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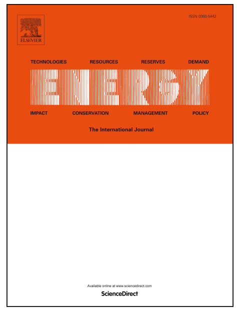

Joint train scheduling optimization with service quality and energy efficiency in urban rail transit networks

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Joint Train Scheduling Optimization with Service Quality and Energy Efficiency in Urban Rail Transit Networks

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Abstract

Focusing on service quality improvement and energy consumption reduction in an urban rail transit network, this paper proposes a multi-objective programming model to jointly optimize timetables through considering total passenger trip time and operational energy consumption. The time-variant quantities are adopted to represent the dynamic passenger demands, with which passenger boarding, alighting and transferring process are taken into consideration for calculating total travel time and variation of in-service train mass. To effectively measure the total energy consumption, three parts of energy consumption are specified, including traction energy consumption, auxiliary energy consumption and usage of regenerative energy. In particular, the regenerative energy is allowable to simultaneously reuse by traction trains on the same line or in supply regions of different lines nearby the same transfer station. A compromise for service quality and energy consumption from the viewpoint of system optimization is especially proposed through adjusting headways in different lines. To effectively solve the proposed model, a tabu search algorithm is designed to obtain near-optimal timetables of the whole transit network. With the practical data of Line 5, Line 10 and Yizhuang Line in Beijing rail transit network, the effectiveness of this model and solution method is demonstrated by a series of numerical experiments.

Keywords: Train scheduling; Energy efficiency; Time-variant passenger demands; Regenerative energy

1 Introduction

The urban rail transit (URT), as a major role in the functioning of economics and society activities in the city, provides transportation services for reducing traffic congestion and carbon emission. In comparison to other traffic modes, the URT typically has advantages of safety, punctuality, efficiency and environmental friendship. However, the operation of URT systems practically consumes a large amount of electric energy each year, which also takes a rapid growth trend because of increasing operational mileage in some large cities. For instance, in Beijing subway system, the total energy consumption is 1430 million kW·h in 2014 with 527 km operational mileage, which occupies about forty percent of the total operating cost. Up to 2020, with the planned mileage up to 1036 km, which is almost the double of the current system, the total energy consumption, relevant operating cost and carbon emission will inevitably increase in a drastic tendency. Therefore, it is necessary for subway operation company to design effective strategies for decreasing operating cost and carbon emission by reducing the total energy consumption. Practically, in comparison to the auxiliary systems (like air-condition, ventilation, etc.), operational energy use of the

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