International Energy Systems in Transition
- Perspectives from Science and Industry -
The 15th IERE General Meeting & German Forum
Abstract Format

Title: Adverse effects on the power system stability due to inverter power sources increasingly connected to the power system

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Keywords: Power system stability, inverter power source, inertia of synchronous generator, synchronizing power

Abstract
Renewable energy has been increasingly connected to power systems in Europe and the United States, and renewable energy will continue to increase. Renewable energy sources such as wind and PV are connected to power systems via inverters, and we call these sources *inverter power sources*. When the percentage of inverter power sources in the power system increases, the percentage of synchronous generators (SG) used in nuclear, thermal and hydro power plants decreases. When the percentage of SG decreases, the inertia and synchronizing power of SG in the power system also decrease. Consequently, the following three problems occur. These are (1) power system instability, (2) an increased frequency fluctuation, and (3) a decreased short circuit level. These problems can easily occur in power systems not synchronously interconnected to neighboring countries. In this presentation, the inertia and synchronizing power of SG are explained. We explain the reasons why three problems above occur when the inertia and synchronizing power of SG decrease. We introduce the Great Britain power system because this system is not synchronously interconnected to neighboring countries, and the percentage of inverter power sources in this system is expected to increase. In the TSO (National Grid) report on the power system, the inertia constant will be 2 seconds during the off-peak demand in 2034/35. This figure is about 20% compared to 2014/2015. Moreover, the short circuit level in 2033/34 will also decrease by more than 40% compared to 2013/2014. Therefore, power quality problems such as the increasing rate of voltage fluctuation and voltage distortion may occur if measures for maintaining a short circuit level are not properly taken. To solve the three problems above, the following measures are needed. The measure 1 is to increase the number of SGs (synchronous condensers and flywheel generators are also included in SGs) connected to the power system. The measure 2 is to utilize voltage source inverters. There are two measures to utilize these inverters. The measure 2a is to accurately mimic the behavior of SGs. The measure 2b is to control the active and reactive power to suppress the power and voltage disturbances. In the Great Britain power system the inertia constant is needed to maintain inertia more than 4.2 seconds (about half of the present figure) through measures 1 and 2a since it takes 6 seconds to reach the lower limit frequency of 49.2 Hz after a 1,800 MW loss.