The Plan of Green Island to Move towards a Zero-carbon Island

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Introduction:

The power system in Green Island (Taiwan) is independent and small-scale. It is estimated that by 2023, the peak daily load of Green Island will reach 6.2MW. However, due to the poor condition of the generation unit, the current reliable output of the system is 6.2MVA. The power supply is tight. Meanwhile, the off-peak daily load is 1.1MW, and the low-load situation of this system will make the single-unit proportion of the system too high.

In addition, referring to the conclusion of the previous technical report on the system analysis of Green Island units, it is recommended that at least 3 diesel engines are turned on to avoid under-frequency relay triggered by single-unit failures. The units of Green Island Power Plant are also recommended to operate over half of their capacity. This operation mode will reduce carbon deposits and increase operating efficiency.

Currently, Taipower plans to build 2MW of renewable energy by the end of 2023, and its output fluctuation and high penetration rate will affect the system scheduling and operation.

In view of the fact that the reliable output of Green Island diesel units is only 50~70% of the original unit capacity, considering the problems of aged units, insufficient spare parts, aging local maintenance personnel, and difficult maintenance in remote locations, it is necessary to actively plan the construction of new units. In this period of replacement of aged units in Green Island, if the power generation is carried out by the combination of renewable energy and storage system, the shortage of power supply will be alleviated in the short term. In the mid/long term, the number of diesel units in operation will be reduced, and the decommissioning of diesel units will be accelerated. With that, we can come closer to the zero-carbon island vision.

Moving towards a zero-carbon island:

In order to make Green Island move towards low-carbon operation situation, renewable energy must be added in the system. The capacity evaluation of energy-type and power-type energy storage systems should be carried out under the conditions of off-peak days. Furthermore, we should take the grid operation control structure and the transition to zero carbon island situation into account.

1. The capacity evaluation of energy storage

Based on the simulated renewable energy curve and the situation that the system must be fixed with two 1MW generators running at half-load, the laboratory calculates that the energy to be shifted by the system is 5.5MWh, as shown in Figure 1. Considering the renewable energy and cloud cover effect, the energy-based energy storage must have a margin for ramp control to suppress this effect. In addition, considering the condition of charge-discharge loss of the energy storage and the recommended Lithium battery minimum depth of discharge capacity, 2MW/8MWh energy-type energy storage capacity for energy shift and ramp control is recommended.

In addition, based on the experience of building energy storage abroad, the maximum unit capacity in the system is 2MW and the starting time of the diesel engine is 0.5 hours as the estimated capacity standard for power energy storage. The capacity of power-type energy storage is for preventing low-frequency relay triggered (by generator tripping) or even the system

blackout.

Figure 1　2MW solar energy to be shifted

2.Grid Operation Control Architecture Recommendations

The laboratory borrows the structure of the foreign construction plan and the Shulin micro-grid plan to propose a Green Island power grid operation control structure. We plan to use the micro-grid controller with the PMU to measure the state of the power grid system and diesel engine, and to switch the mode of solar photovoltaic and energy storage at high speed. The control structure can overcome the condition that the system's only diesel engine accidentally trips. The system must quickly switch the energy storage mode from Grid-following to Grid-forming to become the stable voltage source of the Green Island power grid, as shown in Figure 2.

Figure 2　Green Island Power Grid Operation Structure

3. Zero carbon island test plan

Because the Luwen feeder is an overhead feeder, there are many line accidents during typhoon days, the user tolerance is relatively high, and the load is small. It is tentatively suggested to test the zero-carbon feeder when it is off-peak in winter. The test grid structure is shown in Figure 3. According to foreign construction experience, the availability rate of energy storage equipment is about 95% under the condition of well maintenance. Therefore, when energy storage is the main power source of the system, the energy storage system should be built in a backup mode, and the energy storage system needs to be the same brand.

In the case of zero-carbon feeders, power-type energy storage provides the grid-forming function and frequency control function to stabilize the system frequency. The energy-type energy storage offers the energy shift and ramp control functions to reduce the instability of renewable energy. A long-term operation test is carried out to understand the high-speed control logic of the microgrid controller, the actual operation function and characteristics of the energy storage, and the actual characteristics of the island system.

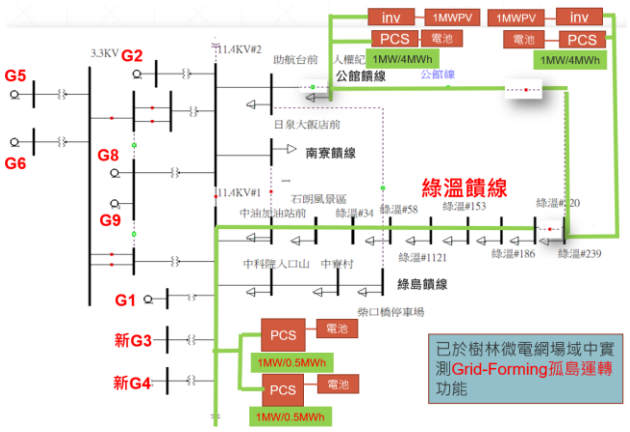

Figure 3　Test grid structure of zero carbon feeder

Conclusion:

In the Green Island power system, several issues are identified including aged units, high carbon

emissions and noise, poor operating efficiency at low load, and high proportion of single unit operation, which is easy to cause unit trips condition and unloading of feeders.

At present, it is the period of replacing the aged units in Green Island power system. The reliable output is too low, and the electricity consumption is increasing year by year, so that Green Island is facing the problem of tight power supply. Therefore, there is a need to study the feasibility of a zero-carbon island to accelerate the unit replacement.

When the renewable energy and energy storage are completed, the departments of construction, operation, and research will conduct a rolling review together through the steps of low-carbon operation scenario analysis and figure out a new way of operation to reduce the number of diesel engines in operation. With the improvement of operation mode, the vision of a zero-carbon island can be realized.

At the initial stage, we can spend more time analyzing the zero-carbon operation mode (via Luwen feeder). With that, we will be able to make a detailed plan if a large amount of renewable energy will be installed in the future.