Jinko ESS Liquid Cooling Solution of Micro-grid AC- coupled System

250kW/645kWh Li-ion BESS Project in Lebanon

Case Study

Project Overview

The project is situated in a rural area of Lebanon, characterized by extensive land and low population density where grid power is not available, and the facility is running only on diesel generators.

This project focuses on implementing an AC-coupled Energy Storage System (ESS) for a chicken farm. The solution aims to enhance energy efficiency, reduce electricity costs, and improve power reliability by integrating battery storage and PV with the existing power infrastructure.

Jinko has developed a comprehensive solution comprising PV, DGs, and battery energy storage systems (BESS) to ensure stable power supply, while DGs only serve as backup power sources.

The facility has achieved a remarkable reduction of 93% in diesel consumption by decreasing the DGs running hours from 24H to 1.5H per day.

The system is designed to operate for over 10 years, with more than 300 days of potential support from purely green energy.

ESS
JinKO

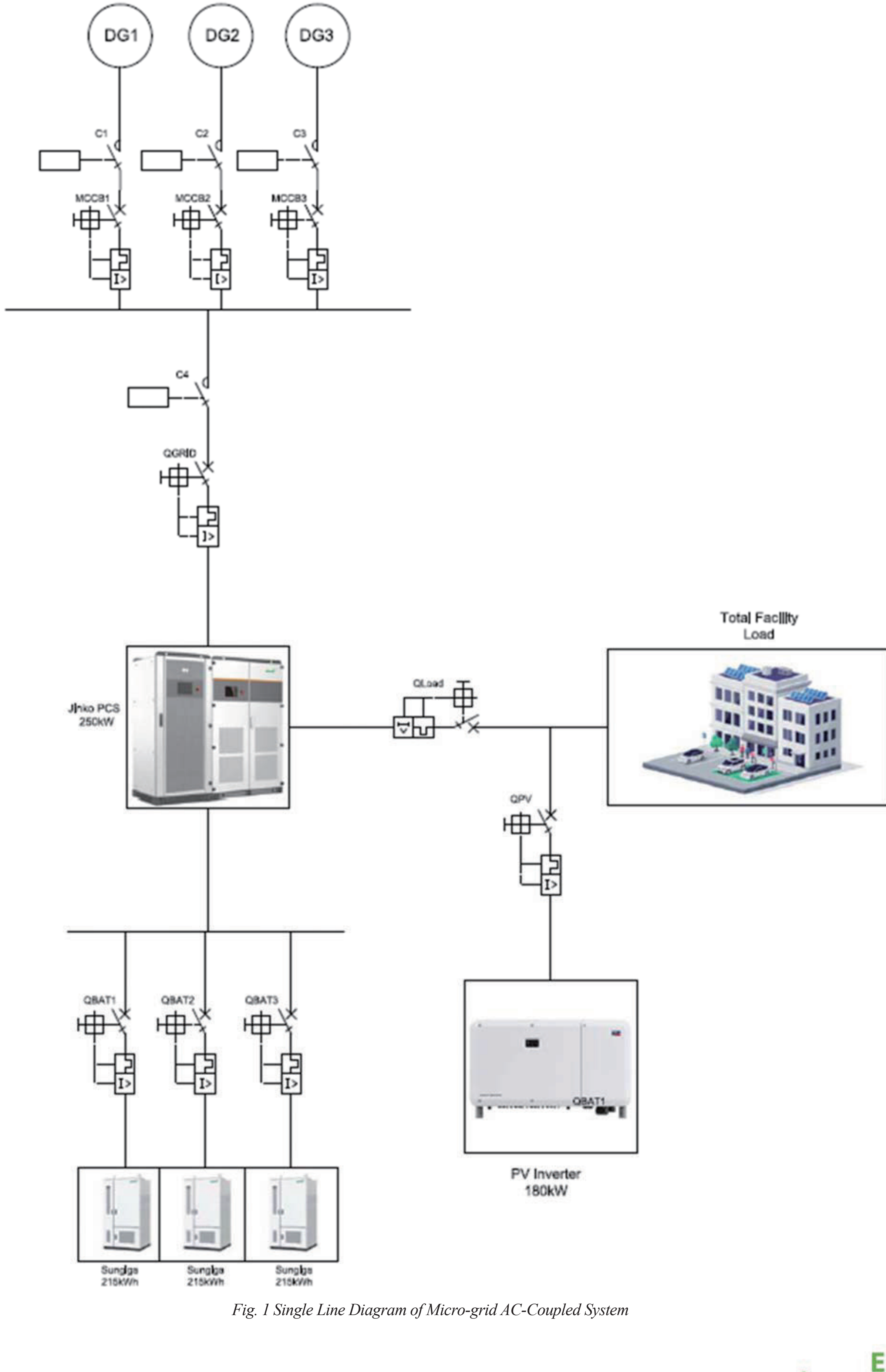

Fig. 1 Single Line Diagram of Micro-grid AC-Coupled System

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The Solution

Adopting 645kWh Jinko SunGiga energy storage cabinets, the client will benefit from the inherent advantages of its integrated design, simplified installation and maintenance procedures, while achieving a high level of system integration.

