Case Study

EJiNa Wide Area Microgrid

A wide area microgrid with off-grid operation capability

NR ELECTRIC CO., LTD.

At 5:28 a.m. on June 17th, 2023, EJiNa wide area microgrid commenced off-grid operation with high renewables penetration, after 49 hours of stable operation, it switched over to on-grid mode at 6:36 a.m. on June 19. This milestone stands as a testament to the accomplished long-term off-grid operational testing of China's pioneering wide area microgrid.

Project Overview

EJiNa county is located at the westernmost extremity of Inner Mongolia, with a vast territory of 114,600km2. The EJiNa regional power grid assumes responsibility for the seamless power supply to the EJiNa region as well as its adjacent areas. .The power distribution scope covers around 490km from east to west and 324km from north to south with about 950km total length of transmission lines. The historical peak load is 75MW. As a renewable power base, the installed capacity of wind and solar power reaches 110MW. Consequently, the EJiNa regional grid has the characteristics of no conventional synchronous power source, extremely high penetration of renewables, and inherent power fluctuations of both sources and loads. This regional grid is solely connected to the primary network through a 440km single circuit 220kV overhead line. Once the 220kV overhead line (OHL) trips or under maintenance, it can lead to a complete loss of power, seriously affecting residents' lives and enterprise production.

Fig 1 PCS container

Contemporary Challenges

- Low power security

  Once the 220kV overhead line is out of service, the entire regional grid will experience a power outage. Furthermore, the maintenance duration is considerable, resulting in a significant impact.

- Significant losses in the event of a complete power outage.
- Difficulty in scheduled maintenance

  The 220kV Overhead Transmission Line (OHL) primarily traverses uninhabited regions, including deserts and the Gobi, characterized by rugged natural terrain and challenging meteorological conditions. Sustaining the line poses formidable maintenance challenges due to the elevated fault occurrence rate and prolonged maintenance intervals. The challenges associated with establishing a secondary long-distance overhead line (OHL) connection are substantial. The construction of this second OHL connection entails significant costs and intricate implementation procedures, rendering its realization within a short timeframe unfeasible.

The Proposed Resolution

1. With the aim of fortifying power security, based on "Three-Defense-Line" principle, NR Electric has devised a comprehensive wide area microgrid solution. This encompassing solution comprises a power stability control system, a coordinated control system, an energy management system, and a grid-forming battery storage system (BESS). A state-of-the-art grid-forming Battery Energy Storage System (BESS) station has been successfully erected. This endeavor includes the installation of a novel power stability control system, a sophisticated coordinate control system, and an advanced energy management system, all integrated into a unified control framework. It is noteworthy that the wind and solar parks are pre-existing infrastructures. The implementation of this comprehensive solution has notably augmented power security through the seamless facilitation of on/off-grid operations within the expansive microgrid network.

2. The BESS station comprises a 25MW/25MWh grid-forming BESS system and 4×1.8MW diesel generators, both of them are outdoor installed. The BESS and DG connect to two 10kV busbars of the 110kV Dalaihubu substation.

The BESS system is designed with an overcurrent capacity that is 2.25 times its nominal rating and operates seamlessly in a grid-forming mode for both on-grid and off-grid scenarios, eliminating the necessity for mode switching.

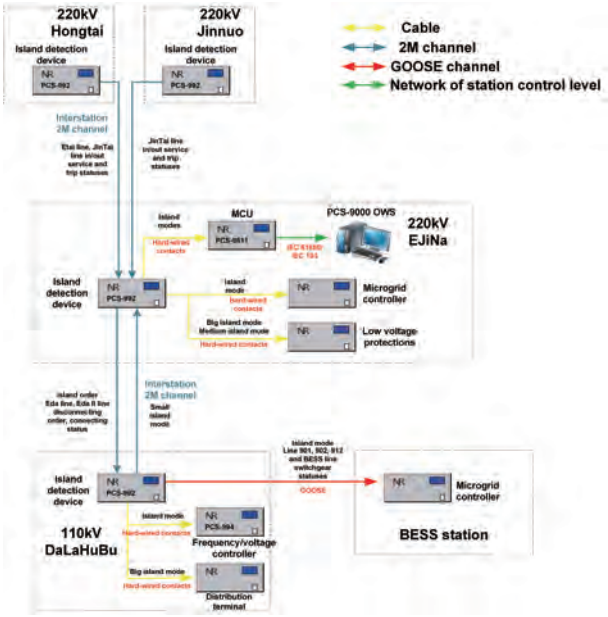


Fig 2 System architecture

NR Electric's grid-forming Battery Energy Storage System (BESS) not only encompasses conventional energy storage functions such as peak valley shifting, renewable power smoothing, black start capability, and power backup, but also attains self-synchronization control through precise manipulation of internal electric potential amplitude and phase angle. This results in the manifestation of distinct voltage source characteristics.

