Enhancement of System Operation by Green Energy Regulation Mechanism

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(I) Introduction

To comply with the energy transition policy of the government, 20 GW solar photovoltaic and 6.5GW wind power system shall be integrated into Taipower's grid. High green energy penetration, e.g. 50% or above in light load seasons, will lead to insufficient system inertia and reactive power, and in turn cause negative impacts to the stability of power supply and voltage quality. To strengthen the operation capability of the power system, management system of green energy control and the analysis of green energy's control mechanism and its integration with the energy management system are of utmost importance. This paper aims to discuss the function of green energy regulation mechanism and the on-site control test of the output of the green energy system. When encountering N-1 contingency, the problems of grid congestion and abnormal substation voltage can be resolved by ancillary services- the management of real and reactive power control.

To integrate the green energy control mechanism into the scope of transmission system dispatching, the following issues are discussed in this paper: 1) the transmission system dispatch mode of the energy management system (EMS) currently used by the Taipower Dispatching Office and the Area Power Supply Offices; 2) according to the regional green energy regulation power generation forecast and green energy auxiliary service function dispatch, evaluate different scenarios of Taipower transmission system under normal operating conditions or contingencies, such as generator tripping and short circuit of transmission lines; 3) analyze the possibility of transmission congestion or abnormal substation voltage; 4) derive control decisions for large-scale solar power plants or wind power plants; 5) through the communication network and the transmission control signal format, control commands are issued from the control center in the power supply area to the gateway of the green energy control power generation system, and the solar photovoltaic intelligent transformation is performed. It also collects power generation information from the test site of the green energy control power generation system, and evaluates the adjustment of the auxiliary service functions of the green energy control power generation system and its effectiveness in solving the problem of the high proportion of green energy in the future Taipower power system.

(II) Research Methods

In order to verify the auxiliary service regulation function of PV smart converter, this paper establishes a green energy monitoring system as shown in Figure 1, and selects a large-scale PV system (100MW Zhangguang case site) for activel and reactive power output regulation tests, and the Kaohsiung CDCC sends control commands to the PV gateway of Changguang Field through the TREMS server located in ADCC in Taichung. The PV gateway then sends the control commands to the PLC controller, which will finally be controlled by the PLC controller. The instructions were sent to the 100 smart converters in the Changguang case to regulate the real and virtual power output of the entire Changguang case, and to discuss the research and analysis of the green energy control mechanism on the control efficiency of the Taipower system.

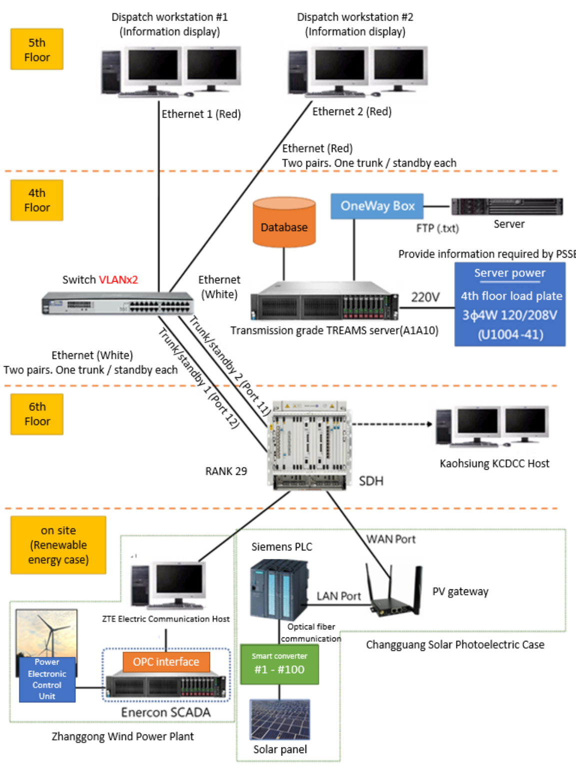

Figure 1 Green energy power generation auxiliary service control demonstration system architecture

A. Power factor control measured results

Figure 2 is the output curve of the measured results of the power factor control. The smart converters of the Changguang site before the control are all operating at a power factor of 1. When the operation reaches 7 seconds, the Kaohsiung CDCC will issue a control command to set the power factor Leading at 0.9. At this time, the real power output is maintained at 36 MW, the reactive power output is increased from 0 Mvar to 21 Mvar, and the control is completed within 5 seconds, and then the reactive power output is maintained at 21 Mvar. The factor setting is restored to 1.0, and the reactive power output is reduced from 21 Mvar to 0 Mvar within 5 seconds.

It can be seen from Figure 2 that the line voltage (blue line) of the Changguang case will decrease with the change of the power factor (yellow line) and the reactive power output (gray line). When the power factor control is 0.9 leading, the Changguang case will absorb 20 Mvar of reactive power from the system, and the line voltage of the Changguang case will reduce from 162.5 kV to 162.15 kV, which can effectively suppress the problem of excessive voltage. It can be seen from the actually measured results that the implementation of power factor control through the smart converter can effectively reduce the PV field voltage and improve the overvoltage problem caused by a large amount of green energy control and grid connection.

