Jinko Sungiga Liquid Cooled Solution of Micro-grid DC- coupled System

1MW/2.15MWh Li-ion BESS Project in DRC- Makoro Mini-grid

Case Study

Project Overview

The project is situated in Makoro, Haut-Uele Province, in northeastern part of DRC. The location of the project is a remote region with no grid access and the solution would be used to power hundreds of households in Faradje Territory of the province.

This project focuses on implementing an DC-coupled Energy Storage System (ESS) to be integrated with Diesel Genset. The power is then stepped up from transmission and distribution to the grid network in the region. The project aims to showcase the deployment of renewable energy to achieve sustainable development and rural community empowerment.

The project total capacity is a 1 MWp Solar PV system used to charge a 1MW/2.15MWh Micro-grid ESS system. The main components of the installation were in cabinets and containers allowing for fast deployment and commissioning.

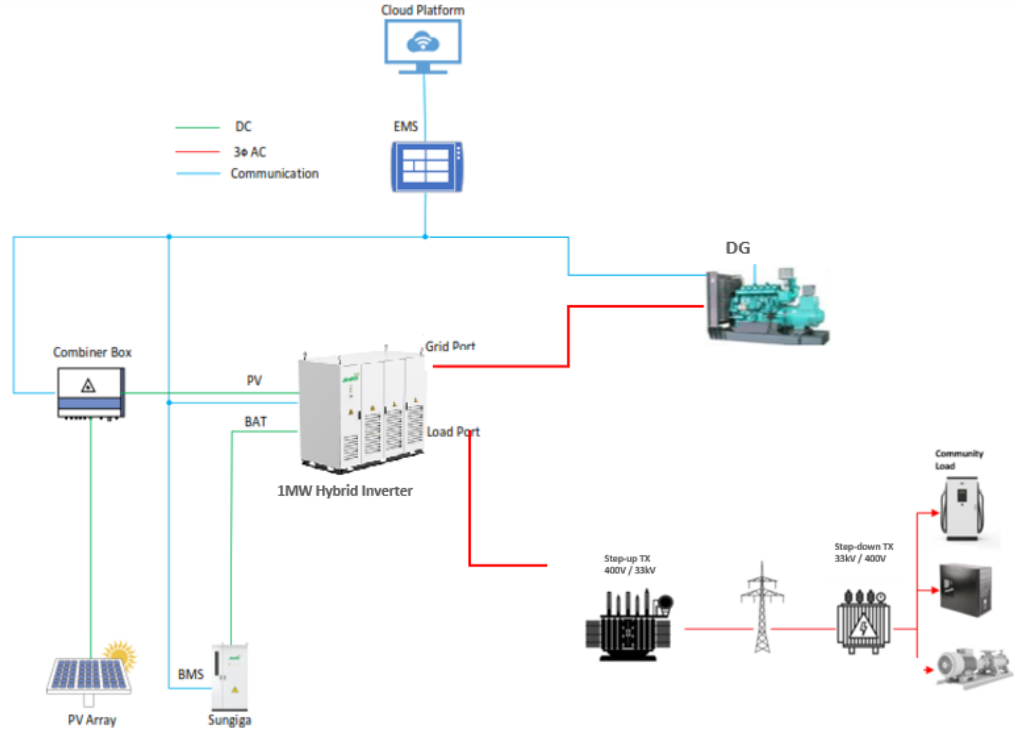

Fig. 1 Single Line Diagram of Micro-grid DC-Coupled System

The Solution

The Micro-grid Solution is a highly reliable system, using the automatic switching technology for off-grid and maximum power tracking technology of PV energy, which can smooth out the power fluctuation between PV and batteries, coordinate and control the power output of PV and energy storage batteries, and output AC power that meets the standard requirements to supply power to important loads on the micro-grid side through energy storage converter technology to ensure long-term stable operation of the system.

