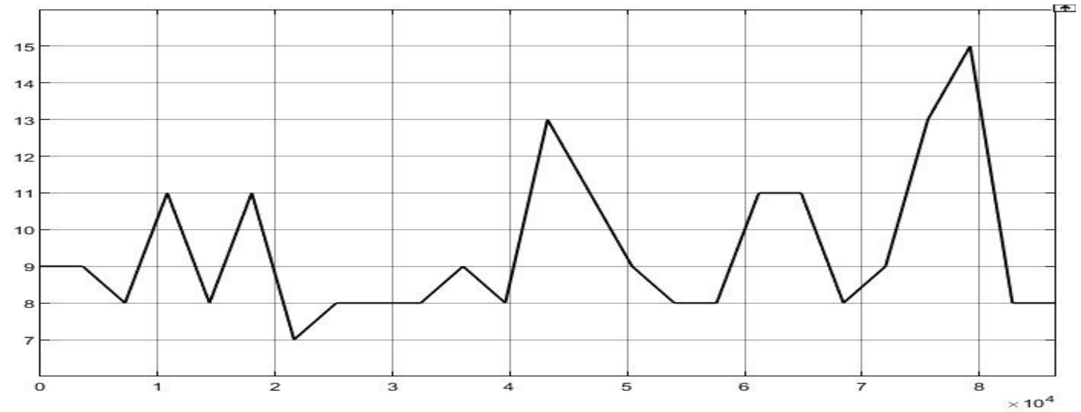

Figure 4: Graphical representation of wind profile

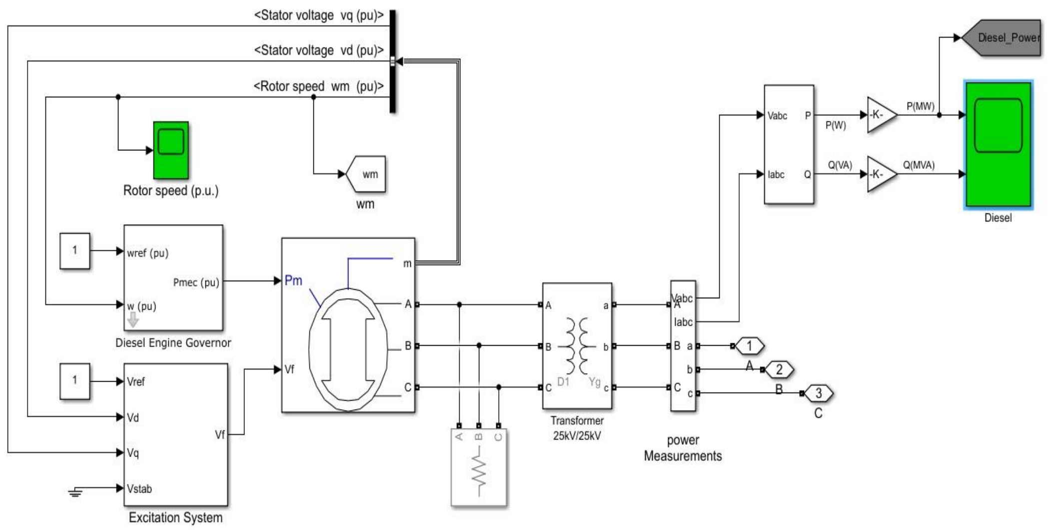

Figure5 :Diesel Generator

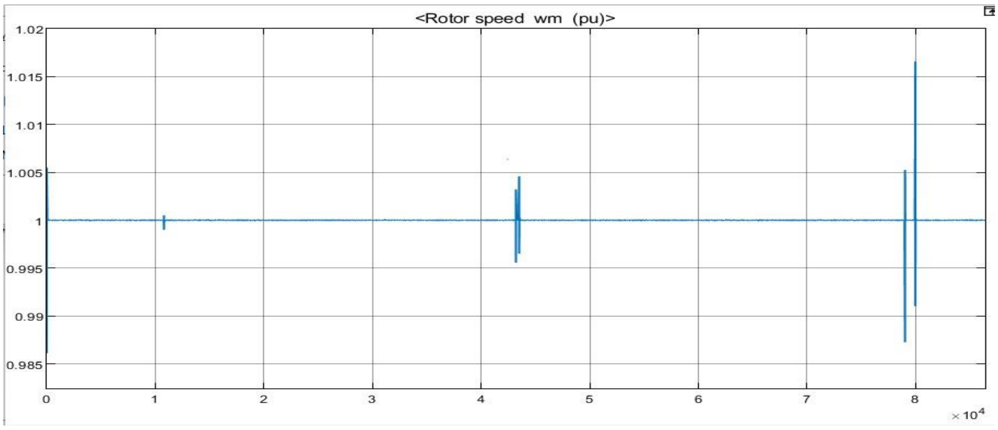

Figure6 :Rotor Speed (mu)

