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THE PARADOX OF EFFICIENCY IN TERMS OF ENERGY NEEDS OF ROAD TRANSPORT IN THE EUROPEAN UNION

PARADOKS EFEKTYWNOŚCI W ZAKRESIE POTRZEB ENERGETYCZNYCH TRANSPORTU DROGOWEGO W UNII EUROPEJSKIEJ

Streszczenie

Posiadając dane ilościowe i jakościowe, podjęto próbę zbadania zależności i związków zachodzących między rozwojem transportu a efektywnością wykorzystania zasobów paliwowych, co stanowiło zasadniczy cel artykułu. Przeprowadzona analiza pozwoliła stwierdzić, że transport drogowy zyskał obecnie szczególny status w życiu codziennym społeczeństwa. Wzrost mobilności mieszkańców Europy spowodował, że samochody osobowe są aktualnie w największym stopniu odpowiedzialne za potrzeby energetyczne transportu drogowego. Stało się tak mimo poprawy efektywności energetycznej tych samochodów oraz wzrostu przewozów towarowych. Prognozowany wzrost przewozów towarowych spowoduje dalsze zmiany w strukturze zużycia energii przez transport samochodowy. Poprawa efektywności energetycznej transportu osobowego i ciężarowego nie zrównoważy wzrostu zapotrzebowania na energię w transporcie drogowym. Przedstawione powyżej prawidłowości wyznaczają kluczowe wyzwanie stojące przed systemem transportowym – sprostanie ciągle rosnącemu zapotrzebowaniu na energię.

Słowa kluczowe: transport, transport drogowy, mobilność, efektywność energetyczna, zużycie energii w transporcie

JEL classification: O11, Q56, R41

Introduction

A major challenge which faces the Community is to ensure the mobility of sustainable development, without reducing its effectiveness. Research on the development of fuel needs that has been conducted for many years, confirms that 93% of the energy consumed in the transport sector, the EU still comes from

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petroleum, and transportation is the largest user, consuming 55% of the total supply. The desire to transform the European transport system in a competitive and sustainable system requires among others reducing Europe's dependence on imported oil, improvement the environment and reduction greenhouse gas emissions. Meanwhile the growing importance of road transport in the implementation of the modal observed since the 90s of the twentieth century is not in line with the sustainable development strategy.

Medium-term strategy for greening fuels for transport

The aim of sustainable growth, which has been recognized as one of the three priorities of the EU Strategy 2020, is to support the transition to a resource-efficient, low-carbon economy[1]. Sustainable growth is both a major challenge and opportunity for all Member States and regions of the EU. Resource efficient and more competitive economy can contribute to employment growth and development of market opportunities, in particular through the development of renewable energy sources, energy efficiency and efficient use of resources. Success in achieving the objectives of the EU 2020 strategy will largely depend on the strategy for the various sectoral policies, including transport policy. In the transport sector, moved with a road map for the 2050 White Paper target of reducing by 2050 implies a reduction of greenhouse gas emissions in the EU by 60% compared to the base year. In the medium term, the implementation of this order is carried out, among others, as a result of implementation of the climate and energy package[2].

Climate and energy package identified courses of action for decarbonisation of the economy in sectors that generate the most CO_2 emissions, e.g. energy, transport and industry. Transport is the only sector of the economy in which greenhouse gas emissions have increased continuously over the last twenty years and in 2014 grew up by one third compared to 1990[3]. Technological progress has contributed to a more efficient use of energy, but not enough to offset the effects of rising transport volumes. Introduction of increasingly stringent emissions standards of vehicles (class "Euro") and to improve the quality of fuels resulted in a significant reduction in emissions and particulate matter from transport. The level of air pollution however still exceeds the legal limit in some urban areas and other sensitive areas. Therefore further efforts are needed to improve air quality and reduce greenhouse gas emissions.

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[1] *Europe 2020. A strategy for smart, sustainable and inclusive growth*, COM(2010) 2020, Brussels 2010, p. 4.