The 2.15MWh ESS system is designed in cabinets configuration, integrated with different sub systems to deliver optimal performance and safety. These include battery racks (10 in number), 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, o v e r -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.

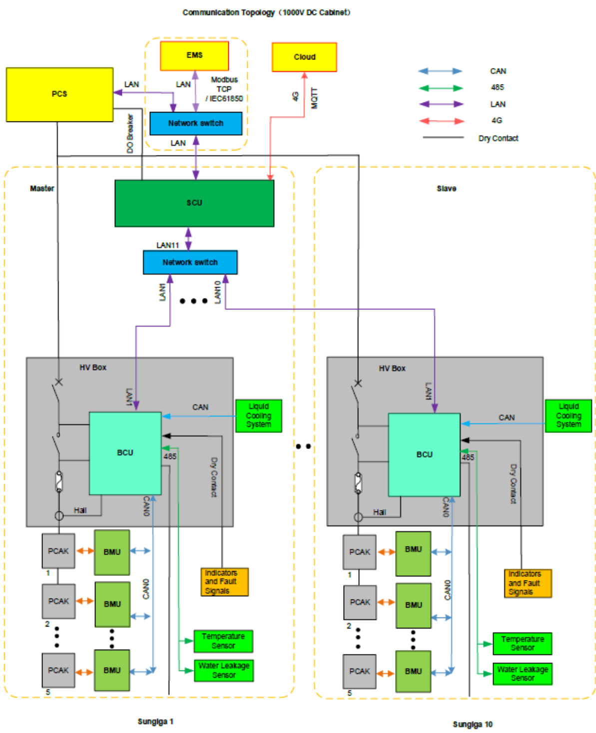

Fig. 2 BMS Communication Topology

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.

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 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

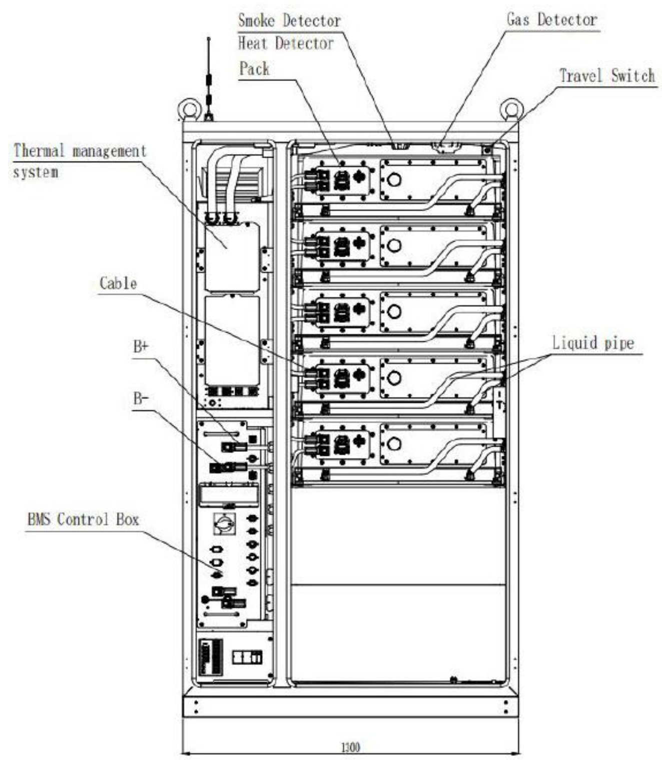

Fig.3 Sungiga Cabinet layout

Power Conversion System (PCS)

The solution adopts a hybrid 1000Kw (2 units of 500kW) PCS with built in isolation transformers for high load adaptability, support simultaneous access to load, battery, and PV. All the components & protection schemes of the PCS are assembled within 20 ft container allowing for plug and play onsite.

The Topology of the PCS can be divided into two parts: DC-AC conversion side and DC-BUS.