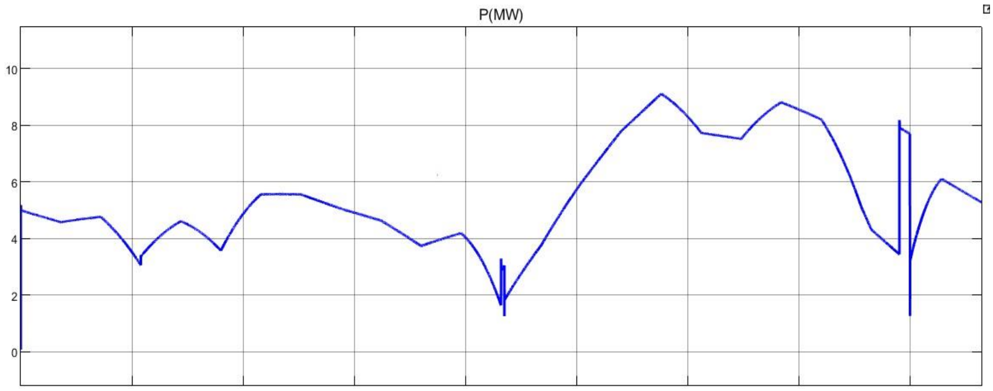

Figure 6a:Results of Diesel Generator

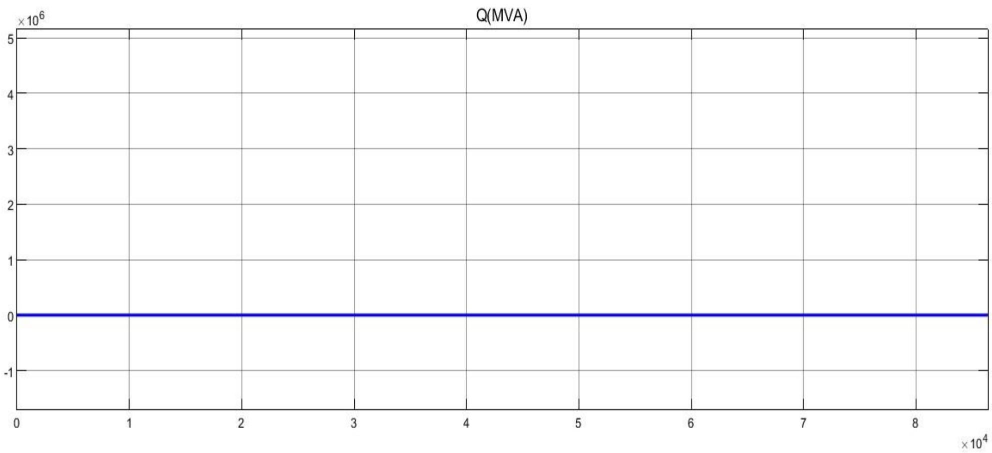

Figure 6b:Results of Diesel Generator

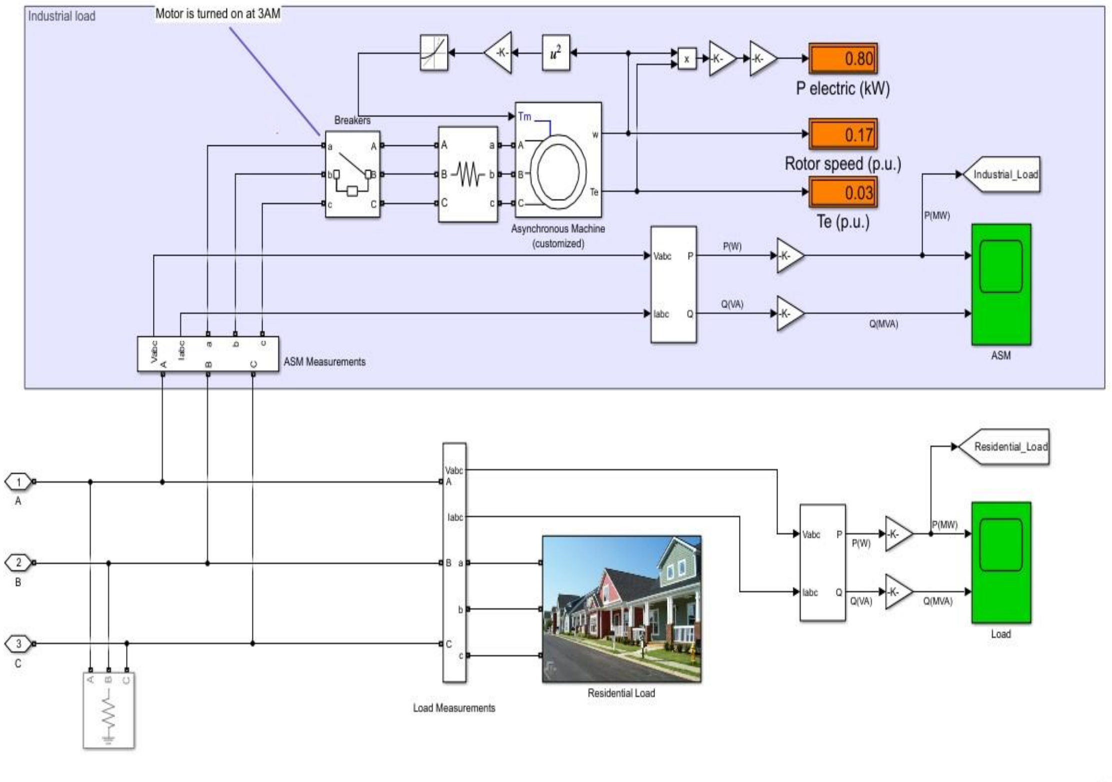

Figure7:Simulink block diagram of Residential Load

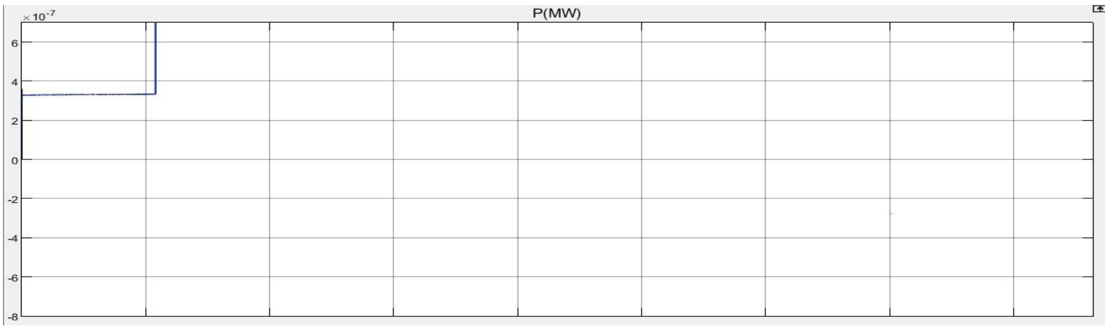

FIGURE 8:ASM Measurement

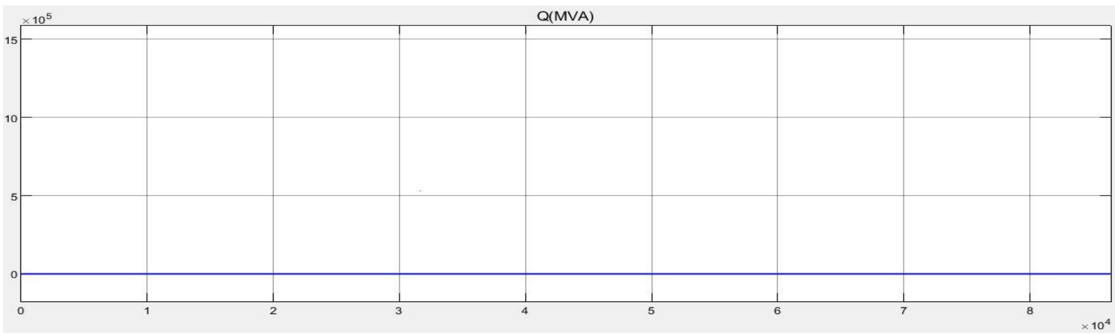

Figure9 :ASM Measurement

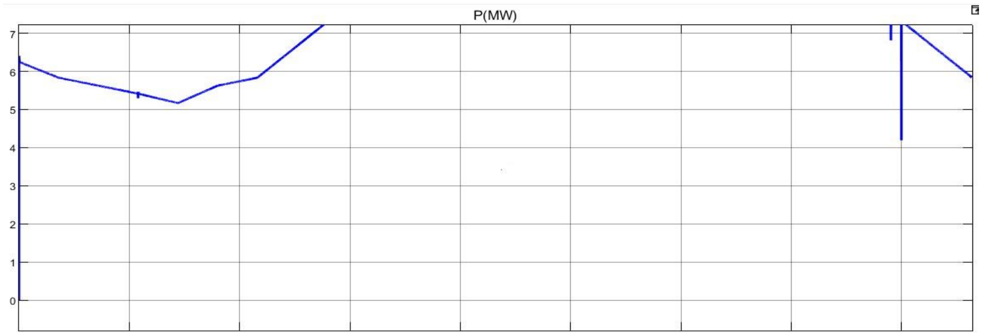

Figure 10a:Load Measurement

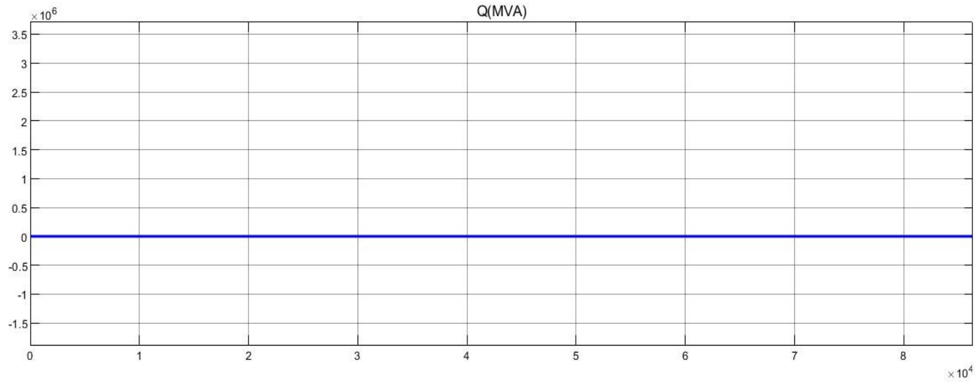

Figure 10b :Load Measurement

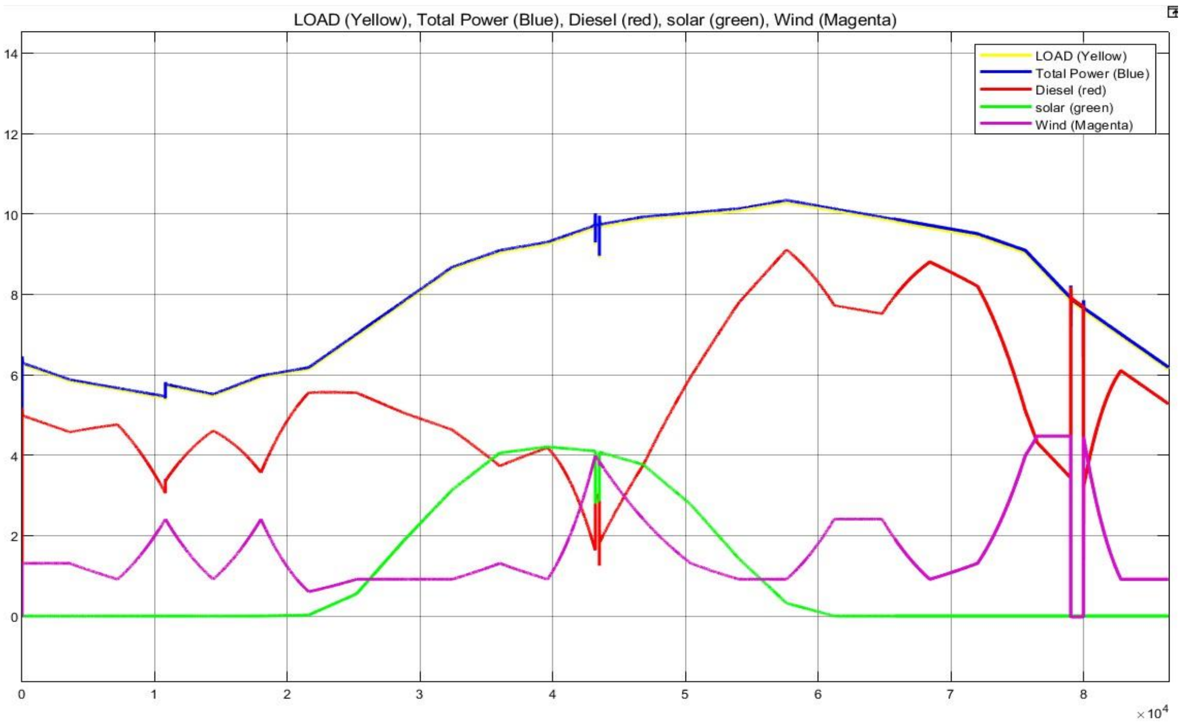

Figure 11:Graphical representation of hybrid power system

Figure11 displays the evolution of the total system load (yellow), the sum of all generation (blue), and the individual power contributions from diesel (red) solar (green), and wind (magenta) over a simulated 24-hour period. Here's how to interpret each trace:

1. **Load (Yellow)**
   - The yellow curve represents the demand on the system. It begins at about 6 MW then rises to around 10 MW, and drops toward the day's end.

