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Emissions and Total Cost of Ownership Assessment of Hybrid Propulsion Concepts for Bus Transport with Compressed Natural Gases or Diesel Engine

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Abstract : Air pollution is one of the emerging problems in our society. Targets of reduction of CO_2 emissions address low-carbon and resource-efficient transport. (Plug-in) hybrid electric propulsion concepts offer the possibility to reduce total cost of ownership (TCO) and emissions for public transport vehicles (e.g., bus application). In this context, typically, diesel engines are used to form the hybrid propulsion system of the vehicle. Though the technological development of diesel engines experience major advantages, some challenges such as the high amount of particle emissions remain relevant. Gaseous fuels (i.e., compressed natural gases (CNGs) or liquefied petroleum gases (LPGs) represent an attractive alternative to diesel because of their composition. In the framework of the research project 'Optimised Real-world Cost-Competitive Modular Hybrid Architecture' (ORCA), which was funded by the EU, two different hybrid-electric propulsion concepts have been investigated: one using a diesel engine as internal combustion engine and one using CNG as fuel. The aim of the current study is to analyze specific benefits for the aforementioned hybrid propulsion systems for predefined driving scenarios with regard to emissions and total cost of ownership in bus application. Engine models based on experimental data for diesel and CNG were developed. For the purpose of designing optimal energy management strategies for each propulsion system, maps-driven or quasi-static models for specific engine types are used in the simulation framework. An analogous modelling approach has been chosen to represent emissions. This paper compares the two concepts regarding their CO_2 and NOx emissions. This comparison is performed for relevant bus missions (urban, suburban, with and without zero-emission zone) and with different energy management strategies. In addition to the emissions, also the downsizing potential of the combustion engine has been analysed to minimize the powertrain TCO (pTCO) for plug-in hybrid electric buses. The results of the performed analyses show that the hybrid vehicle concept using the CNG engine shows advantages both with respect to emissions as well as to pTCO. The pTCO is 10% lower, CO_2 emissions are 13% lower, and the NOx emissions are more than 50% lower than with the diesel combustion engine. These results are consistent across all usage profiles under investigation.

Keywords : bus transport, emissions, hybrid propulsion, pTCO, CNG
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