Summary

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Title: A study of the use of microgrids as energy islands integrating prosumers, producers and recipients using smart grid infrastructure.

This dissertation presents the issue of the use of a developed tool, optimising generation sources and the grid structure in energy islands, while optimally selecting the operating locations of individual devices, as well as enabling the support of the National Power System in individual operating modes.

The first chapter contains an introduction to the paper, which also defines its initial purpose. The next chapter characterises the power system in Poland, the electricity market and low-voltage microgrids. The technical characteristics of the main devices included in the microgrids were presented, such as: microgrids, electricity storage, controllable loads, converters or protection equipment. The third chapter is devoted to the characteristics of the selected research area, where more than 200 metering devices were implemented at electricity consumers for the purpose of the research. The actual electricity demand patterns, the breakdown of consumers according to tariffs and the seasonality of consumption are presented. The next two chapters were devoted to the formulation of the objective and thesis of the dissertation and the research problem. The issues and tools used for the research were presented in detail. This chapter also discusses the optimisation tasks, together with the mathematical models. Chapter six is devoted to a description of the test microgrid, feeding a rural municipality, used to carry out the optimisation calculations and to present these results. It includes the necessary input data in the form of electricity demand profiles, actual levels of renewable electricity generation and technical data of the equipment connected to the test microgrids. Results from individual optimisation tasks containing year-long calculations of microgrid electricity balancing at 15-minute intervals are also included. From a technical point of view, it was crucial to identify and select suitable renewable energy sources, such as photovoltaic systems and wind turbines, and energy storage systems that ensure the stability of the energy supply, even under varying weather conditions. In addition, the results of the analysis of the distribution network load capacity in the study location, the impact on the power system, were presented. The analysis of

the load capacity of the power lines showed that, despite the variability of RES generation, the maximum load on the lines did not exceed 12% of the allowable value, which confirms a sufficient operational safety margin. In addition, as part of the analyses carried out, the cost-effectiveness of implementing a fully functional energy island was also investigated, in terms of the comparative marginal cost of a kilowatt-hour produced in the microgrid versus purchase from the market.

Technical and economic analyses have shown that microgrids, can be a cost-effective solution for meeting local electricity demand. From a technical perspective, the application of the Microgrid Design and Simulation tool enabled the precise optimisation of the microgrid structure and the modelling of different scenarios of its operation, both in island mode and in connection with the National Electricity System. The optimisation strategies developed, the use of advanced control algorithms and the use of RES and energy storage technologies allow competitive energy costs to be achieved while ensuring a high level of reliability and energy security. Further integration of the microgrid into the NPS and the development of energy storage technologies offer prospects for even greater efficiency and flexibility of this solution in the future.