   You'll see small step changes or dips—these show load fluctuations (e.g. changes in residential/industrial demand).

2. **Total Power (Blue)**
   - The blue line shows the total power generation meeting the demand. •It almost matches the yellow load line indicating that power production tracks usage in real time.
   - When the blue line sits above the yellow, the system may have a small excess, or it could be due to measurement precision limits.

3. **Diesel (Red)**
   - The diesel generator changes its output to bridge the gap between the load and available solar/wind power.
   - When solar or wind power is high, diesel power goes down; when renewables drop, diesel ramps up to keep the supply steady. • You can see this power change from about 2 MW to over 9 MW based on how much renewable energy is available and how much power is needed.

4. **Solar (Green)**
   - The solar farm doesn't produce power at night and starts to generate during the day.
   - The green curve reaches its highest point at midday (around 3–4 × 10^4 seconds, or 8–11 AM depending on your time offset) and then drops back to almost zero by evening.
   - Short drops might show partial shade or clouds passing by, as the irradiance input models.

5. Wind (Magenta)

- The wind farm's power output changes throughout the day based on the wind pattern.
- It can swing from almost 0 MW to about 3–4 MW, depending on the simulated wind conditions.
- Look at the regular peaks and valleys common in gusty wind or a daily wind cycle.

Overall, the graph shows how diesel, solar, and wind outputs work together to meet the changing load over time, with the diesel unit stepping in or "filling gaps" when renewable alone can't keep up.

V CONCLUSION

A power system combining wind solar, and diesel provides a reliable, efficient, and eco-friendly energy solution. This hybrid setup blends clean energy from wind and solar with a traditional diesel generator to manage renewable energy fluctuations and ensure steady power supply. Wind and solar contribute clean energy reducing fossil fuel reliance and benefiting the environment. The diesel generator serves as a backup guaranteeing power during low renewable production or high demand periods. This arrangement enhances energy security and cost-effectiveness in remote or off-grid locations.

Hybrid power systems help us improve energy production by reducing fuel consumption and cutting maintenance costs, as renewable components lessen the burden on diesel generators. To optimize these systems, we need to consider their design, sizing, and real-time management. Adding energy storage batteries and implementing smart controls will boost the flexibility and dependability of these setups. In the big picture, a power system that combines wind solar, and diesel offers a practical and versatile approach to decrease pollution, boost energy independence, and move towards a more sustainable future particularly in areas with limited access to grid power.

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