Wrocław, 19.03.2021

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SUMMARY

„Microgrid energy management systems with hybrid optimizers, embedded deep learning forecasters and e-vehicle charging stations"

The modern electrical power system is characterized by increased complexity and dynamics. This is due to the increased integration of renewable energy sources, controllable loads optimization of the operation of existing assets, e-mobility and decentralization of the power system itself all of which are adopted due to the society's need to switch to a sustainable future .

The above-mentioned approaches to a net zero emissions environment creates additional challenges such as the increased share of renewables in the energy mix which leads to uncertainty in the power outputs making the problem of energy balancing more complex. Optimizing the power system involves deployment of optimization algorithms (conventional and intelligent) modelled specifically for intended power networks. E-mobility while decarbonizing the transportation sector represents a significant load with a stochastic nature. Finally, the aspect of decentralization leads to questions regarding energy security and independence from the power system operators.

This thesis attempts to address a few of these challenges. It explores the use of deep-learning based forecasting algorithms such as the Long Short-Term Memory (LSTM), Convolutional Neural Networks (CNN), CNN-LSTM and other similar architectures in-order to model the stochastic nature of power outputs from renewable energy sources. For the purpose of optimization, hybrid optimizers such as the MIDACO – MATPOWER, GA – MATPOWER, PSO – MATPOWER, PO – MATPOWER and LA - MATPOWER are implemented in this study in-order to leverage both the global solution search capabilities of intelligent optimization algorithms and the speed of MATPOWER. The best performing optimizer is used for energy management in a modern microgrid modelled upon the installation present at Wroclaw University of Science and Technology with the objective of minimizing the Levelized Cost of Energy (LCOE). The installation consists of renewable energy sources such

as solar PV modules, micro-hydro power plant, li-ion battery storage systems and fuel cells with hydrogen storage tanks. Problems concerned with E-mobility are addressed by way of deploying coordinated charging in Electrical Vehicle Charging Stations (EVCS) in order to manage the sudden increase in energy demand and finding the optimal location for such an EVCS within the existing network. Finally, all the above-mentioned methods are applied to networks of different configurations under different scenarios in order to understand, extend and generalize their applicability.

This study uses a combination of both real and modelled data obtained from installations available locally and from collaborating institutions abroad. All the power flows calculated are based on the alternating-current model

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