The low voltage side of DC-DC is composed of independent modules, each module adopts non isolated bidirectional DC-DC conversion topology, which can be directly connected to PV and energy storage units, and can conduct constant voltage/current control as required, while the DC-AC conversion side adopts two-level three-phase full bridge topology.

When the system is connected to the grid, the AC side of DC-AC converter is connected to the grid for power control. When the system is off grid, the DC-AC converter is controlled at constant voltage and frequency to provide stable AC power for the load. One notable feature of our PCS is its ability to support long-term overload operation at 110% rated power, ensuring sustained performance under demanding conditions.

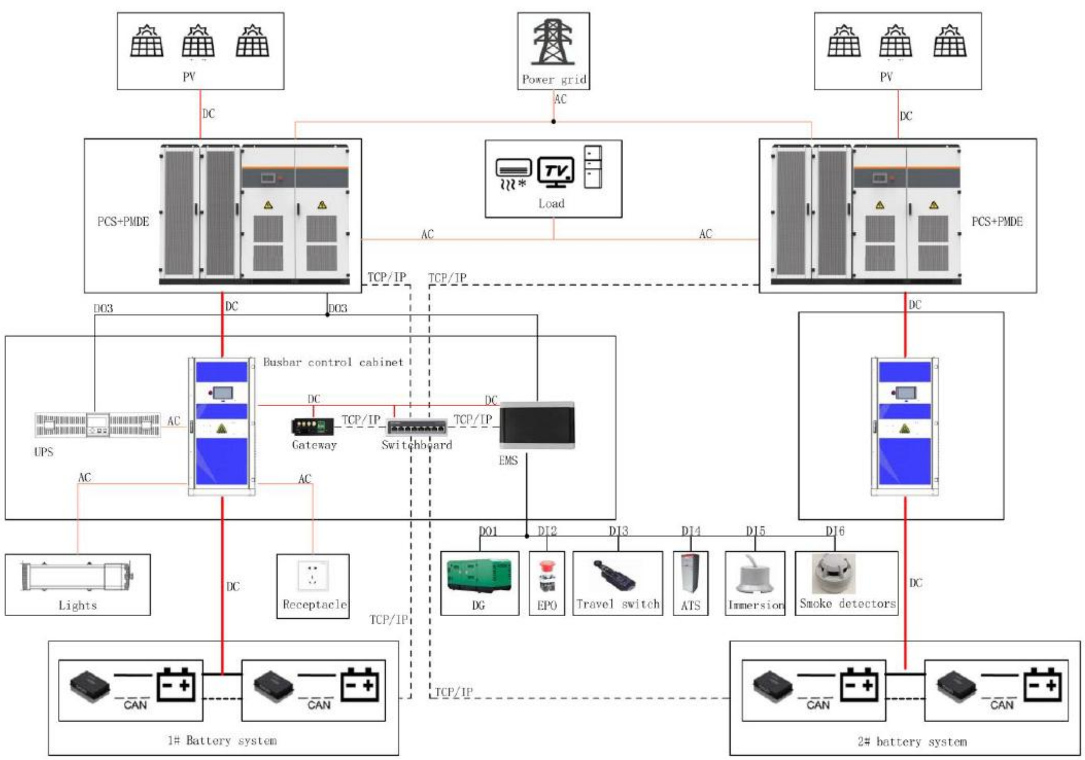

Fig. 4 Hybrid PCS Set Up

Energy Management System (EMS)

The Energy Management System (EMS) in battery energy storage systems 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 various applications and energy ecosystems.

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 battery energy storage systems. With its visual interface, cloud platform integration, massive data storage, and traceable system operation logs, the EMS ensures efficient management, seamless connectivity, and reliable performance in various energy storage applications.