The 645kWh ESS system is designed in cabinets configuration, integrated with different sub systems to deliver optimal performance and safety. These include battery racks, battery management system (BMS), liquid cooling system, fire suppression system, power conversion system (PCS) and energy management system (EMS).

Battery Rack

Each battery rack of 215kWh consists of 5 battery packs of 153.6V rated voltage connected in series to reach a total 768V. Alongside a high voltage box (HVB) consisting of electrical protection for high and low voltage circuit and a battery cluster unit (BCU) responsible for collecting and processing data received from the battery pack units.

Battery Management System

The solution adopts a BMS with two stage architecture using CAN bus communication: battery management unit (BMU) and battery cluster unit (BCU).

The BMU is integrated into each pack to monitor the cell voltages, temperature and current. The BCU is integrated into the HVB summarizing the data received by the BMUs.

The BMS is responsible for real time detection of thermal and electrical parameters (voltage, current, temperature, etc...), accurate estimation of battery state of charge (SOC) and state of health (SOH) with auto calibration and support over-charge protection, over-discharge protection, short circuit protection, reverse polarity protection, overload protection, and over-temperature protection.

The BMS can swiftly isolate local faults, report fault information and provide real time alarms.

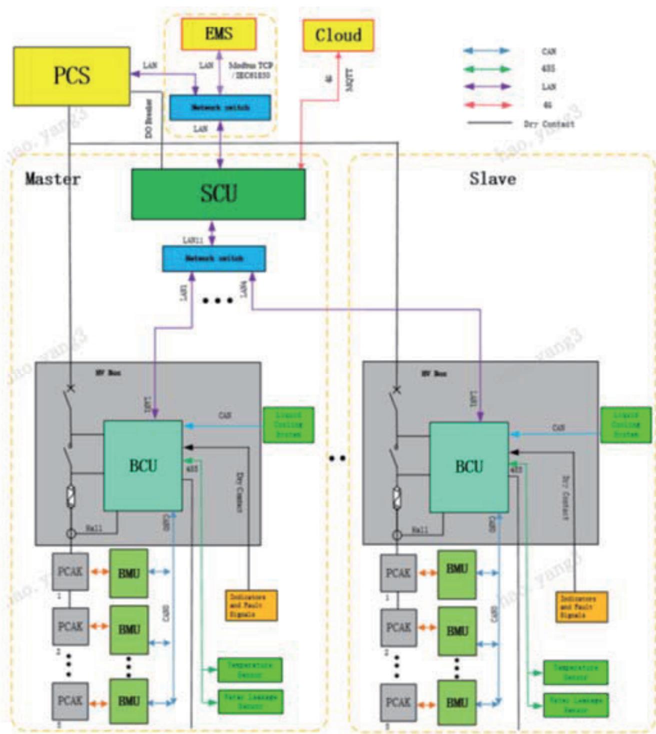

Fig. 2 BMS Communication Topology

Liquid Cooling System

The solution adopts a liquid cooling system, which consists of liquid cooling host, liquid transmission pipeline and battery liquid cooling plate, and multi-mode refined thermal management control logic to maintain normal temperature and improve system consistency and lifetime. The liquid cooling unit has a low rated capacity pf 4kW.

Fire Suppression System

The fire suppression system integrated within the ESS system is designed to ensure safety and minimize the risk of fire incidents using aerosol. The FSS consists of temperature and smoke detectors to promptly identify the occurrence of thermal runaway within the ESS cabinet.

When the protected area reaches the temperature threshold, the fire extinguishing device will be triggered, releasing the extinguishing agent and extinguishing the fire; at the same time, a dry contact signal is fed back to the upper unit to remind the relevant personnel that the gas extinguishing agent has been released.

