SUMMARY

„Application of computational intelligence methods for optimization of microgrid operation"

The changes taking place in the power engineering stimulated by the development of distributed generation, energy storage and electromobility require the development of new solutions in the power system structure. Combining power generation sources, loads and energy storage devices in separate entities, microgrids, with optimal selection of devices parameters and smart control of energy flow, will increase the safety, efficiency and quality of modern transmission and distribution system.

The subject of the dissertation are issues related to the application of computational intelligence (CI) methods to optimize the operation of the microgrid. The dissertation reviews and evaluates the state of current knowledge in the field of computational intelligence methods. The work includes a general description of algorithms falling under this notion. The division of CI methods according to the type of source of inspiration of the intelligence used is presented. Detailed comparative studies of selected algorithms were performed due to their properties. Simulation calculations were carried out to compare the following algorithms: particle swarm optimization (PSO), genetic algorithm (GA), central force optimization (CFO) and gravitational search algorithm (GSA) in terms of calculation speed and accuracy. Very detailed tests were performed for the PSO algorithm.

It was analyzed how parameters such as inertia, acceleration coefficients, swarm size, number of iterations and the nature of the objective test function influence the method. The conducted research allowed to select the most efficient and predisposed method for the tasks of optimization of microgrid devices parameters and for optimization of control methods in the microgrid. The result of the research was the development of an innovative way of evaluating PSO algorithms, based on tracking changes in the volume and structure of the swarm during subsequent iteration steps. This approach allowed to observe the characteristic features of the algorithm used and the influence of modification of its coefficients on the obtained data processing results.

The dissertation covers the characteristics of the microgrid, the type of systems in terms of the way they work and the description of the basic elements of the microgrid. The types of generation used, various energy storage technologies and standard load profiles

of industrial and public facilities are presented. During the research, numerical algorithms were programmed and used to simulate the storage units operating in the microgrid. In particular, the influence of modelling of charging and discharging characteristics defining technological limitations of storage devices on control possibilities was studied.

The key issue was to develop scenarios for controlling the energy flow in the microgrid, which in combination with CI methods were used to optimize the characteristics and to control according to the selected objective function. A number of new scenarios of energy flow control in the microgrid were studied, including load minimization, load equalization to a given curve, control of the level of cooperation between individual elements of the microgrid. For the selected scenarios, the installed power of the photovoltaic power plant PV and energy storage parameters were optimized. The energy flow control strategy was also optimized by selecting scenario coefficients. The particle swarm optimization PSO was used to directly control the storage unit power in a multidimensional space of solutions.

The study presents power flows calculated using the direct-current and alternating-current methods and using measurement data recorded in real systems. The analyses indicate the benefits of the approach, e.g. by comparing the power flows exchanged between the microgrid and the distribution system in many detailed cases. The results of the research confirm the effectiveness of CI methods to optimize the operation of the microgrid, especially in cases of complex objective functions or data-consuming.

Raczkowska

PhD student signature