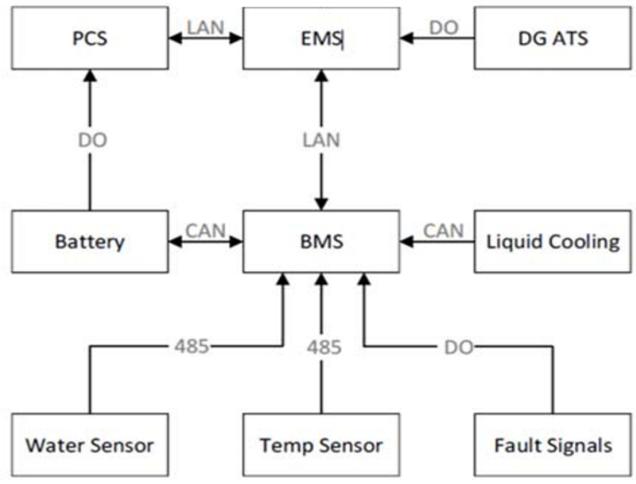

Fig.5: EMS Communication Topology

Operation Logic

1. In the first phase of this project, the grid is always off and cut off from electricity as per the project description. The PCS is under off-grid mode when DG is off. PV and batteries will provide energy to the load under this circumstance. When PCS detects that battery SOC <20%, the PCS will automatically shut off. After the diesel generator switched on and load-shed has been implemented manually, and the real-time detection is the consistent to the grid voltage magnitude, frequency and phase, the PCS will be at on-grid mode.

①PPV≥PLOAD+PBAT

PV will provide energy to user`s loads as first priority, if there is more energy from PV, the energy will be used to chargeup batteries. After the batteries are fully charged, if PPV> PLOAD, the PCS will run at power limited operation.

②PPV＜PLOAD＜PPV+PBAT

PV and batteries provide energy to the load together until the batteries SOC < 20% (set point resettable), PCS will automatically shut off. After the diesel generator switched on and load-shed has been implemented manually, one 500kW PCS will be operating again at on-grid mode. DG and PV will supply the load together

③PPV＜PLOAD＜PPV+PBAT

When the battery SOC > 80% (this set point resettable), PCS will send Dry Contact signals to shut down the diesel generator, PV and batteries provide energy to user`s load all together.

2. In the second phase of this project, the grid is always off and cut off from electricity as per the project description. The PCS is under off-grid mode when DG is off. PV and batteries will provide energy to the load under this circumstance. When MPS detects that battery SOC <20%, then MPS will send Dry Contact signal to start the diesel generator. After the diesel generator started successfully, if the real-time detection is the consistent to the grid voltage magnitude, frequency and phase, the MPS will be at on-grid mode.

①PPV≥PLOAD+PBAT

PV will provide energy to user`s loads as first priority, if there is more energy from PV, the energy will be used to charge up batteries. After the batteries are fully charged, if PPV> PLOAD, the PCS will run at power limited operation.

②PPV＜PLOAD＜PPV+PBAT

PV and batteries provide energy to the load together, whenthe batteries SOC < 20% (set point resettable), PCS will send the starting signal to DG controller so that the diesel generator is started.The load will be supplied from PV and DG.

③PPV＜PLOAD＜PPV+PBAT

When the battery SOC > 80% (this set point resettable), PCS will send Dry Contact signals to shut down the diesel generator, PV and batteries provide energy to user`s load all together.

BESS Operation Mode

Four (4) operation models are designed for the Jinko microgrid battery subsystem which are Charging Mode, Discharging Mode, Standby Mode and Shutdown Mode.

Charging Mode: The charging mode includes constant voltage charging mode, constant current charging mode and constant power charging mode.

Discharging Mode: The discharging mode is constant AC power discharge mode.

Standby Mode: The PCS does not work and accepts the start-up instructions at any time.

Notes: The PCS and the BMS will be also set to the standby model during the whole system in the standby model. to keep the lowest power consumption. The protection and remote dispatching of EMS will be still activated.

