



Evaluation of energy consumption of vehicles in EU Trans-European Transport Network



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ABSTRACT

The paper presents the results of field tests evaluating energy consumption in the vehicles of Trans-European Transport Network (TEN-T) of selected EU countries: Poland, Germany and France. The energy consumption of vehicles in a highway system was assessed based on the telemetry analysis systems for traction parameters, tachograph record of digital speed waveform and their statistical analysis. The empirical cumulative distribution functions of speed transitions (acceleration, deceleration) were used to determine the kinetic energy losses of the vehicle (fuel consumption). To assess the statistical significance of differences between cumulative distribution functions the Smirnov–Kolmogorov test was used.

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1. Introduction

The dynamic development of demand for transport services in Europe poses serious problems for the efficient handling of growing traffic loads. We are dealing with increasing congestion of the existing roads, insufficient technical condition of many parts of the existing infrastructure, the so-called “bottlenecks”, a small number of high-performance multi-modal international connections, lack of interoperability of the European railway network, inefficient seaports and airports. These are the factors that force the relevant institutions of the European Community and the authorities of the Member States to take measures to significantly reduce barriers existing in the Trans-European Transport Network (TEN-T). The first agreement, i.e. the European Agreement on Main International Traffic Arteries was made in Geneva, 15 November 1975. This agreement established the basic scheme of European roads, forming a more or less uniform system, it set the technical standards that must be met by these roads, it also pointed out at the need to make some priority modernization investments in order to adapt the existing roads to European standards. In addition, loan guarantees were provided for the investments from the European Investment Fund (or other financial institutions of the EU).

Transport services of goods considerably depend on two major factors: energy consumption and the incurred costs (García-Álvarez et al., 2013; Vanek and Sun, 2008) as well as time requirements, i.e. speed and timely delivery (Stead, 2001).

According to the EU guidelines the optimal use of transport and infrastructure can be achieved through innovative traffic management and information systems (Jarašūniene, 2007). In road transport of goods using of ITS can substantially reduce energy consumption (Gattuso and Pellicanò, 2014).

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2. Characteristics of the Trans-European Transport Network

The Trans-European Transport Network was established by the Treaty of Maastricht in 1992. The TEN-T is to contribute to the improvement of transport infrastructure, facilitate access to the infrastructure, improve interoperability between the national networks and promote better connections both between the transport modes and national networks. Particular emphasis is placed on the need to link island, landlocked and peripheral regions with the EU central regions.

The EU plans of new countries' accession created a need to develop the concept of development in transportation infrastructure that would extend beyond the boundaries of the then existing Community. Thus, at the transport conferences that took place in Crete in 1994 and in Helsinki in 1997, the Representatives of the EU and the European Conference of Ministers of Transport decided on the location of 10 transport corridors, named pan-European, passing through the countries of East-Central Europe and connected to the network of EU Member States. The corridors initially included 20,000 km of railway lines, 18,000 km of roads, 38 airports, 13 seaports and 49 inland ports.

In 2004 the European Commission set up a High Level Group on the “extension of major European routes towards neighboring countries and regions”. The Group focused on identifying the priority transport axes ([European Commission, 2005](#)):

- Northern axis, linking Norway, Belarus and Russia to the EU,
- Central axis linking Ukraine and the Black Sea region to the EU,
- South-eastern axis, linking the Balkans, Turkey, the Caucasus countries, the Red Sea, the Caspian Sea, and in the future also the Gulf countries to the EU,
- South-western axis, linking the EU to Morocco and, in the future, to the North-African countries,
- A system of the sea highways, passing through the Black Sea and the Mediterranean Sea.

These axes were to have a total cover up to 27 countries. The group was also responsible for developing a list of priority investment projects, the routes of which would run through the states and regions neighboring the EU ([Neider, 2008](#)).

By decision of the European Commission of 26 October, 2006 the Trans-European Transport Network Executive Agency came into existence in Brussels ([European Commission, 2007](#)). The Agency was established for the period from 1 November 2006 to 31 December 2008, and its operation period was extended to 31 December 2015 ([European Commission, 2008](#)). In order to create a coherent system of transport networks, also other actions were taken in Europe under the auspices of the United Nations Economic Commission for Europe, so they included not only the members of the Community. In the agreements made, the technical and operational parameters were specified for the different transport networks essential for the European transport system.

After the enlargement of the EU on 01.01.2007, TEN-T have included 78,000 km of railway lines, 75,200 km of roads, 330 airports, 270 international seaports and 210 inland ports. Sections of four pan-European corridors run through the Polish territory ([Jaszczuk, 2008](#)):

- Corridor I: Helsinki – Tallinn – Riga – Kaunas – Warsaw,
- Corridor II: Berlin – Warsaw – Minsk – Moscow – Nizhny Novgorod,
- Corridor III: Berlin/Dresden – Wrocław – Katowice – Krakow – Lviv – Kyiv,
- Corridor VI: Nordic countries – Gdynia/Gdansk – Lodz/Warsaw – Katowice – Žilina – Ostrava/Bratislava (with the extension to Austria and Italy).

The creation of efficient transport infrastructure networks was one of the twelve key actions identified by the [European Commission \(2011\)](#). In order to accelerate investments in the field of Trans-European networks in the transport, telecommunication and energy sectors and to increase funding opportunities, the “Connecting Europe Facility – CEF” instrument was established ([European Parliament, 2013](#)).

3. The subject matter and purpose

The basic element of the road infrastructure TEN-T is a highway system with national and local express roads. It is necessary to ensure safety and environment protection in transport development ([European Commission, 1992](#)). In addition, a number of other aspects of the transport is regulated by the EU law, in terms of the competition found between carriers, the profession's opportunities or the working conditions and technical standards for vehicles ([Council of the European Union, 1996](#)).

There is, therefore, a need for a comprehensive study of transport, especially in terms of energy consumption of a vehicle (kinetic losses), fuel consumption and related CO₂ emissions ([Bauer et al., 2010](#); [Demir et al., 2011](#); [Zamboni et al., 2015](#); [Krautzberger and Wetzels, 2012](#)). The previous studies of energy consumption in transport infrastructure vehicles (including highway system) were performed using analog tachograph recordings ([Burski and Wasilewski, 2012](#); [Wasilewski et al., 2014](#)). Currently, vehicle performance tests require the use of digital recording ([Burski et al., 2014](#)). Digital recording, due to a very large system memory (up to 40 thousand measurements) and accuracy (up to 1 s) allows to obtain accurate results.

According to the guidelines of the EU, the most efficient use of transport and infrastructure can be achieved mainly through the introduction of new technologies for traffic management and information. In the case of transport of goods

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