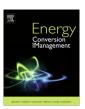


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Review

An assessment of available measures to reduce traction energy use in railway networks



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ABSTRACT

Rail is becoming an increasingly popular choice to satisfy transportation demands locally, nationally and internationally, due to its inherent efficiency and high capacity. Despite this, operators are facing pressure to reduce rail energy consumption to meet efficiency targets, whilst still maintaining service quality and managing increased demand. A number of individual measures have been proposed to reduce energy in the rail sector, often showing good results on specific case studies. It is generally agreed that the attainable savings of a given measure change dependant on the route, vehicle and service characteristics. However, there is little information in the literature specifically regarding which measures are most suitable for given network types, or how they interact. This paper therefore aims to begin evaluating the available measures in terms of their suitability for different systems. Firstly, networks are defined in terms of their distinguishing features. As traction accounts for the majority of all energy use in the rail sector, the traction flow through a vehicle is considered as the starting point for an evaluation of measures. Current technologies and procedures are reviewed and categorised based on which area of traction use they target. Thought is given to the factors that affect implementation and the networks where they are applied. A key output of this paper is a comparison of the achievable energy savings of different measures dependent on the network type. It is hoped that this will provide a good starting point for identifying which measures are most applicable for a given network, and the characteristics that affect their success.

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Nomenclature AC **Alternating Current** HS High Speed Rail ATO **Automatic Train Operation** HS1 High Speed One **Automatic Train Protection HVAC** Heating, Ventilation, Air Conditioning ATP BY7 Beijing Yizhuang Line IC Inter City **CBTC** Communications Based Train Control LED Light Emitting Diode C-DAS Connected Driver Advisory System Linear Programming ΙP **PMSM** Permanent Magnet Synchronous Motor DAS **Driver Advisory Systems** DC Direct Current RBE Recovered Braking Energy DTC **Direct Torque Control** RTCR Reversible Thyristor Controlled Rectifier **ECML** East Coast Main Line T2K Ticket to Kyoto FTCS European Train Control System TMS Traffic Management System **EDLC Electrochemical Double Layer Capacitors** UIC International Union of Railways **ERTMS** European Rail Traffic Management System VVVF Variable Voltage, Variable Frequency WESS Wayside Energy Storage System FSS **Energy Storage Systems FBS** Fixed Block Signalling GA Genetic Algorithm GSM-R Global System for Mobile Communications-Railway

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1. Introduction

Rail transport is arguably one of the most efficient methods for mass transportation of passengers. This makes it a popular choice for satisfying increasing transport demands in an environmentally concerned economy [1]. However, despite the inherent efficiency, European Union reports show there is still significant energy usage by the rail industry [2]. The increased demand placed on rail services by a growing population will no doubt further increase consumption [3]. As such, environmental objectives have been set by international organisations aiming to improve energy efficiency and reduce carbon emissions, whilst also acknowledging growth predictions. Targets in Great Britain to improve efficiency by 50%, and reduce carbon emissions by 25% are already in place [4,5], with similar targets identified for countries across the world.

In order to meet the specified energy efficiency targets railway networks have to be improved. A wide variety of measures can be applied to save energy and improve network efficiency. Specific applications may involve changes to the infrastructure, operations or rolling stock on a particular network or line, or in more than one of these areas. Through the development of accurate models and simulators, researchers are better able to predict the energy savings from implementation of measures [6]. However, many researched methods are very limited, being only applicable to small line sections or certain types of railway under exact conditions. Network Operators therefore face a difficult decision when choosing combinations of methods to implement. Current research often simplifies the network complexity and focusses on single

methods without considering the interactions between them. It is also important that whilst improving energy efficiency the railway is able to provide a punctual, timely, affordable service with greater capacity for the future [3].

As traction energy use accounts for the majority of the total energy consumption in rail, between 60% and 80% [7–9], it is a key area for energy reduction and the focus of this review. Successful implementation of an energy saving measure can depend upon the route, vehicle and service characteristics of where it is implemented. Therefore, identifying the features which differentiate networks is a key step in recognising which characteristics impact on the success of measures. The traction energy flow through systems is then evaluated, highlighting the key areas for energy reduction. A comprehensive overview of available measures is conducted, in terms of the savings achieved for each network type. Finally, conclusions are presented which aim to give guidance on the most suitable methods for a given system.

2. Defining rail systems

Throughout the course of this review, numerous terms have been found to describe similar networks. For example metro, mass transit, light rail, suburban, rapid transit, etc. Although differences do exist between these types, they are subtle in comparison to the characteristic differences between routes such as metro and intercity, or metro and high speed. The following section defines a way to categorise lines into one of three types: Urban, High Speed

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