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Architecture and Analysis of Micro-grid Demonstration Case

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ABSTRACT:

In order to integrate products of subordinate units and extend the use of new energy, a group company has built a micro-grid system composed of wind power, photovoltaic power and energy storage units, which loads at a certain place in Beijing. The system has completed the 240 hours(240h for short) trial operation of micro-grid and achieved good operation data. This paper introduces the architecture of the micro-grid, analyzes the 240h trial operation data, and discovers key points of designing the micro-grid.

Keywords: Wind power generation, Photovoltaic power generation, Energy storage, Load, Micro-grid, Green energy.

1. INTRODUCTION

In the wave of carbon peaking and carbon neutrality, green power has become one of the effective measures to reduce carbon emissions. Among all sorts of green power, wind power and photovoltaic power with characteristics of flexible site selection, convenient layout and low energy cost, are more universal and competitive. Therefore, this paper introduces the architecture of multi-energy micro-grid to provide a sample for green power generation.

After comprehensive consideration of site selection, meteorological resources, product integration and demonstration effect, the final scale of the micro-grid demonstration project is composed of four 5kW horizontal axis wind turbines, a system of 20kW photovoltaic power generation, a unit of 40kW (3h) energy storage and 40kW power load.

2. MICRO-GRID ARCHITECTURE

2.1 GENERAL DISTRIBUTION CABINET

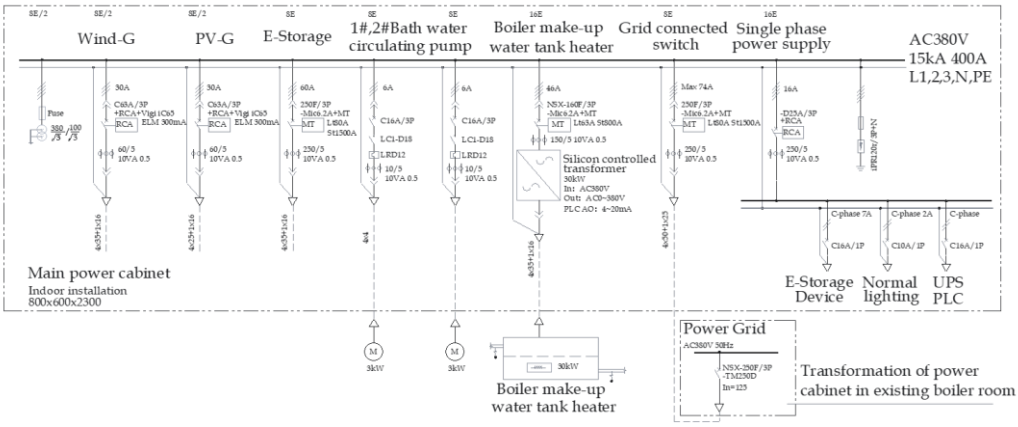

Fig. 1. System diagram of general distribution cabinet of micro-grid system

The general distribution cabinet of the micro-grid is the junction of power generation, load and the power grid. As is shown in Figure 1, branches of the cabinet include wind generator incoming line, photovoltaic power incoming line, 40kW (3h) lithium battery energy storage system incoming line, 10kW basic load feeder, 30kW adjustable load feeder and main switch to the power grid

One grid connection point of the micro-grid parallel line is a molded case circuit breaker of the existing power cabinet in the boiler room, and the other point is in the micro-grid general distribution cabinet. The 250A molded case circuit breaker in the general distribution cabinet is controlled by the PLC system in the central control room to complete the connection to the municipal power grid when there is no power at the micro-grid side.

2.2 WIND GENERATION SYSTEM

As is shown in Figure 2, the rated power of single wind turbine generator is 5kW, the starting wind speed is 2.5m/s, and the rated wind speed is 12m/s. The control unit adopts grid connected controller, which has protection functions including overvoltage, overcurrent, over rotation, and high temperature protection to the motor and power grid fault monitoring.

