V&P Microgrid

Wind Energy, Diesel Genset & Energy Storage System

Application Case Study

Introduction & Project Background

This case is on a remote island, which traditionally relied on diesel gensets as the primary power source. The aim of the project is to integrate wind power generation to reduce fuel costs and achieve a greener energy structure. However, the intermittency of wind power and fluctuations in load have resulted in prolonged operation of diesel gensets in fuel inefficient ranges, accompanied by high maintenance costs. Given that power stability is the most critical consideration in the design, a 500kW/620kWh energy storage system has been incorporated during the upgrade. The goal is to establish an intelligent hybrid energy microgrid that achieves economical operation, reduces carbon emissions, and enhances power supply reliability.

1. System Configuration

1.1 Existing Site Configuration: Cummins Diesel Generators (DG): 3 units x 800kW (rated voltage 400V, frequency 50Hz), totaling 2400kW.

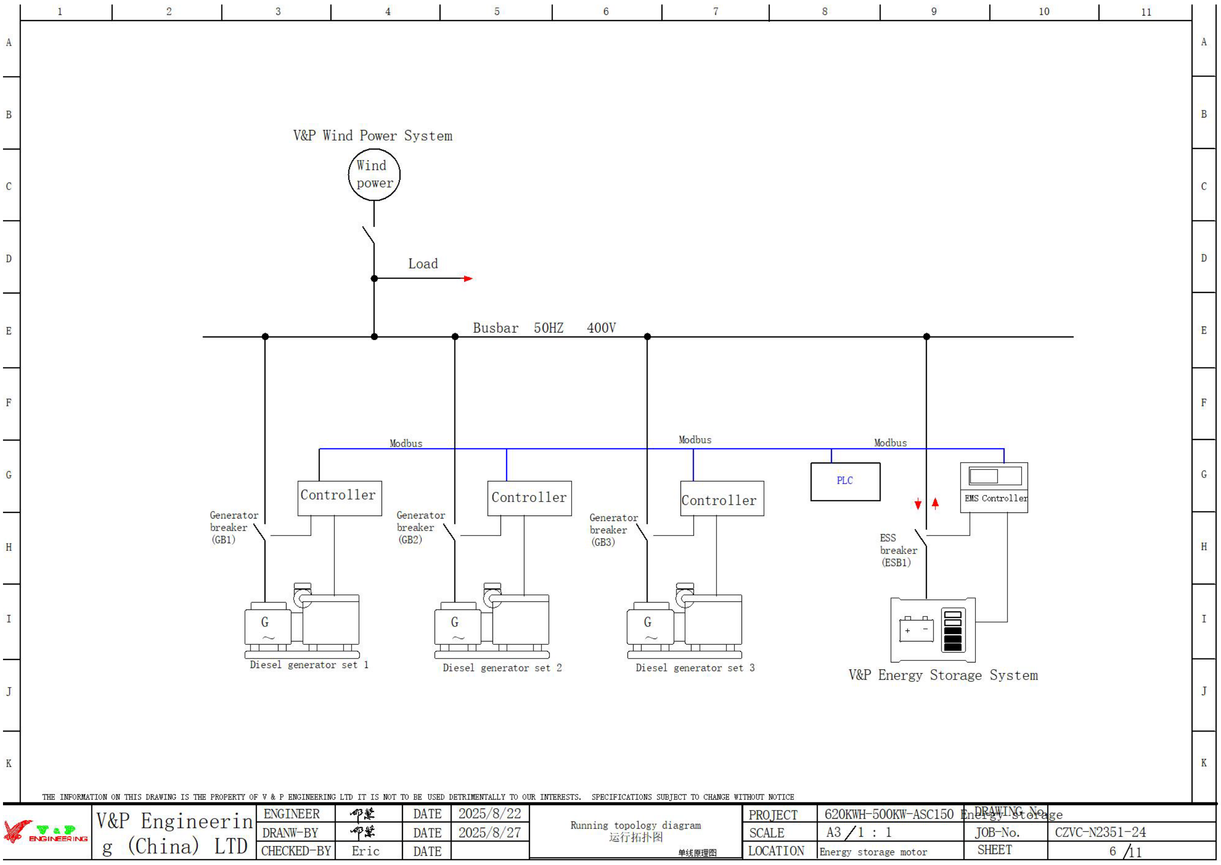
1.2 New Addition 1: Energy Storage System (ESS)

One 20-foot standard containerized Lithium Iron Phosphate (LFP) battery energy storage system, with a rated power of 500kW and a rated capacity of 620kWh, equipped with a PCS (bi-directional converter) and an EMS (Energy Management System).

1.3 **New Addition 2:** Wind Turbine Generator (WTG):

One 200kW horizontal-axis wind turbine generator.

