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EcoTrain: the Erzgebirgsbahn's new hybrid railway vehicle

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Abstract

Climate change is one of the greatest challenges of the 21st century. To counteract increasing temperatures and to decrease the dependency on fossil fuels various projects are currently conducted aiming at the private and all the different industrial sectors. One of them is the EcoTrain project which is an undertaking of a consortium of several project partners lead by Deutsche Bahn. Working closely with DB RegioNetz Verkehrs GmbH, the Erzgebirgsbahn, the TU Dresden, the Fraunhofer IVI as well as the TU Chemnitz, these partners explore and work on new approaches to finding solutions for an energy-efficient mass transit vehicle. The EcoTrain project aims at developing a hybrid railcar for the Erzgebirgsbahn: A standard class 642 rail vehicle is going to be converted to a cutting-edge and innovative hybrid railcar. Later on, this prototype will serve as basis for converting the entire Erzgebirgsbahn railcar fleet. This paper deals with the development of a drive train concept for the EcoTrain. Three different approaches to hybridization are explained in conjunction with their respective advantages and disadvantages. The hybridization concepts are assessed and the drive train concept of the EcoTrain is introduced. Furthermore the simulation tool IVIision which was used to dimension the drive train components is explained along with the achieved simulation results. The paper concludes with an introduction to the so-called energy management module which is developed by Fraunhofer IVI. This module predicts the vehicle's movement along the track and calculates recommendations for energy flow and driving style based on the schedule and current position.

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1. Motivation

Climate change currently presents itself as one of the greatest challenges of the 21st century. In their 2014 synthesis report, the Intergovernmental Panel on Climate Change (IPCC) observes that “Human influence on the climate system is clear, and recent anthropogenic emissions of greenhouse gases are the highest in history. Recent climate changes have had widespread impacts on human and natural systems.” Intending to make a considerable contribution to limiting global warming, the German Federal Government adopted the “Aktionsprogramm Klimaschutz 2020” (Action Program for Climate Protection 2020) in 2014. The aim of this program is to reduce the amount of greenhouse gases emitted in the period from 1990 to 2020 by at least 40 percent. In order to achieve this goal, a large number of measures have been introduced spanning diverse sectors such as energy management, industry, transportation, and even agriculture and forestry. In the transportation sector, urban public transport takes a leading role in the pursuit of these goals. A multitude of past and current projects have analyzed the suitability of hybrid and full-electric propulsion concepts and their challenges in terms of operational procedures and infrastructure. The AutoTram[®] Extra Grand and EDDA-Bus projects, which were both conducted at the Fraunhofer IVI, are only two examples of many. Such vehicles enable partial or entire abstention from conventional combustion-engine energy generation. In conjunction with renewable energies, significant emission reductions can be achieved. This becomes apparent with regard to exhaust gas emissions as well as noise emissions.

Nomenclature

ENG	combustion engine
GEN	generator
AUX	auxiliaries
AC	alternating current
DC	direct current
EXT PWR	external power
EA	energy accumulator
DLC	double layer capacitor
BAT	battery
TM	traction motor
FD	final drive
HE	high-energy
HP	high-power
W	wheels

2. Project partners and objectives

The EcoTrain project is an undertaking of a consortium of several project partners lead by Deutsche Bahn. Working closely with DB RegioNetz Verkehrs GmbH, the Erzgebirgsbahn, the TU Dresden, the Fraunhofer IVI as well as the TU Chemnitz, these partners explore and work on new approaches to finding solutions for an energy-efficient mass transit vehicle. The Erzgebirgsbahn was founded in 2008. Its daily rail transport services cover the Erzgebirge (Ore Mountains). The following routes for passenger traffic operate on a regular basis:

- Chemnitz – Aue
- Zwickau – Johanngeorgenstadt
- Flöha – Olbernhau
- Flöha – Annaberg-Buchholz – Cranzahl

The railway network has a total length of 217 km and comprises 68 train stations and stops. The routes feature the challenging profile of a branch line with the characteristics of a low mountain range. On these winding routes the trains vanquish up to 450 m in altitude and longitudinal inclinations of up to 4 ‰. The typical speed ranges from 60 to

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