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«System Technical Performance»
PS2 Energy storage in distribution systems

Experimental Studies of the Energy Storage System
to Provide Multi-Level Integration of Generating Stations and Consumers

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Currently the interest to the energy storage systems (ESS) is significantly increasing due to activating the works on creation the systems of distributing power including renewable energy sources, where energy storage systems play a role of one of the key elements. Now there is the tendency for organization of multilevel approach to energy storage and distribution systems. To increase the technical and economic features of distributed generation and power storage systems there is provided the concept of multilevel integration of generating stations and power costumers.

Multilevel control of controlled load consumers being created for maintaining the flexibility of power system allows to obtain the effects of decreasing the rated capacity of guaranteeing power generation systems and reliability growth of their run.

The method of the use of power storage systems for multilevel integration of generating stations and consumers is based on the account:

- The main structure of electric grid consumption in regards to the power spectrum of active and reactive power influence of consumers and generating stations according to;
- The problems of fuel efficiency at small consumption, augmented operation mode, perturbations of temperature operation modes, mechanical overloads, torque pulsations, overshoot in generator excitation system resulting in power surges, oscillations, dips and breakdowns.
- Provision of specified quality: symmetric components, harmonic elimination, provision of active current component in the specified point of the power system, transient voltage suppression.
- Special mention should go to the consumption category where it is necessary to use a single converter as the most effective but having controlled load dips (due to commutation) during short time or double converter providing continuous power with specified quality.

- Occurrence of wind or photovoltaic power plants or and other sources with specified generating power spectrum. The possibility of connection to AC or DC network stabilized or not both on voltage and frequency.

In the context of the ESS it is necessary to take into account the following:

- Total efficiency of charge/discharge cycle.
- Availability of specific modes – power quality adjustment at specified connection point, UPS operation mode, voltage boost, controlled current/power source.
- External controller control providing specified using criteria - according to tariff, voltage stabilization/frequency stabilization, etc.
- Structure of the energy storage system – the use of supercapacitors for elimination of excessive DC currents and current pulsation.

To perform the necessary examinations and tests there was developed the test table including an independent power source (Gas turbine power station--GTPS) with capacity up to 1.5MW, the set of active and reactive loads and the necessary commutation and measuring instruments, there were developed the methods of system tests.

The tests were performed in the following work modes of the network energy storage system:

- Maintenance of continuous power supply during specified time range, elimination of voltage slumps or voltage loss during seconds to tens of minutes.
- Definition of stability area at parallel work of the network energy storage system inverters. Checking the correct control algorithm operation of the network energy storage system at parallel work; maintenance of continuous power supply during specified time range, elimination of voltage slumps or voltage loss during seconds to tens of minutes;
- Analysis of stability area and research of limitations in using the network energy storage system together with the generator of the same capacity at parallel work for a total load in the local network. Performance of control algorithms for extension the area of stability work in using the network energy storage systems in this mode;
- Research of the energy storage system in the mode of frequency regulation in working with the diesel driven generator for a total load according to control engineer`s commands;
- Research of the network energy storage system in the mode of smoothing load fluctuations at parallel work;
- Definition of dynamic characteristics of the system at load off/on rise in the island operation. Analysis of system stability area at load on/off in the island operation.

The main results of this work:

1. It was developed the test for energy storage systems with capacity up to several MW.
2. It was proposed the multi level control system of power storage and consumers for providing the strong work of decentralized and non-conventional power sources working both independently and as a part of power systems.
3. It was performed the test complex of the network energy storage system during whose test there were constituted the preferences of using the multi level integration of generating stations and consumers