The BESS system has 2.25 times of short-time overload capacity, realizes instantaneous frequency regulation, inertia providing, etc., it effectively improves the system inertia and short circuit capacity, improves the damping characteristics of the power grid, and can provide fast dynamic reactive power compensation, enhance the voltage support for the power grid. Undoubtedly, it serves as a pivotal cornerstone, ensuring the stable operation of vulnerable power grid.

The power stability control system, coordination control system and energy management system collectively serve as the cognitive core of EJiNa microgrid. In addition to the conventional operation & monitoring functions, it has the decision-making ability to ensure stable operation of the power grid under various operating modes, such as planned and unplanned grid switchovers, black start, and self-adaptive protection configuration.

The Assessment of Performance

- Long-term off-grid operation

  On June 17th to June 19th, the EJiNa grid successfully executed an extensive off-grid operational test, involving one 220kV substation, six 110kV substations, and ten 35kV substations, achieving 100% renewable power supply for the entire area load, facilitated exclusively by advanced power electronic equipment.

  At 5:28 am on June 17th, based on precise power flow control of the interconnection line, the grid seamlessly switched over to off grid mode. After 49 hours of safe and stable operation, it reconnected to the main network at 6:36 am on June 19th. During the off-grid operation, the grid run with 100% renewable energy for up to 22 hours. Meanwhile, the grid has withstood severe challenge, such as 10kV line grounding fault, large capacity load impact exceeding 30% of the total load power, and wind turbines cut off, fully verifying the capability of grid-forming BESS to support wide area microgrid with 100% renewable sources and fluctuated loads.

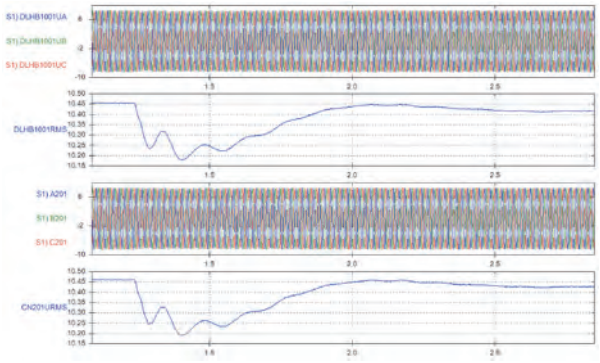


Fig 3 Large capacity load impact

- Wide area black start

  On May 26th, the first wide area black start with 100% renewables was successfully completed in China. This milestone encompassed three distinct voltage levels: 110kV, 35kV, and 10kV.

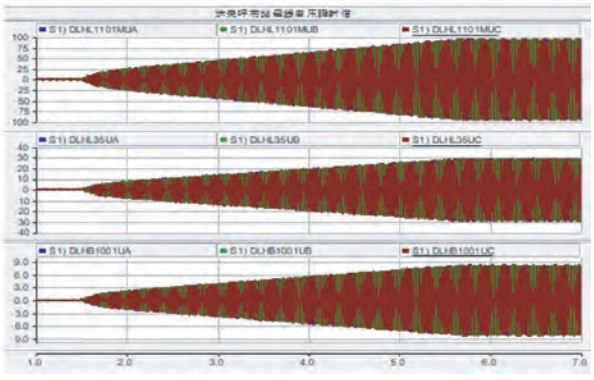


Fig 4 Waveform of black start

- Unplanned seamless on/off grid switching over

  The power stability control system issues off-grid order to the coordination control system in case of island mode detection. In this scenario, the grid-forming Battery Energy Storage System (BESS) functions as a voltage source, ensuring uninterrupted power supply.