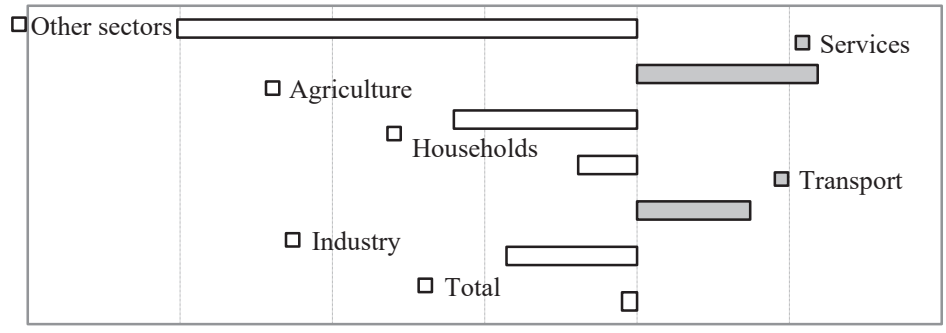
[2] *White Paper. Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system*, COM (2011) 144 final, Brussels 2011, p. 3.

[3] *Energy, transport and environment indicators*, Statistical Pocketbook, European Union 2015, pp. 150–155.

The economy is based on the assumptions that sustainable development should seek to minimize the consumption of non-renewable resources and energy to replace non-renewable fuels by renewable energy sources. Control of energy consumption, increased use of energy from renewable sources, including energy savings and increased energy efficiency are important elements in the process of building a more sustainable future for the transport sector[4]. In pursuit of this purpose you can use several methods. In particular, increasing technological improvements, incentives for the use of public transport and its development, the use of energy efficient technologies and renewable energy sources in transport are some of the most effective tools by which the Community can reduce its dependence on imported oil in the transport sector, in which the problem of security of energy supply is the most acute, and influences the fuel market in this sector.

Identification of transport energy needs

Transport is one of the most important sectors of the economy, whose operation causes an increase in energy demand (Graph 1). In 2014, total energy consumption of the transport sector (excluding international shipping) was about 353 Mtoe[5], up almost 15% more compared to the energy consumption in this sector in 1995. In the analyzed period, high growth in energy demand was also noted for the growing service sector. A downward trend was experienced in other sectors of the economy.



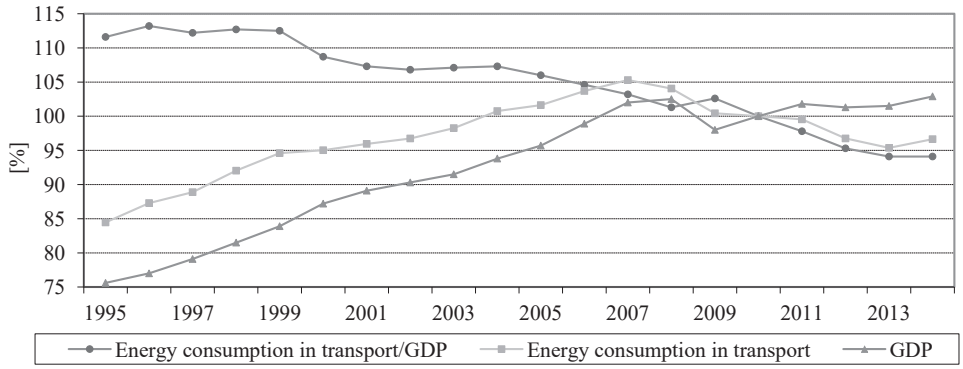
Graph 1. Changes in total energy consumption in the EU-28 in the years 1995–2014

Source: Own elaboration based on EUROSTAT, http://ec.europa.eu/eurostat/tgm/table [access: 12.01.2017].

[4] T. Litman, *Well Measured: Developing Indicators for Sustainable and Livable Transportation Planning 5*, pdf, http://www.vtpi.org [access: 07.01.2017].