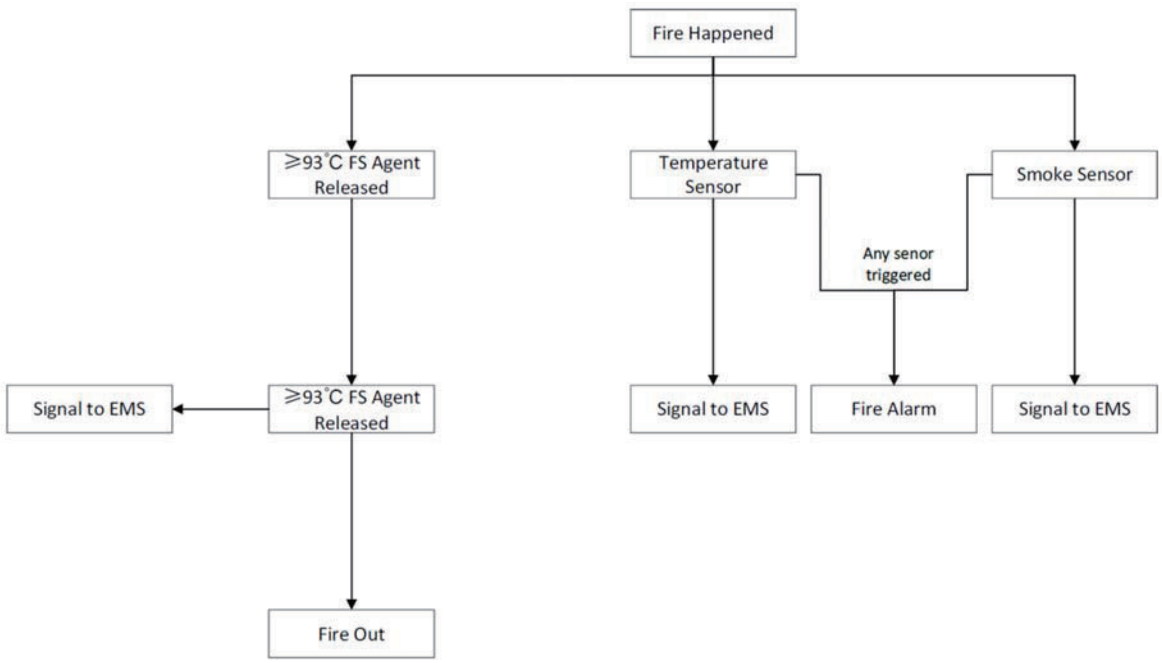

Fig. 3 FSS Workflow

Power Conversion System (PCS)

The solution adopts a grid forming 250kW PCS with built in isolation transformers for high load adaptability, support simultaneous access to load, battery, DG and PV inverters, and ensure smooth switching between grid following and grid forming mode for uninterrupted load power supply.

The PCS is equipped with DCAC converter. In the grid following mode (PQ mode), the DCAC converter is connected to the grid for power control.

In grid forming mode (VF), the DC-AC converter is controlled at constant voltage and frequency to provide stable AC power for the load and reference for PV inverters to operate based on the system operation logic.

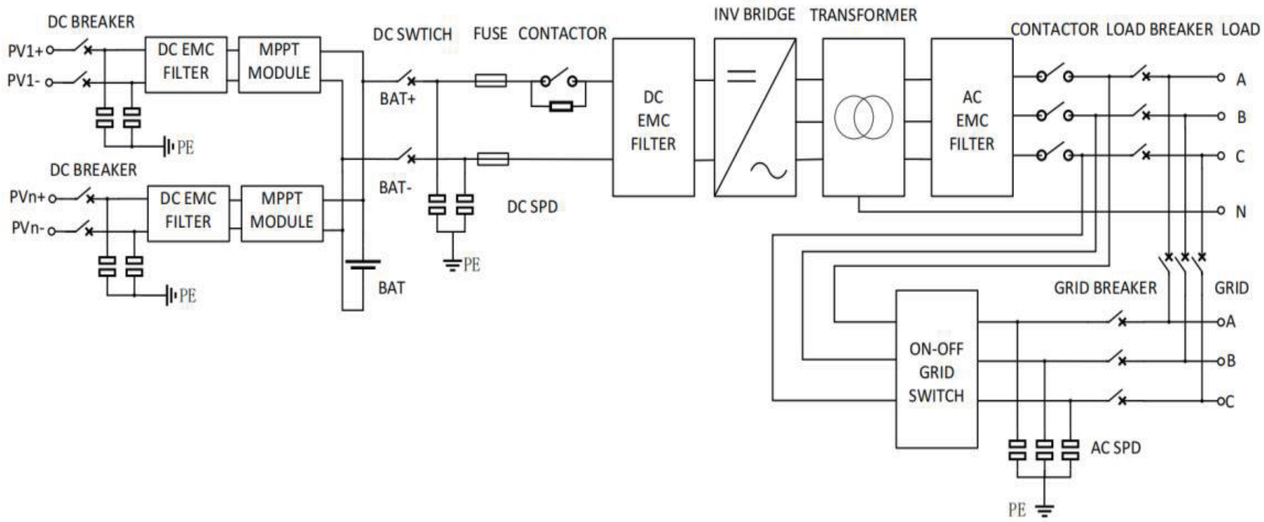

Fig. 4: PCS Single Line Diagram

Energy Management System (EMS)

The EMS integrated with the ESS system offers a comprehensive range of functionalities to ensure efficient and reliable operation. It serves as a central control unit that optimizes energy flow, enhances system performance, and enables seamless integration with existing SMA PV inverters.

The EMS provides real-time monitoring and control of the system, allowing users to monitor crucial parameters, such as state of charge (SOC), state of health (SOH), and power flow. Through a user-friendly visual interface, users can directly manage and adjust system settings, ensuring optimal performance and maximizing energy utilization.

The EMS plays a critical role in optimizing the operation of the ESS system to ensure efficient management between PV inverters, battery cabinets and DGs existing on site.

The BMS, PCS and PV inverters are connected to the EMS through Modbus TCP/IP. The EMS is communication with the existing DG through hard wiring configurable dry contact based on batteries state of charge % (SOC).