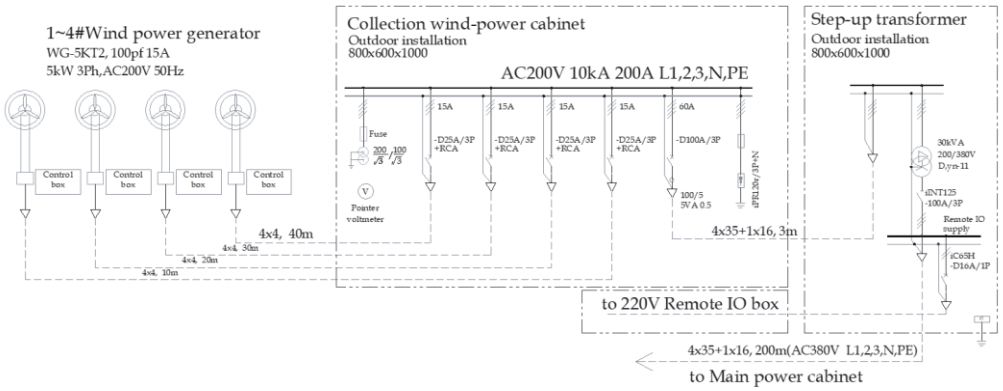

Fig. 2. Wind power generation system diagram

2.3 PHOTOVOLTAIC POWER GENERATION SYSTEM

In figure 3, the maximum power of the photovoltaic power generation system is 20kW. The grid connected photovoltaic inverter control cabinet has functions including detection of isolated island, monitoring of voltage amplitude, power grid quality and power grid frequency, and short circuit protection. The PV inverter can communicate with PLC and can be remotely controlled and monitored. The maximum power of solar cell array at the DC side of the photovoltaic inverter is 22kW. Its rated voltage is 350V, maximum AC current is 32A, rated current of its overcurrent protection device is 35A, the total current waveform distortion rate (at rated power) is less than 3%, the rated frequency is 50Hz±1.5Hz and the maximum efficiency is 94.8%.

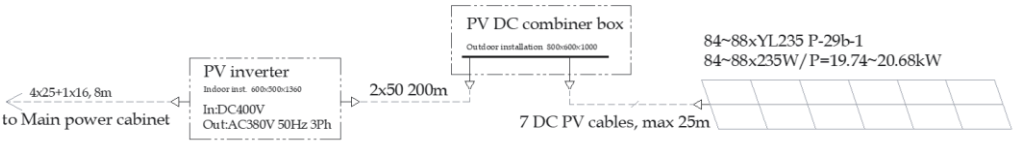

Fig. 3. Photovoltaic power generation system diagram

2.4 ENERGY STORAGE BATTERY SYSTEM

The energy storage battery system in Figure 4 is composed of energy storage battery stack, battery management system (BMS) and power conversion system (PCS).

1) Lithium-ferrous phosphate battery is used for energy storage battery stack. Rated voltage of battery pack is 691V (216x3.2V), and rated energy of battery pack is 124kWh (180Ah×691V).

2) Functions of BMS include monitoring battery system status, calculating the number of cycles of battery pack, fault diagnosis, fault alarm, protection control & alarm, battery equalization, and thermal management.

3) PCS is a device to realize bidirectional conversion and connection of AC and DC electric energy. When the energy storage battery system is combined with local load, wind power and photovoltaic to form micro-grid, PCS can provides stable voltage and frequency for the load in the micro-grid. The rated capacity of PCS is 84kVA to exchange energy with local power grid in the form of charging and discharging. The state switching time is less than 200ms.

2.5 CONTROL AND MEASUREMENT SCHEME

The micro-grid control system is composed of local PLC, remote IO, operator station and large screen display terminal. It communicates with the wind generator controller, photovoltaic inverter, energy storage PCS and BMS module through MODBUS and industrial Ethernet.

3. OPERATION AND ANALYSIS OF MICRO-GRID

3.1 OPERATION STAGE

From March to August in 2012, micro-grid has successively completed four stages: 600h equipment self-inspection, 240h trial operation, 720h unattended and normal operation.

3.2 TRIAL OPERATION CURVE AND ANALYSIS

This article takes 240h trial operation as an example, namely from 12 o'clock on May 25 to 12 o'clock on June 4. The

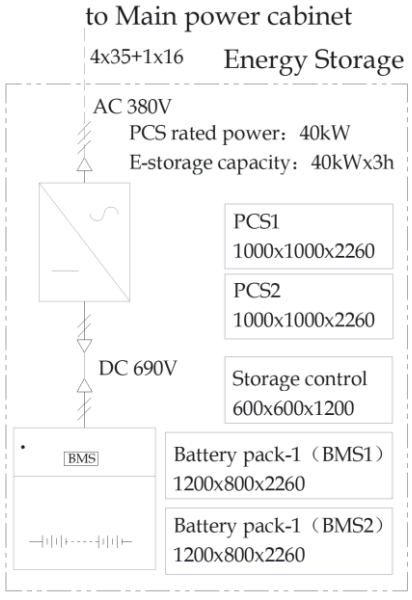

Fig. 3 Energy storage system diagram

monitoring system took samples every 3 minutes. Figure 5 shows the operation curve which is drawn with 165 sampling points extracted at an interval of 1.45 hours

during 240h trial operation.