1.4 The System Single Line Diagram as follows:



2. Operation Logic

2.1 Prior to New Equipment Deployment

a. The island experienced significant load fluctuations, ranging from 300 kW to 700 kW, with substantial difference between daytime and nighttime power demand.

b. Typically, 1-2 diesel generators (DG) were operational, while the third unit served as a backup.

c. The average load utilization of the diesel generators was only 30-45%(due to the need for power reserve to accommodate sudden load surge).

d. If wind power were integrated without energy storage, the increased volatility would further reduce the average load utilization of the diesel generators to an estimated range 15-20%, escalating fuel inefficiency and maintenance costs.

2.2 Operational Logic After New Equipment Deployment

a. The wind turbine generator (WTG) and V&P Energy Storage System (ESS)will be permanently connected to the system.

b. Wind power generation fluctuates with wind speed, and the V&P ESS will intelligently compensate for the remaining power demand to ensure grid stability.

c. If necessary, one 800kW diesel generator (DG) will automatically start to supply power and simultaneously charge up the energy storage system (ESS).

d. Through the V&P EMS control system and PLC programming, the diesel generator’s load will be intelligently maintained within a stable range of 70–85% (adjustable in the controller).

e. All operations of the diesel generators and the V&P ESS are fully automated, adjusting dynamically based on grid load, wind power generation, and battery SOC (State of Charge) without manual intervention.

f. The entire system is compatible with existing generator sets and grid-parallel configurations, ensuring no wastage of resources.

3. Economic Benefit Analysis

3.1 Cummins K38 Diesel Generator Fuel Consumption Curve:

- 25% Load: 251 g/kWh
- 50% Load: 225 g/kWh
- 75% Load: 207 g/kWh (Optimal Efficiency Point)
- 100% Load: 202 g/kWh

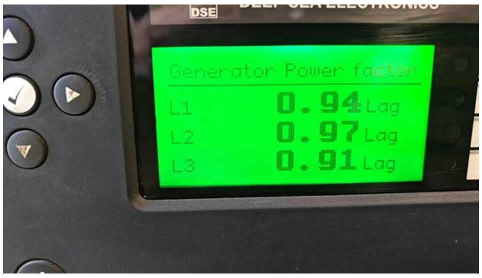
By increasing the average load rate from 20% to 75-80%, the fuel consumption rate of diesel power generation is reduced by 20%.

3.2 By reducing the operating hours of the diesel generator sets by 50-70%, the consumption of consumables and the frequency of major overhauls—both directly linked to engine running hour—are significantly decreased, thereby indirectly lowering the overall cost of diesel power generation.

3.3 The annual return on investment (ROI) for the wind power equipment is approximately 15-25% (in case solar power is allowed by environmental conditions, the ROI could be even higher). The V&P energy storage system ensures that the returns from renewable energy are not wasted in inefficient fuel consumption losses.

3.4 Thanks to the integration of the energy storage system (ESS), the power factor of the distribution system has been improved, and copper losses in cables have been reduced. The average power factor has now increased from 0.8 to 0.95

The power factor before the ESS was deployed



The power factor after the ESS deployment

3.5 With the integration of wind power and the energy storage system, the diesel generator sets on the site in future can be replaced with 2-3 units of 400kW gensets, further reducing initial investment while maintaining power supply stability.

4. Summary

- Historical Context: Renewable energy applications were previously limited to large-scale national projects (tens MW or more) connected to the main grid. With technological advancements and product popularity, they are now deployed in microgrids (10-2000 kW) for households, factories, and remote areas, offering attractive returns. The annualized return on investment (excluding installation, transportation, and taxes) can reach 25-40% for photovoltaic systems and 18-25% for wind power systems.

- Challenges in Diesel-Based Microgrids: Integrating renewables into diesel-dependent microgrids poses risks due to the volatility of renewable power generation. In order to backup possible sudden renewable power lose, diesel generators often operate at low loads for prolonged periods, leading to carbon accumulation inside engine and high fuel consumption, ultimately undermining overall returns. Energy storage systems (ESS) are essential in order to resolve the issue.

- Role of Energy Storage: ESS often plays an indispensable role in ensuring the economic returns of such projects. Although these systems are smaller in scale, their intelligence and technical requirements are more demanding than those of large-scale energy storage equipment.

- Economic Incentives in Remote Areas: Fuel costs are typically higher in remote locations, making fuel savings through ESS integration even more significant.

- Grid Stability Enhancement: In remote areas with unstable main grids, power supply often alter between diesel gensets and the grid. ESS enables seamless transitions between these sources, ensuring uninterrupted electricity supply

- Specification of ESS and renewable energy should match the need of load in order to maximize the return. Thus, they should not be sold as a standard commodity. Instead they should be designed according to individual project need.