Shutdown Mode: Including fault shutdown and no-fault shutdown. When a fault occurs in the hybrid inverter, the inverter power supply immediately disconnects the AC and DC side contactors and shuts down the system to ensure system safety. If the fault is not eliminated, the fault state is maintained; when the fault is eliminated, the start-up command is manually reset.

Monitoring Systems

SCU Monitoring

The solution is equipped with two SCUs each connected to 5 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 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.

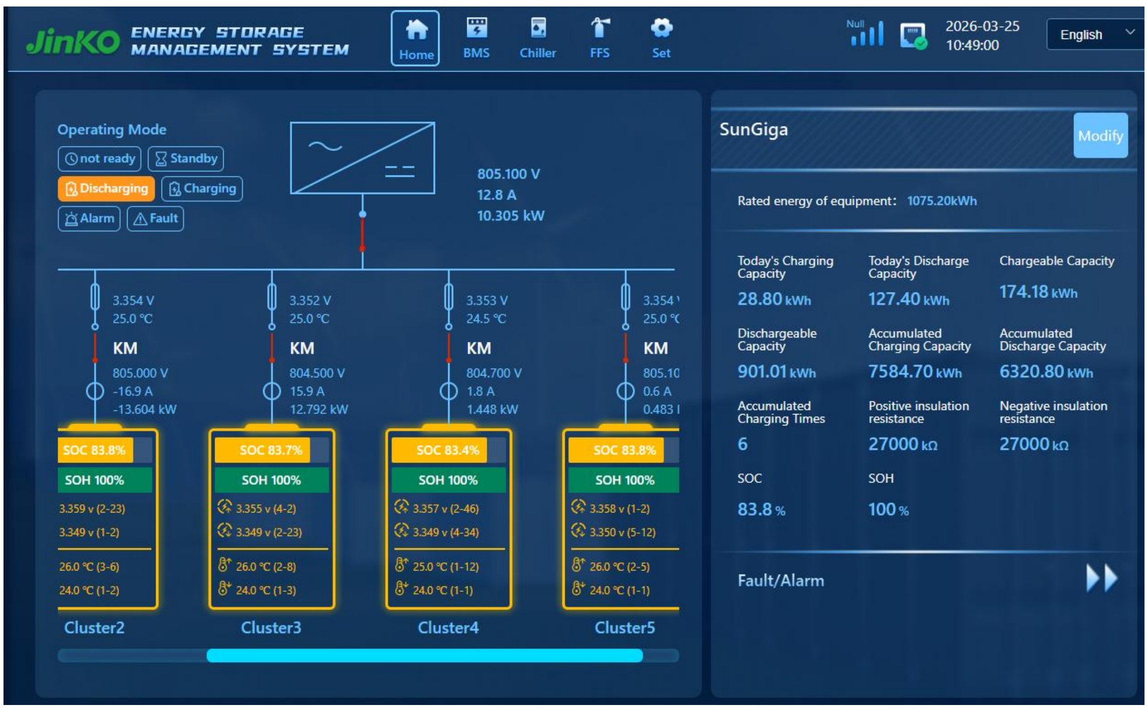

Fig. 6: SCU Cloud Monitoring Display

EMS Monitoring

The Jinko EMS cloud platform is an intelligent management system designed to control and monitor the ESS power systems on the Hybrid PCS by displaying the connected PV generation, Battery charging, grid & load consumption. The BMS, PCS and EMS HMI are connected to the IoT router located inside the local EMS controller integrated cabinet through Modbus TCP/IP. The router is connected to cloud monitoring platform through WAN connection coming from the client internet router.

Fig. 7: Jinkor Cloud Monitoring Platform

Conclusion

This case study shows the benefits in terms of efficiency, cost savings and flexibility, enhancing the project's objectives of resilience and sustainability. This integration supports the benefits of decentralized power plants to bridge the gaps of energy access in this community.

The successful deployment of this project paves way for similar expansions in the future to provide reliable & cheaper energy source for similar key facilities across the country.

* 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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