Grid Stabilization Solution That Helps Ensure a Stable Supply of Electric Power: Grid Energy Storage System for Italy's ENEL

FUJITA Yoshikazu

Abstract

In sunny southern Italy, energy production from renewable sources such as solar and wind power has been growing rapidly. As these forms of energy can be difficult to deliver consistently, ensuring stabilized operation of electric grids that use these sources is now a big issue. Italy's largest distribution system operator, ENEL Distribuzione sees the energy storage system as one of the most promising solutions for the stabilization of electric grids accompanied by the massive introduction of renewable energy. To help ENEL prepare for full deployment of the energy storage, NEC implemented a demonstration system in the field. The energy storage system for electric grids installed by NEC at an ENEL substation in southern Italy has been highly evaluated in terms of both performance and quality.

Keywords

lithium-ion battery, power storage system, system stabilization

1. Introduction

The European Union (EU) has declared the targets of reducing greenhouse gas emissions by 20% compared to 1990 as well as increasing the ratio of renewable energy in total energy consumption by 20% and improving energy efficiency by 20% by 2020 as the measures against climate change. Italy is no exception in making efforts to promote the introduction of renewable energy based on the EU's targets. Among the country's efforts, solar and wind power generation has been massively popularized in southern Italy due to the region's geographical and environmental factors - such as the amount of sunshine and the type of wind conditions - which make it ideal for renewable energy production (**Fig. 1**).

ENEL Distribuzione (hereinafter referred to as ENEL), Italy's largest power distribution system operator, is investigating the introduction of large scale energy storage system as a means of stabilizing a power system undergoing a massive introduction of renewable energy. In this paper, we will look at one of the most promising solutions of this type, a grid energy storage system installed by NEC in the Calabria region of southern Italy in 2014, which is now being used for stabilization validation tests of ENEL's power distribution systems.

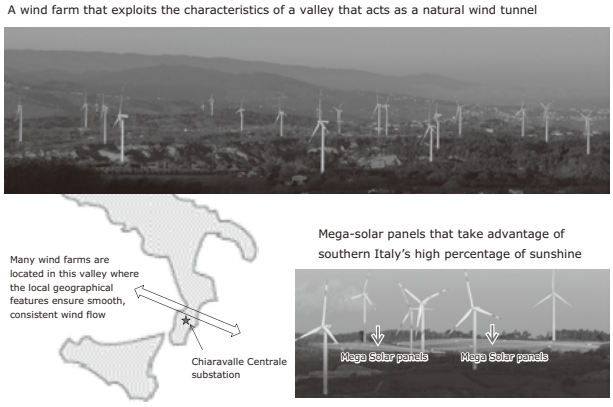

Fig. 1 Renewable energy in southern Italy.

2. Issues of System Stabilization in Southern Italy

Headquartered in Rome, ENEL is Italy's largest elec-

tric power company and operates about 85% of the domestic distribution network. As it moves to increase the amount of power generated using renewables in order to meet the EU's energy targets, ENEL has faced a number of challenges.

The primary problem is that renewable energy sources are highly dependent on the weather. Intermittent wind or cloudy skies can significantly reduce the energy produced from these sources, which makes it difficult to forecast the amount of electricity that will be generated. When a power grid draws a large amount of power from renewable energy sources, it becomes more difficult to adjust supply to meet demand in real time and to keep the power frequency within the specified range.

Recently, we have seen renewable energy being frequently connected to downstream substations. This has caused voltages in many of the major substations to increase and created reverse power flows from medium-voltage cables to high-voltage cables. This can result in unexpected generation of electric currents, producing instability in the power transmission and causing the quality of power to deteriorate.

The Chiaravalle Centrale substation (Calabria, Italy), where NEC installed the grid energy storage system, has a huge number of solar and wind systems connected to its distribution networks. Dues to the high percentage of sunshine, the power generated by renewables in this region often exceeds - more often than the year before - the total demand from the substation's coverage area. This has caused unexpected reverse power flows to the distribution networks, resulting in unstable power transmission and poor power quality.

3. Grid Energy Storage System

To solve the problem of ensuring a stable power grid when large amounts of renewable energy are incorporated in the system, ENEL chose NEC. A grid energy storage system (**Photo**) was installed that uses lithium-ion batteries capable of storing 2-MWh power and validation tests were conducted to see how effective this storage system was at stabilizing the grid.

Photo View of the grid storage system.

NEC's grid energy storage system was installed at the Chiaravalle Centrale substation. To ensure a stable supply of high-quality power, it incorporates the following functions.

(1) Balancing control between supply and demand
As mentioned above, the amount of energy produced by renewables such as solar and wind fluctuates depending on the level of sunshine and wind conditions. This makes it difficult to forecast generated power and prepare a generation plan in advance. To maintain the frequency of an electric power grid, supply and demand need to be coordinated with each other at all times. An energy storage system is used to fill the gap created by the errors in the planned and actual values of a supply-demand balance. ENEL's operation center monitors actual demand and supply and, when an error occurs between the planned and actual values, sends commands to the storage system to charge or discharge as necessary in order to correct the error.

(2) Frequency regulation
As described in (1) above, controlling the supply-demand balance based on commands from the power supply command center is effective in correcting the imbalance for longer time cycles from less than an hour to a few hours. However, the response times of communication networks and systems mean that it is not effective when dealing with shorter time cycles from a few seconds to a few minutes. The energy storage system monitors power system frequency 24/7, compensating for any deviations from the specified range by autonomously charging and discharging according to the degree of deviation.

(3) Voltage regulation
In the same way as it does with the frequency regulation function, the energy storage system always monitors the voltage of the power system. When the voltage deviates from the specified range, it autonomously controls reactive power according to the degree of deviation and compensates the voltage.

(4) Backup power supplies in the event of a blackout
Backup power supplies are supplied to critical facilities such as hospitals, police stations, and factories whenever a blackout occurs. Even if the auxiliary power unit goes down, the energy storage system can continue to supply power to critical facilities while powering itself using its own lithium-ion batteries.

(5) Power quality compensation functions
To maintain the quality of power, the energy storage function has a voltage compensation function

that compensates for any sudden drop in voltage by supplying effective power, as well as a function that suppresses higher harmonic waves mixed in the power system.

In the validation tests for ENEL as described above, we have verified the technological effectiveness of the system's ability to supply power when a momentary voltage drop or even blackout occurs, as well as to stabilize the frequency and voltage within the specified ranges.

4. Conclusion

As a key component of strategies to reduce greenhouse gas emissions, renewable energy is of growing importance not only for Europe but for the whole world. Increasing the effectiveness and reliability of renewable energy, as well as improving the operation capability of power transmission networks connected to significant renewable energy sources, is becoming more and more critical.

ENEL's comprehensive testing of NEC's grid energy storage system resulted in a high evaluation of our technological expertise and project management capability, as well as the high-level performance and quality of our systems.

ENEL is looking forward to the achievement of flexible power networks in which conventional energy and renewable energy coexist by using our ICT and energy storage system. As a world leader in both ICT and electricity storage technologies, NEC will continue to contribute to the construction of new power networks centering around renewable energy.

Authors' Profiles

FUJITA Yoshikazu
Manager
Solution Department
1st Smart Energy Division

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