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Determining the optimum installation of energy storage systems in railway electrical infrastructures by means of swarm and evolutionary optimization algorithms

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Abstract-

The installation of wayside Energy Storage Systems (ESSs) in DC-electrified railway systems is one of the main measures to improve their energy efficiency. They store the excess of regenerated energy produced by the trains during the braking phases and give it back to the system when necessary. Nevertheless, the big cost of the associated installation can make railway operators hesitate about the convenience of the investment. Additionally, the decisions about the configuration of the installation (locations and sizes for the ESSs) are usually based on the previous experience of the railway operators or, at best, in assessments made with simulation tools with low accuracy. This paper proposes a model to optimize the profitability of the investment. Nature-inspired optimization algorithms are applied in combination with a very realistic railway simulator. The flexibility of the nature-inspired optimization algorithms, together with their ability to successfully deal with the computationally-intensive and highly non-linear and non-convex problem posed by the realistic railway simulator, makes them the perfect choice. Three different nature-inspired optimization algorithms have been selected and compared: the Genetic Algorithm (GA) as the main exponent of the evolutionary algorithms, the Particle Swarm Optimization algorithm (PSO) as the main exponent of the swarm algorithms and the Fireworks Algorithm (FA) as another variant of the swarm algorithms. The algorithms have shown an excellent behavior, providing solutions that combine the increase of energy efficiency with a very good profitability of the installation required to obtain that increase.

Index Terms- Nature-inspired optimization algorithms; Optimization of energy storage systems; Railway power systems; Railway simulation; Energy efficiency

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