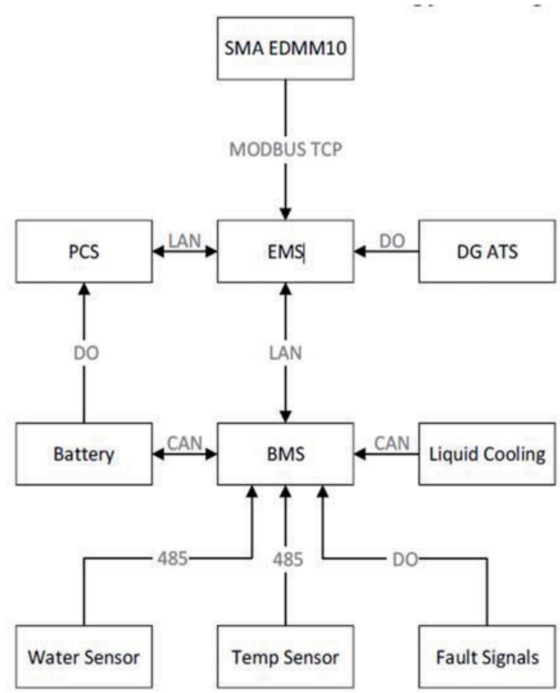

Fig. 5: EMS Communication Topology

Operation Logic

The system will run in off grid mode during the day when the PCS switches to grid forming mode to give the PV inverters constant voltage and frequency to charge the batteries and feed the facility load.

As the PV capacity of 180kW is less than the maximum allowable charging capacity, the EMS will send 100% power setpoint to PV inverters when the battery SOC is between 0 and 90%.

At 90% SOC, the EMS will start limiting the charging from PV by sending power setpoint to the PV inverters equal to:

$$P_{Setpoint} = P_{Charging} + P_{Load}$$

$$P_{Setpoint} = 0.3XPCS_{Capacity} + P_{Load}$$

$$P_{Setpoint} = 75kW + P_{Load}$$

At 95% SOC, the EMS will continue limiting the charging from PV inverters to reach charging PV setpoint of 150% of PCS capacity:

$$P_{Setpoint} = 0.10XPCS_{Capacity} + P_{Load}$$

$$P_{Setpoint} = 25kW + P_{Load}$$

At 98% SOC, the EMS will reduce the charging from PV to 0 and the power production will be only limited to maintain the facility load:

$$P_{Setpoint} = P_{Load}$$

The above thresholds were set on the EMS human machine interface existing inside the PCS integrated cabinet to avoid battery over charging.

When the battery reaches the low SOC set to be 20%, the EMS will trigger DO1 signal to turn on automatically the DG. When DG is connected, the PCS will switch from grid forming to grid following mode. Since charging from diesel generator is forbidden by the client, DG will keep on feeding the load until the batteries charge from PV and reach 30% SOC.

When the system reaches the DG turn off SOC (30%), DO1 signal will be disabled by the EMS and the DG will stop operating and the PCS switch again to off grid mode.

To ensure protection on the diesel generators, the EMS integrated a minimum load % threshold parameter to be set based on the generator capacity and manufacturer. The existing generators are Volvo which can be run at a minimum load of 25% of their capacities. When DG is ON manually by the operator, the EMS will shut down the PV inverters and let the generator cover the load power taking into consideration the minimum load % threshold. However, charging from DG is forbidden, the DG will charge the batteries if and only if the facility load is less than the DG minimum load %. In this case the DG will charge the batteries at a power equal to:

$$P_{charging\ from\ DG} = P_{minimum\ DG\ load} - P_{Load}$$

$$DG_{capacity} = 250kW$$

$$P_{charging\ from\ DG} = 62kW - P_{Load}$$

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Fig. 5: EMS HMI Display

Fig. 6: EMS PV Inverters Power Limit Thresholds.

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Monitoring Systems

SCU Monitoring

The solution is equipped with one SCU connected to the 3 battery cabinets to monitor and control all connected subsystems (cooling system, FSS, BMUs, BCUs, etc…) and provide real time data for cluster and cells voltage, temperature and current as well as the alarms log and running status of the SunGiga cabinets.

The SCU is connected to cloud via LAN cable connected to the client router. The SCU is accessed remotely through VPN.