[5] Tonne of oil equivalent (toe) – this is the energy equivalent of one metric ton of crude oil with a calorific value equal to 10,000 kcal/kg. Mtoe = 1,000,000 toe.

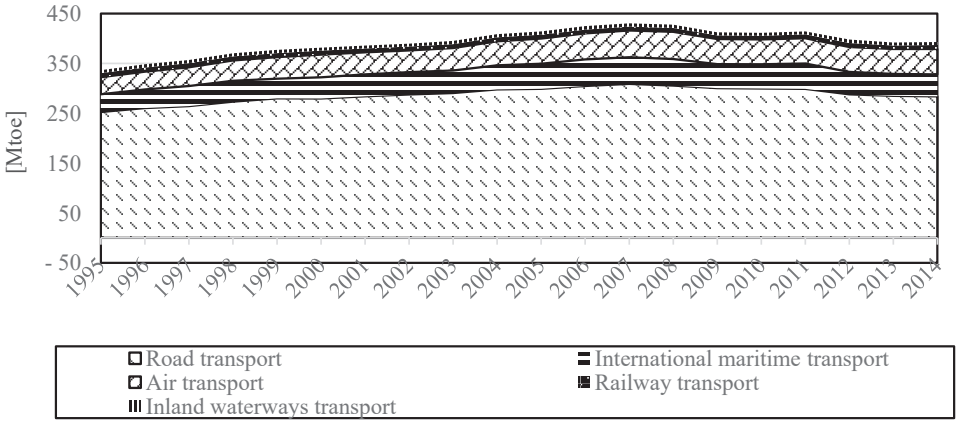
The changes that have been made on the energy needs of the various sectors of the economy were reflected in the total energy consumption. The share of transport in total energy consumption in the EU-28 increased from 28% in 1995 to 33% in 2014. It is expected that a growing share of transport in total energy consumption in the EU will continue in the next decades. In the years 1995–2014 the improvement of energy efficiency in transport was insufficient in relation to the growth in demand for transport services. Analysis of energy consumption in the transport sector in relation to GDP growth shows little evidence of the relative separation of the relationship between energy demand in the transport and economic growth. As shown in Graph 2, in 2000–2007, consumption of energy in transport in the EU-28 increased by an average of 1,4% per year, while the GDP growth rate was higher and amounted to 2.1% per year. This trend was interrupted in 2008, when the financial crisis contributed to the collapse of the European economy. As a result, there was a decline in GDP growth and reduce energy consumption in transport. However since 2010 there is a noticeable return to the old trend.



Graph 2. Energy consumption in the transport excluding shipping and pipelines in the EU-28 in the years 1995–2014 (2010 = 100)

Source: Own elaboration based on EUROSTAT, http://ec.europa.eu/eurostat/tgm/table [access: 12.01.2017].

In summary, we can conclude that during the considered period energy efficiency in the transport sector improved slightly. The gains were not entirely used to reduce overall fuel consumption and have proven to be insufficient to offset the development of transport systems (Graph 3).



Graph 3. Total consumption of energy in transport in the EU-28 in the years 1995–2014 (Mtoe)

Source: Own elaboration based on EU transport in figures, Statistical Pocketbook, Publications Office of the European Union 2015, p. 89.

Data presented in Graph 3 show that the development of road transport was associated with a gradual increase in demand for energy. Compared to 1995, energy consumption in this mode has increased by over 12.5% and accounted for 72.3% of total energy consumption in the transport of the EU in 2014. The greatest growth in energy consumption during this period showed air transport and maritime transport. In 2014, energy consumption in these sectors was respectively 50% and 24% higher than 1995. Also their share of total energy consumption in transport has increased, which amounted to 11.2% (sea) and 13.0% (air transport) in 2014. Rail transport has decreased its share from 2.4% in 1995 to 2.0% in 2011. According to forecasts, the downward trend will continue in the coming years as a result of the decreasing share of rail in freight and increase in railway electrification. 1.5% of total energy consumption was the inland waterway in the transport sector in February 2014. This share is to be rather stable character in the future, which confirms the low utilization of this type of transport in the implementation of transport services.