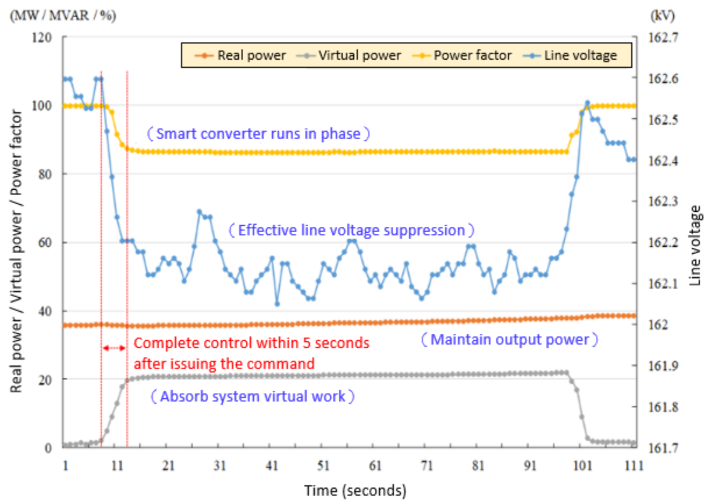

Figure 2 Measured results of power factor control in Changguang case

B. Active power control measurement results

The active power control results of the Changguang case are shown in Figure 3. The active power generation capacity of the Changguang case is about 35.5 MW before the control. When the system has run for 48 seconds, the Kaohsiung CDCC will issue the actual power control command to reduce the active power. When the output is reduced, the active power generation is 10%, and the regulation is completed within 5 seconds, and the active power output becomes about 30 MW. When the load continues to run for 182 seconds after derating, the active power output will be adjusted to slowly increase the load by 5% in stages, and then the load will be increased by 5% after a period of time to gradually increase the active power output. Since the active power output of Changguang's case control is only 5 MW, the impact on the system frequency is relatively insignificant.

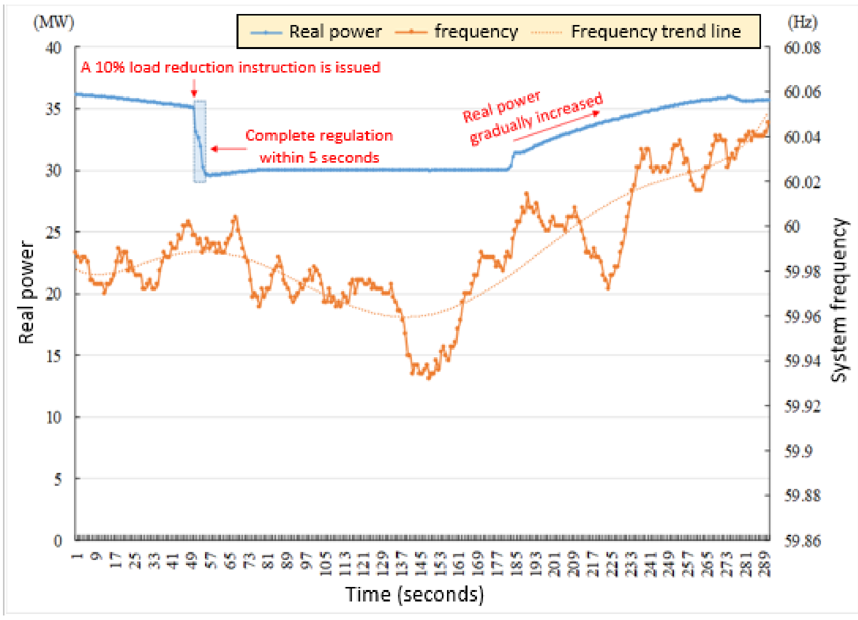

Figure 3 Measured results of actual power control at the Changguang case site

(III) Research results

This study aims to explore the regulation mechanism of the auxiliary services of the green energy power generation system to achieve the automatic power generation and power factor control functions of the virtual synchronous generator, so as to improve the operation and dispatching ability of the Taipower system with a high proportion of green energy in the future. When a line N-1 accident occurs in the system, the problem of line congestion and abnormal voltage is solved through the analysis of the green energy control mechanism. In order to verify the research, analysis and control function of the green energy control mechanism, the Taipower Changguang Solar Photonics case was selected as the test object, and a demonstration system for the research and analysis of the green energy control mechanism was built to simulate the trip of the transmission line in the Taiwan Power transmission system to derive smart conversion The Taichung ADCC sends control commands to the PV gateway to perform active and reactive output control functions, to effectively reduce the system impact caused by a large amount of green energy control and grid connection.

Through the research and analysis of the green energy control mechanism, this study analyzes the sensitivity of PV power generation in each district to the line and voltage of the system in the jurisdiction for the overload circuit and busbar overvoltage problems under the line trip accident, and calculate and control the active power and the amount of reactive power generation that can effectively solve the problem of line congestion and abnormal voltage. In addition, in the scenario of high proportion of green energy in the future, due to insufficient system inertia, it can be used to generate power through PV abandonment and wind abandonment and load reduction in advance to provide system backup capacity to improve system transient stability and avoid low-frequency unloading . This study uses system simulation analysis and field test of green energy power generation system to fully verify the research and analysis of green energy regulation mechanism. The result of this study will substantially improve the operation capacity of Teclast's system with a high proportion of green energy in the future.