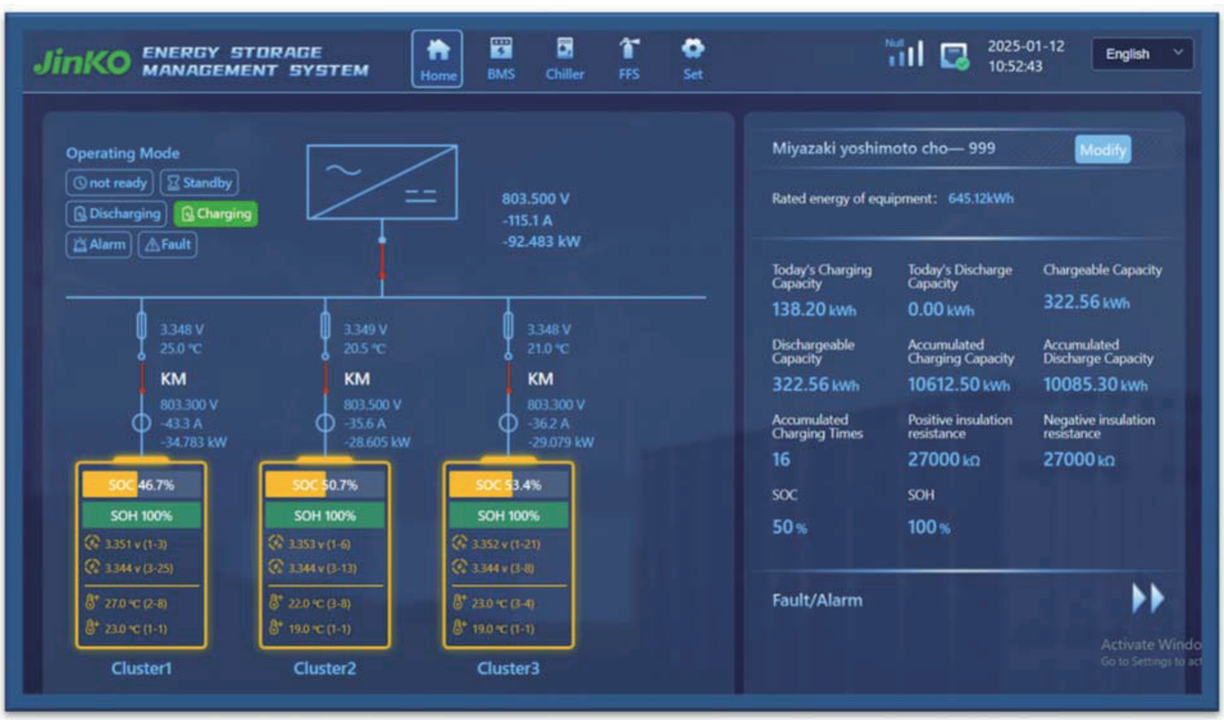

Fig. 6: SCU Cloud Monitoring Display

EMS Monitoring

The EMS cloud platform is an intelligent management system designed to control and monitor the ESS power systems.

The BMS, PV inverters, PCS and EMS HMI are connected to the IoT router located inside the EMS integrated cabinet through Modbus TCP/IP. The router is connected to cloud monitoring platform through WAN connection coming from the client internet router.

N.B: The router can be connected to cloud through 4G Sim Card.

Fig. 7: System IoT Router

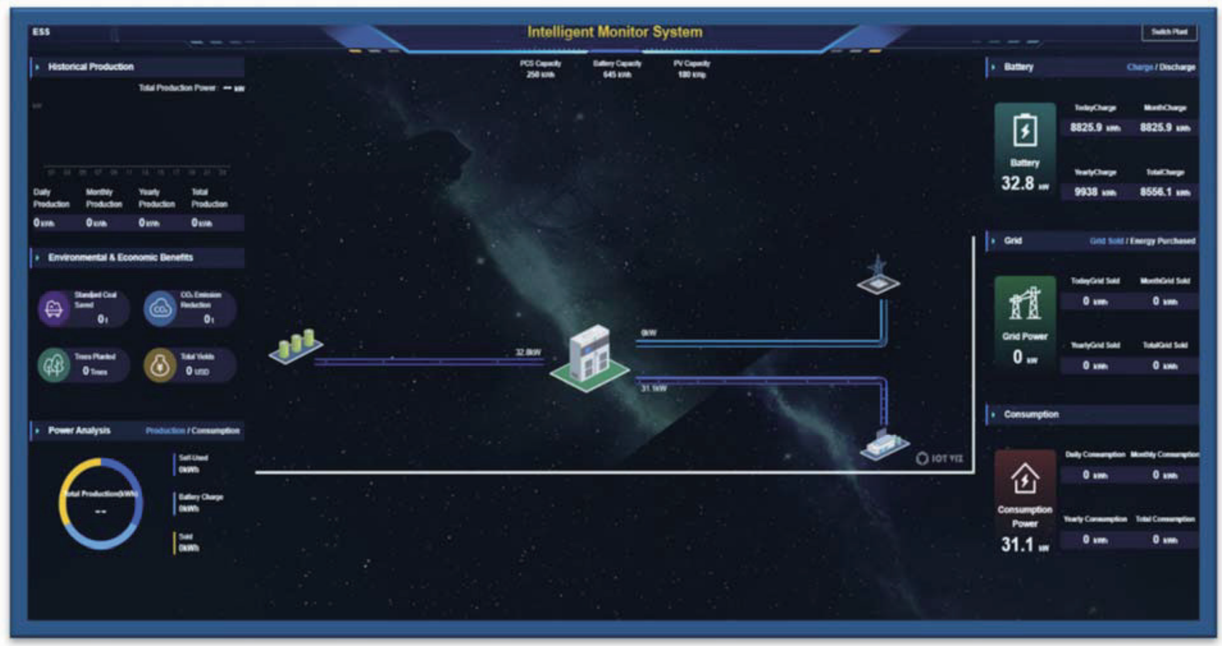

Fig. 8: EMS Cloud Monitoring Platform

Data Analysis

20%≤SOC≤90

The PV inverters are working at 100% active power setpoint since the system SOC % is less than the power limit 1st threshold (90%) as shown in the figure 9 below:

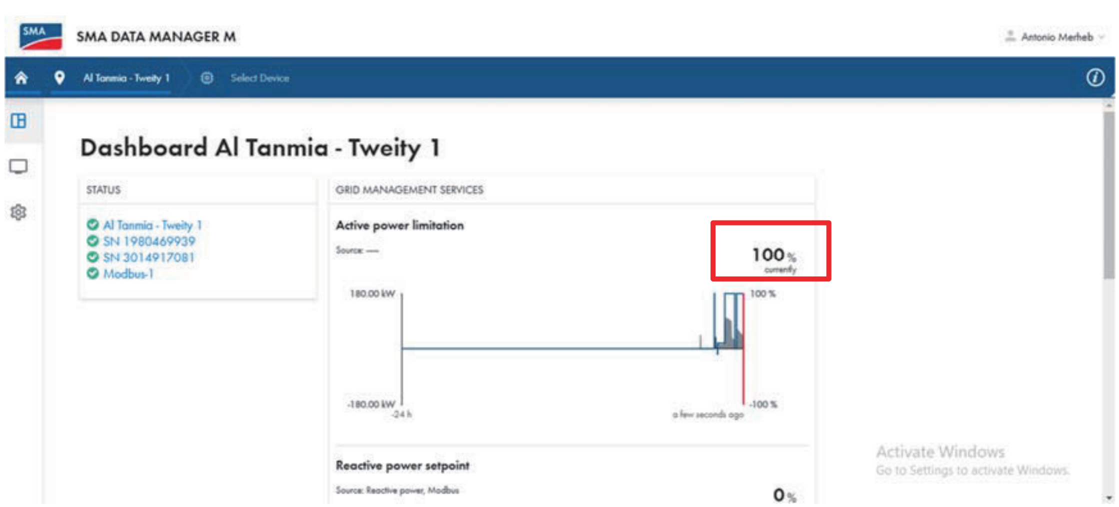

Fig. 9: SMA Monitoring platform showing 100% setpoint received from EMS

90%≤SOC≤95

In this case PV inverters charging power will be limited to 75kW (30% of PCS capacity), taking into consideration a load power of 35kW. As shown in figure 10 below, the PV inverters power setpoint received is 66% of PV total capacity which makes sense based on the load power:

$$P_{Load} = 35kW$$

$$Calculated\ PV\ P_{Setpoint} = PV\ P_{Charging} + P_{load}$$

$$Calculated\ PV\ P_{Setpoint} = 75kW + 35kW = 110kW$$

$$Calculated\ PV\ P_{Setpoint}\% = \frac{Expected\ PV\ P_{setpoint}(kW)}{Total\ PV\ Capacity\ (kW)} X100$$

$$Calculated\ PV\ P_{Setpoint}\% = \frac{110kW}{180kW} X100 = 62\%$$

The calculated PV P setpoint is almost the same as the real setpoint shown in figure 10. On other hand, it is clearly shown in figure 11 that the charging power is limited to 71kW which complies with the system operation logic.