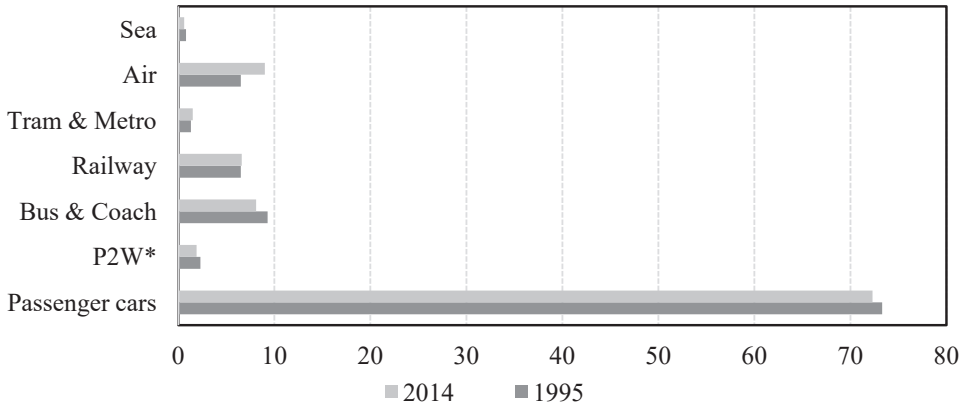
Road transport, as the largest consumer of energy in transport was the least sensitive to the effects of the economic recession. In 2007–2010, the total energy demand in the transport industry decreased by 3.1%. In contrast, the largest decrease in energy consumption during this period was recorded in the inland country (10.2%), followed by international maritime transport (9.1%) and aviation (7.3%). Energy reduction in railway transport was 5.4% in 2007–2010. In summary, between 2007 and 2010 the total consumption of energy in transport has decreased by 4.4%.

Road transport as the dominant form of mobility

Changes in the product mix and the spacer demand for transport, reducing the size of the batch load and increase the quality requirements in the transport resulted in a clear predominance of road transport to use transportation needs in the EU. A similar situation arose in the passenger transport market[6]. The improving living standards, accompanied with increase in the mobility of mankind, the development of tourism and the rapid development of the automotive industry caused major changes in the structure of the branch passenger, also the decrease in the share of rail and road transport growth in the use of transport needs. It should be noted that the driving force of development of road transport is individual, not collective transport (Graph 4).

Among the inhabitants of the EU there is a tendency to use their own means of transport more often than public transport. The complex mechanisms governing the transport of individual transformations are the result of several processes taking place in parallel:

– increase in the number of cars per capita with income per capita;
– rapid increase in the average course of an average car, coming after an increase in wealth, until they reach saturation;
– increase in used cars' weight, correlated with the average disposable income of households;
– increase in the share of passenger cars with diesel drive.



Graph 4. Modal split of passenger transport in UE-28 (pkm as %)

** P2W: Powered two-wheelers*
Source: Own elaboration based on EU transport in figures, op. cit., p. 46.

[6] U. Motowidlak, *Transport policy and sustainable development*, [in:] *Implementation aspects of the implementation of sustainable development*, ed. D. Kiełczewski, Publisher of the Higher School of Economics in Bialystok, Bialystok 2011, pp. 346–348.

As shown in Table 1 the level of motorization also varies significantly between Member States; while historically levels of car ownership in the newer Member States were significantly lower than in the older Member States, this gap has declined due to rapid growth in car ownership in a number of the new Member States.

