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Technical and environmental effects of biodiesel use in local public transport

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ABSTRACT

Biodiesel use in local public transport could be especially significant in improving air quality in cities. The purpose of the experiments described in this paper was to evaluate the various (10, 20 and 50%) blends of biodiesel with diesel in the context of the engine and pollution aspects. As regards the experimental use of these findings on municipal buses, these experiments were the first reference in Hungary. The ages (15–20 years) and types of buses (Ikarus-280, Ikarus-260) used in the experiments are still common vehicles in Hungarian public transport. During our measurements, there was a significant difference between the change in fuel consumption of articulated and solo buses in traffic when compared to test bench measurements. The proportion of the engine performance reduction is nearly the same as that for biodiesel share in the blends. Most pollutants were decreasing (both at idle and full rpm), but this reduction is not directly proportional to the increase of the blending percentage. However, as for CO_2, emission increase was observed in the case of idle rpm in comparison to normal diesel operation, even though this phenomenon was not due to biodiesel use, but the catalytic converter and the fact that biodiesel was used for the first time in the engine concerned.

1. Introduction

Traffic in the EU-28 is one of the most significant sector with around €562 billion in Gross Value Added a year at basic prices (4.9% of total), with 11 million employees (5.1% of total), with 6465 billion passenger km (on average around 12,700 km per person) and with 1173 million ton CO_2-equivalent (24.3% of total) in 2013 (EU, 2015). The largest potential in CO_2 emissions can be achieved with switching to alternate fuels (Borjesson et al., 2014) and (in the future) decarbonization of electricity (Pathak and Shukla, 2016). Growing concerns of fossil fuel depletion, oil-price fluctuations, escalating energy demands and stringent emission regulations are driving the scientific community to find alternative renewable biofuels for use in diesel engines (Datta and Mandal, 2016; Rajesh Kumar and Saravanan, 2016). Today, biodiesel has been touted as the most promising substitution for petroleum-derived diesel (Foo, 2015; Shahir et al., 2015).

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The private car stock in a country has major impacts for the local and global environment. Economic imparities among regions, population migration, policy influences and their interactions to the number of private cars have been investigated by Han and Hayashi (2008). Their results indicate that the total number of private cars, but also the volume of related pollutant emissions will shoot up to considerably higher levels in the near future if recent behavioral trends and the present technical aspects of private car use persist. Theoretically the existence of good public transport can deter car ownership. Paper of Cullinane and Cullinane (2003) asserts, however, that once a car has been acquired, there is a tendency for it to be used irrespective of how good the public transport is.

The starting and destination stations of transport are nearly always located in the same inhabited areas. Furthermore, traffic within settlements accounts for a significant part of total travel but the increasing mobility needs pose a serious problem both from the aspect of pollution and traffic safety. The specific per capita pollutant emission of public transport is much lower than that of car transport. The specific (per passenger km) emission of even the most modern car is still higher than the specific pollutant emission of an obsolete bus. This is especially true if the fuel itself is environmental friendly. For this reason, biodiesel is especially recommended for use in cities and their catchment areas.

Following a significant amount of preparatory work, a biodiesel experiment was carried out with the cooperation of the Centre for Agricultural Sciences of the University of Debrecen and Hajdú Volán and the coordination of the Mayor's Office of Debrecen, within the framework of the CIVITAS program whose aim is to develop environmental friendly urban transport. Although there were already periods when biofuel plants sold biodiesel to transport companies authorised to blend biodiesel into fuel, these examinations were the first Hungarian reference of experimental use of biodiesel in municipal buses.

The experiments described in this paper envisaged the trial of different blends of biodiesel with diesel. In addition to the standard quality biodiesel blend (containing 4.4% biodiesel), 10, 20 and 50% blends were tested in traffic and on test bench. This study presents the engine and pollution-related results of these examinations, as well as the correlations between them. The buses of the same type and average age as those used in the experiment (15–20-year-old Ikarus-280 and Ikarus-260 buses) are still in use in Hungarian public transport (Szász, 2014).

2. Literature review

2.1. Significance of bus traffic

Shifting trips from automobiles to public transport can help mitigate environmental and social problems, by reducing energy consumption and CO_2 emissions, curbing traffic congestion and fatalities, and providing mobility to disadvantaged groups without access to cars (Buehler and Pucher, 2011). Altogether, passenger traffic in the EU increased by 17% between the years of 1995 and 2013. However, the significance of bus traffic significantly decreased after 2000. In 2012, the share of buses in all traffic was only 9.1% in the EU. In Hungary, this transport mode is much more widespread, its share – in terms of passenger km – is the highest (21.5%) among the member states in the EU (2015). In terms of population size, it is also Hungary which has one of the highest rate of passenger km per capita in the EU (1650 passenger km per capita, (KTI, 2014)). According to the estimation of the Institute for Transport Sciences (Hungary), 55% of all passenger traffic in Hungary takes place inside settlements, while the share of local transport within the number of trips can even reach 80% (Hungarian Transport Administration, 2013). Since many trips are local, the analysis by the Department for Transport (UK) shows that 44% of all CO_2 emission from cars comes from journeys of between 5 and 25 miles (Marsden and Rye, 2010). Although the pollutant emission of buses per passenger kilometre is higher than those for trains and trams, their energy consumption is nearly identical and much better than individual transport and airplanes (Fig. 1).

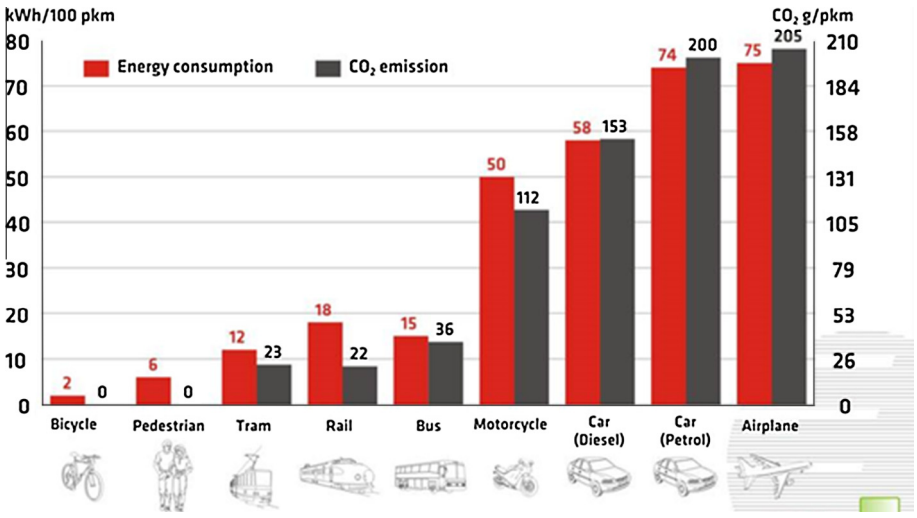

Fig. 1. The average consumption of the transport modes and their CO_2 emission. Source: (KTI, 2014).