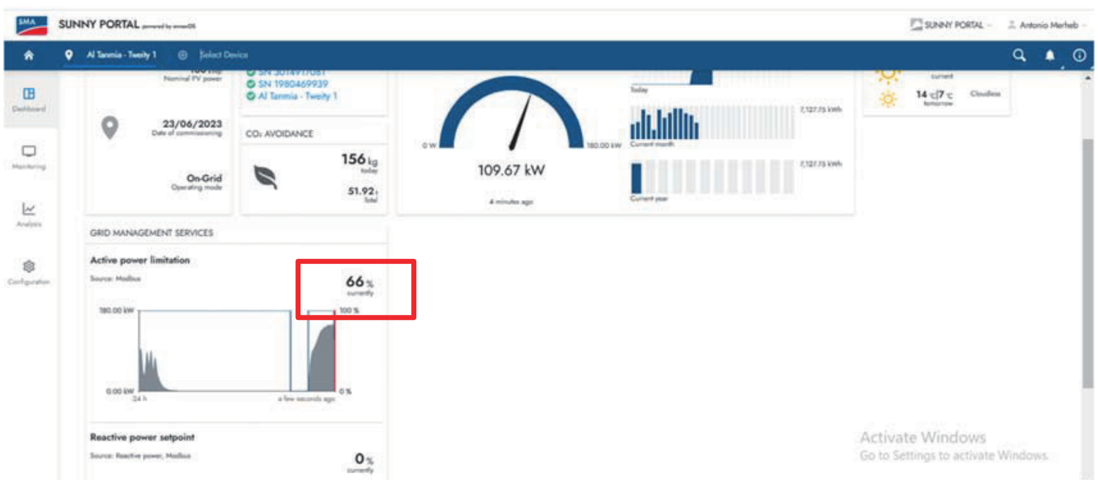

Fig. 10: SMA Monitoring platform showing 66% setpoint received from EMS

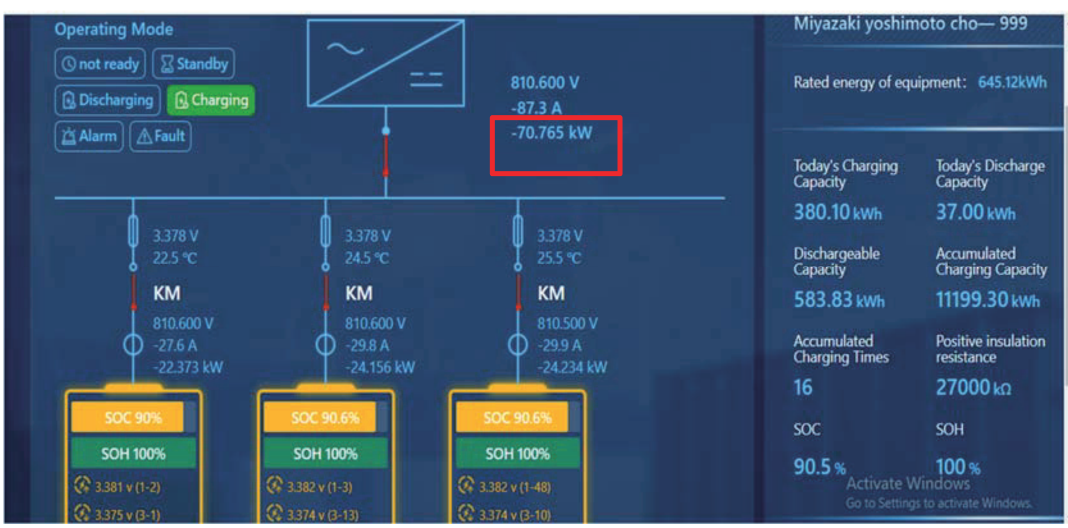

Fig. 11: SCU Monitoring showing charging power limit at 90% SOC

95%≤SOC≤98%

In this case PV inverters charging power will be limited to 25kW (10% of PCS capacity). As shown in figure 12 below, the PV inverters power setpoint received is 25% of PV total capacity which makes sense based on the load power of 20kW at this stage:

$$P_{Load} = 20kW$$

$$Calculated\ PV\ P_{Setpoint} = PV\ P_{Charging} + P_{load}$$

$$Calculated\ PV\ P_{Setpoint} = 25kW + 20kW = 45kW$$

$$Calculated\ PV\ P_{Setpoint}\% = \frac{Expected\ PV\ P_{setpoint}(kW)}{Total\ PV\ Capacity\ (kW)} X100$$

$$Calculated\ PV\ P_{Setpoint}\% = \frac{45kW}{180kW} X100 = 25\%$$

The calculated PV P setpoint is almost the same as the real setpoint shown in figure 12. On other hand, it is clearly shown in figure 13 that the charging power is limited to 25kW which complies with the system operation logic.

