Energy Management System for Micro Grid with Renewable energy integration

Objective:

To build a small working prototype that demonstrates how a house/industry can use renewable energy (solar + wind) to power loads, monitor performance in real time through IoT, and fall back to grid power when renewable energy is insufficient.

- Main Functions:

1. Energy Sources

1. Solar Panel (e.g., 12 V, 20 W)
2. Wind Turbine (small DC motor, 10 W–20 W)
3. Battery Storage (12 V, 15 Ah $LiFePO_4$)
4. Main Grid (as backup source)

2. Power Flow Control

- Priority: Use renewable energy (solar/wind) first.
- Excess renewable energy: Store in battery.
- If renewable is not enough: Battery supports load.
- If still not enough: Automatically switch to grid (via relay / ATS).

3. IoT Monitoring Dashboard

1. Microcontroller (ESP32) collects sensor data:
2. Voltage, Current, Power of solar, wind, battery, load.
3. Battery SOC (state of charge).
4. Data is sent to a web or mobile dashboard (via WiFi/MQTT).
5. User can view generation, consumption, and grid usage in real time.

🔹 How the Prototype Works (Step Flow)

1. Solar panel and wind turbine generate DC → go through respective charge controllers.

2. Energy flows into the DC bus, charging the battery and supplying load (via inverter).

3. ESP32 continuously measures solar, wind, battery, and load conditions via sensors.

4. If renewable energy is sufficient → load runs entirely on solar/wind.

5. If renewable is less → battery discharges to support load.

6. If both renewable and battery are insufficient → relay automatically connects load to grid supply.

7. All readings are sent to the IoT dashboard, where user can see:

- Solar input (W)
- Wind input (W)
- Battery SOC (%)
- Load consumption (W)
- Grid usage (on/off, W consumed)

🔹 Expected Outcome

- A small prototype that powers AC loads (like fan or bulb).
- Live IoT dashboard shows how much energy comes from solar, wind, battery, and grid.
- Automatic switching system ensures reliable power supply.