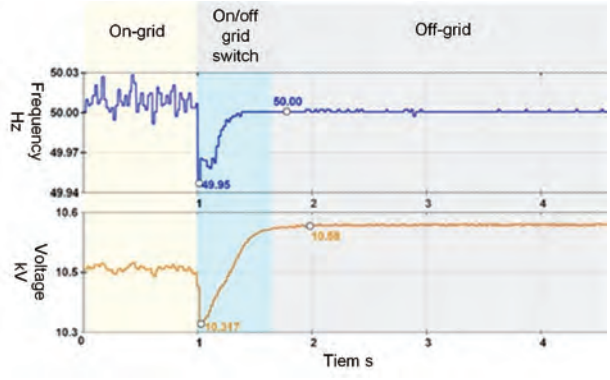


Fig 5 Unplanned on/off grid switching

- On-grid mode

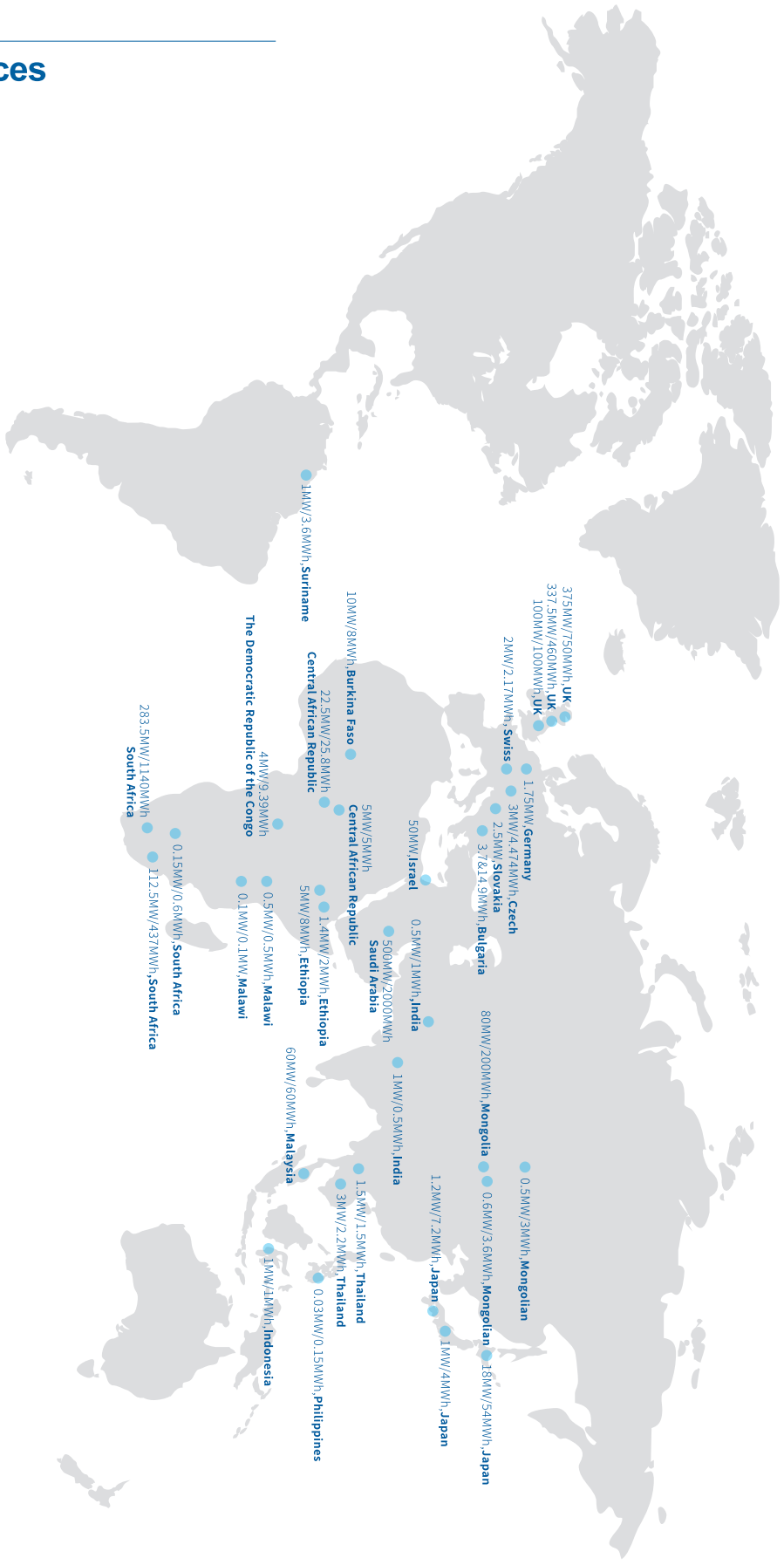
  In an on-grid operational mode, it facilitates enhanced integration of renewable power sources with the grid, resulting in amplified power supply and reduced operational costs through streamlined control coordination and optimized system operation.

Unveiling the Project Value

Firstly, it facilitates the collaborative operation of "wind, solar, diesel, and storage", promotes the integrated development of distributed renewable energy, microgrids, and power networks. This synergy curtails reliance on conventional power networks, effectively addressing the issue of low power reliability in rural areas.

Furthermore, it offers a robust assurance of power supply for both economic and industrial advancements, aligning with the objectives of achieving "dual carbon" targets and fostering economic as well as social progress in border regions.

Global References



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