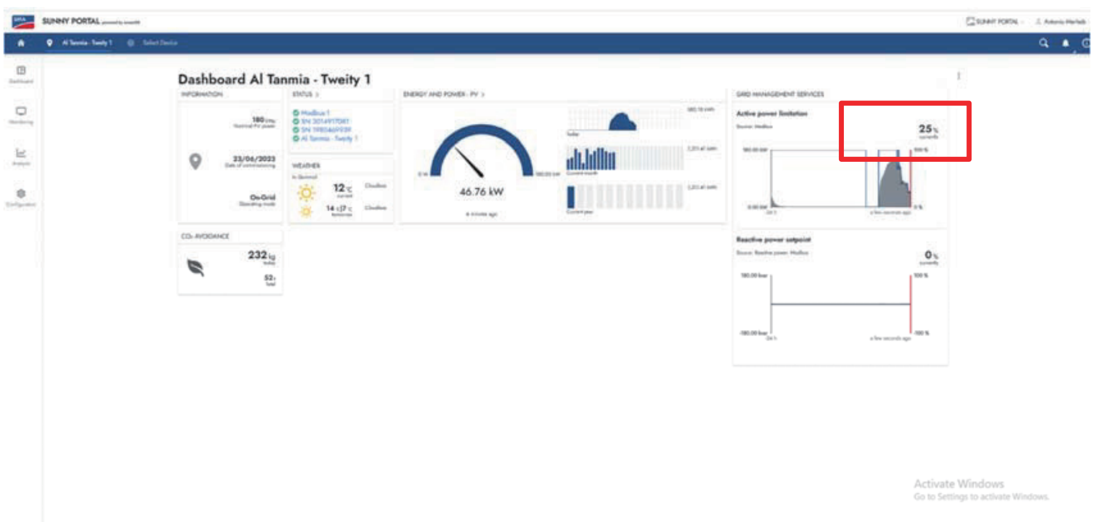

Fig. 12: SMA Monitoring platform showing 25% setpoint received from EMS

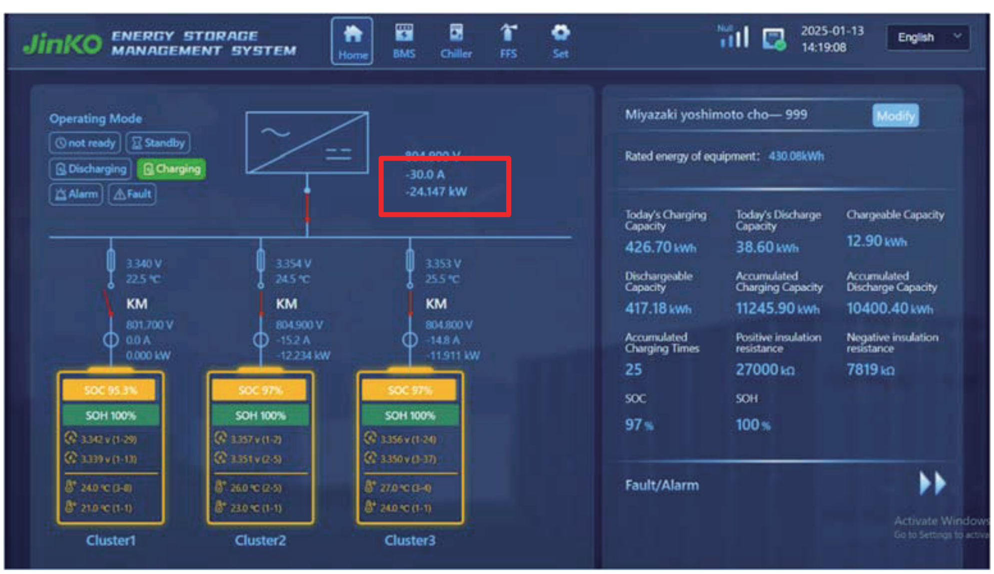

Fig. 13: SCU Monitoring showing charging power limit at 97% SOC

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98%≤SOC

When the batteries reach 98% SOC, the PV inverters charging setpoint will drop to 0% and the total PV power setpoint will be limited only to cover load power:

$$P_{Setpoint} = P_{Load}$$

$$Calculated\ PV\ P_{Setpoint} = 0kW + 55kW = 55kW$$

$$Calculated\ PV\ P_{Setpoint}\% = \frac{Expected\ PV\ P_{setpoint}(kW)}{Total\ PV\ Capacity\ (kW)} X100$$

$$Calculated\ PV\ P_{Setpoint}\% = \frac{55kW}{180kW} X100 = 31\%$$

The calculated PV P setpoint is almost the same as the real setpoint shown in figure 14. On other hand, it is clearly shown in figure 15 that the charging power decreased to 0kW which complies with the system operation logic.

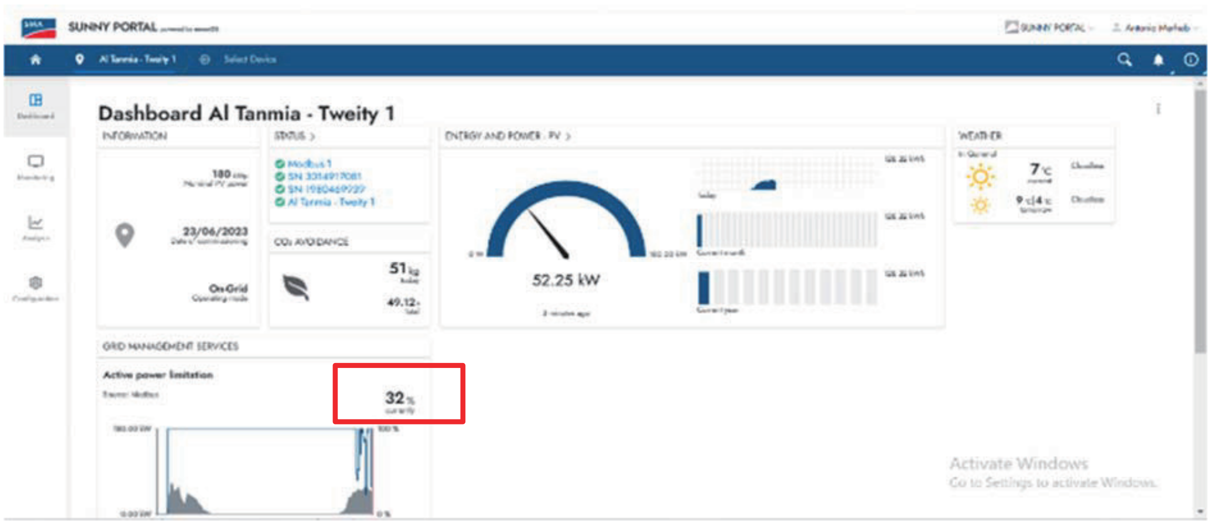

Fig. 12: SMA Monitoring platform showing 32% setpoint received from EMS

Fig. 14: SCU Monitoring showing charging power limit at 98% SOC

Conclusion

Overall, this study underscores the critical role of energy storage in transitioning to a more sustainable and resilient energy infrastructure. The implementation of AC coupled Microgrid solution of 645kWH C&I energy storage system has demonstrated significant advantages in terms of simplified installation, cost savings and environment requirements.

Operational performance data highlighted the system's high efficiency, reliability, and scalability, with minimal degradation over the study period.

Additionally, the project provided valuable insights into battery management strategies and control.

Future expansions and advancements in battery technology and grid interconnection strategies will further enhance the effectiveness of similar ESS deployments.

Gains	Coal saved	CO_2 reduced	SO_2 reduced
23526.3	9.41t	23.46t	705.8kg

* The report serves as a general overview and is subject to updates by Jinko ESS. Jinko ESS reserves the right to modify the content and holds the final authority in its interpretation.

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