The 240h trial operation gives the following preliminary conclusions:

1) During the trial operation, the wind speed exceeded 20m/s at the 77th sampling point (May 29), and last no more than 1 hour. The cumulative power generation was less than 3kwh, and the rest was zero.

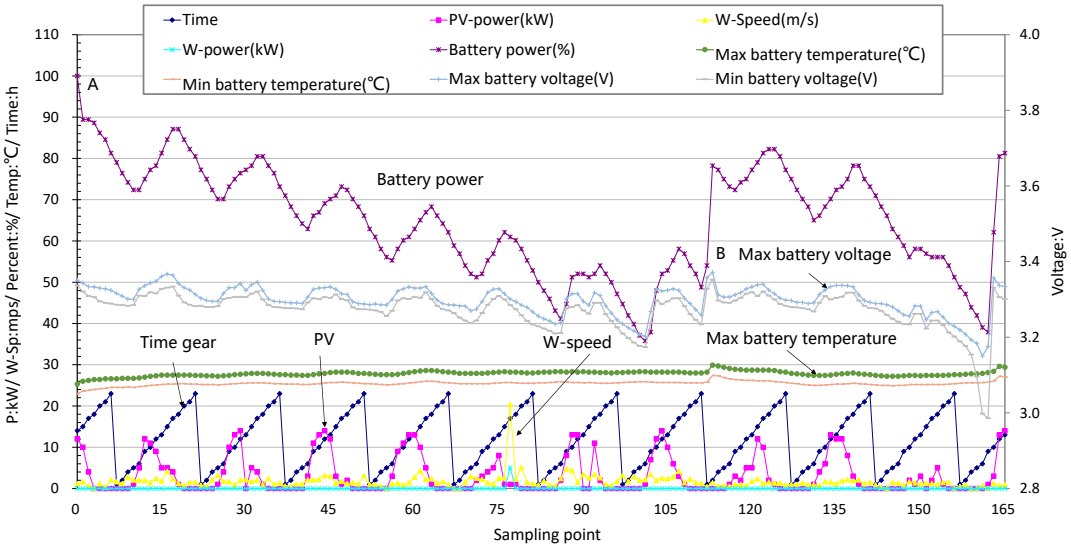

Fig.5 the data curves during 240h test running

2) Photovoltaic power generation worked from 5 a.m. to 18 p.m. every day. The best power generation period was from 6 a.m. to 15 p.m., and the power was between 3 ~ 14kw.

3) The energy storage battery system was connected to the local power grid twice, respectively at the 113th (May 31) and the 164th (June 4) sampling point. All because of the battery power of was no more than 35% and the output power of power generation equipment was no more than 3kW.

4) The temperature of single battery of the energy storage system was controlled between 24 ℃ and 27 ℃, and the maximum and minimum voltage of single battery were also in the charging and discharging state between 3.4 ~ 3.8V.

4. KEY POINTS OF DESIGN OF MICRO-GRID

Based on the data and preliminary conclusions of 240h trial operation, three key points need to be considered in micro-grid design:

1) Analyze the load characteristics of users, and the main indicators are the maximum power load and average daily power generation. The maximum power load of the user is the basis for selecting the rated power of the photovoltaic inverter, while the average daily power generation is the basis for choosing the rated power of the wind generator, photovoltaic panel and the battery pack.

2) Obtain resource data of solar and wind energy. The resource data of solar and wind energy in the project site are important for determining the power of photovoltaic panel, the power of wind generator and equipment layout.

3) Calculate the rated capacity of the battery. The rated power and continuous discharging time of the battery are determined through the matching relationship among the power generation of wind and solar energy, user load and energy storage.

5. CONCLUSIONS

Based on experience of the micro-grid demonstration project, this article introduces the structure of the micro-grid, analyzes the operation data of the micro-grid, and gives key points for designing. From the perspective of green energy, the micro-grid can provide users with considerable green power under the condition of abundant wind and solar resources, which has certain referential significance under dual carbon target currently.

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