

Assessment of energy-saving techniques in direct-current-electrified mass transit systems

A.J. López López, R.R. Pecharromán, A. Fernández-Cardador, A.P. Cucala

Abstract— Railway rapid transit systems are key stones for the sustainability of mass transit in developed countries. The overwhelming majority of these railway systems are direct-current (DC) electrified and several energy-saving techniques have been proposed in the literature for these systems. The use of regenerative-braking in trains is generally recognised as the main tool to improve the efficiency of DC-electrified mass transit railway systems but the energy recovered in braking cannot always be handled efficiently, above all in low traffic-density situations. Several emerging technologies as energy storage systems or reversible traction substations have the potential for making it possible to efficiently use train-braking. However, a systematic evaluation of their effect is missing in the literature.

In this paper, a deep, rigorous and comprehensive study on the factors which affect energy issues in a DC-electrified mass transit railway system is carried out. This study clarifies what the actual potential is for energy saving in each situation. Then, a methodology to assess several energy-saving techniques to improve energy efficiency in DC-electrified mass transit systems is presented, constituting the main contribution of this paper. This methodology has been conceived to help operators in assessing the effect of railway-infrastructure emerging technologies in transit systems, so making it possible to shape planning, capacity, etc. It is stepped out in three basic movements. First of all, a traffic-density scan analysis is conducted in order to clarify the effect of the headway on system behaviour. Secondly, several traffic-density scenarios are simulated for a set of infrastructure-expanded cases. Finally, annual energy saving is evaluated by applying a realistic operation timetable. This methodology has been applied to a case study in Madrid Metro (Spain) to illustrate the steps of its application and the effect of several energy-saving techniques on this specific system. Results confirm that regenerative braking generally leads to an important increase of system energy efficiency - especially at high traffic-density scenarios. It has also been proved that infrastructure improvements can also contribute to energy savings and their contributions are more significant at low traffic densities. Annual energy results have been obtained, which may lead to investment decisions by carrying out an appropriate economic assessment based on cost analysis.

The main results of the study presented here are likely to apply to other electric traction systems, at least qualitatively.

Index Terms— Railway power systems, Energy management, Railway simulation

Due to copyright restriction we cannot distribute this content on the web. However, clicking on the next link, authors will be able to distribute to you the full version of the paper:

[Request full paper to the authors](#)

If your institution has an electronic subscription to Transportation Research Part C - Emerging Technologies, you can download the paper from the journal website:

[Access to the Journal website](#)

Citation:

López López, A.J.; Pecharromán, R.R.; Fernández-Cardador, A.; Cucala, A.P.; "Assessment of energy-saving techniques in direct-current-electrified mass transit systems", Transportation Research Part C - Emerging Technologies, vol.38, no., pp.85-100. January, 2014.