Table 1. Development of individual motorization in the EU 28 in the years 1995–2013

Specification		1995	2000	2005	2010	2013
Number of passenger cars per thousand inhabitants	EU-28	380	417	448	477	491
	EU-15	435	465	489	505	506
	EU-13	190	242	296	368	436
Stock of registered vehicles (thousand)	EU-28	182,462	201,993	221,608	240,427	247,997
	EU-15	167,455	181,781	190,996	202,471	205,036
	EU-13	15,007	20,212	30,612	37,956	42,961
Bilion pkm	EU-28	3,893	4,321	4,564	4,717	4,672
	EU-15	3,549	3,889	4,043	4,180	3,990
	EU-13	344	432	521	652	682

Source: Own elaboration based on EU transport in figures, op. cit., p. 86.

The level of mobility varies significantly between EU countries due to differences in car ownership levels, income, country size and density, ranging from 4211 passenger kilometers (pkm) per capita in Romania to over 16000 pkm per capita in Luxembourg in 2013 year[7]. In general mobility has increased most significantly in the newest Member States as well as Greece and Ireland.

Due to the expected increase in the average number of cars, their weight and the average number of kilometers traveled (Table 2) we can expect a further increase in energy consumption in the transport sector.

Table 2. Trends in individual transport

Specification	2010	2020	2030	2040	2050
Number of passenger cars per thousand inhabitants	477	522	532	540	545
Pkm per capita	3.6	5.9	7.3	8.2	9.0
Average mileage, thou. km/year	8.0	11.3	13.6	15.3	16.5
Number of passenger cars, million	17.3	20.0	20.1	19.6	19.0
Mileage total (billion pkm)	138	227	275	300	314

Source: Elaboration based on 2050.pl journey to a low carbon future, ed. M. Bukowski, Warszawa 2013, http://np2050.pl/pl/raport/r6-2050-pl-podroz-do-niskoemisyjnej-przyszlosci.

[7] B. Lapillonne, K. Pollier, *Energy efficiency trends in the transport sector in the EU*, Enerdata 2015, p. 23.

Energy efficiency in the road transport

The increased mobility of European citizens caused that cars are currently the greatest responsibility for the energy needs of road transport (Graph 5). This happened in spite of improving energy efficiency of these cars and freight transport growth. In 1990–2000, the energy consumption of cars has stable character and accounted for 52.8% of the total energy needs of road transport. Since 2000, there was high growth rate of freight due to the increase in trade and EU enlargement, which resulted in changes in the structure of energy consumption in road transport. In 2010, there was a decrease in energy consumption for passenger cars in total energy consumption by road transport to 48.1%[8]. In turn, fuel consumption by trucks constituted in 2010 30.5% of total energy consumption by road transport, which meant an increase of 1.5 percentage points compared to 1990. In the period 1990–2010 energy consumption by buses and motorcycles was stable and amounted to 3.3% of the total energy needs of road transport in 2010.

The projected continued growth of freight transport will contribute to the further changes in the structure of energy consumption by road transport[9]. Despite the high growth rate of energy efficiency improvement drive trucks, the share of fuel consumption of these vehicles in the total demand for fuel road transport sector will grow to 45.5% in 2030, growth in the share of road freight transport in total freight with a decline in the importance of rail freight and inland waterways will affect the average energy intensity of freight transport. By 2030, the average decrease in energy consumption in the transport will be 0.4% per annum. At the same time the share of the energy consumption of cars will be reduced in 2030 to 50.4% of the total fuel needs transport. Improvement of energy efficiency of passenger transport will be the result of several factors, namely the increase in fuel prices, more efficient driving and more efficient engines. However, the impact of these factors will not offset the increase in energy demand by road.

In the years 1990–2000 there was a low dynamic to improve the energy efficiency of cars, for which to a large extent the trends in the automotive market were responsible. The sale was dominated by larger, stronger and more comfortable cars that consuming more energy per unit of activity "consume" the results to improve the energy efficiency of motors. Since 2000, there has been a significant improvement in the energy efficiency of private passenger transport. Fuel consumption in 2010 by passenger cars accounted for an average of 9.1 l/100 km, while in 2000, the level of consumption was 11,1 l/100 km. This means that in the period 2000–2010 there was a growth rate of energy efficiency

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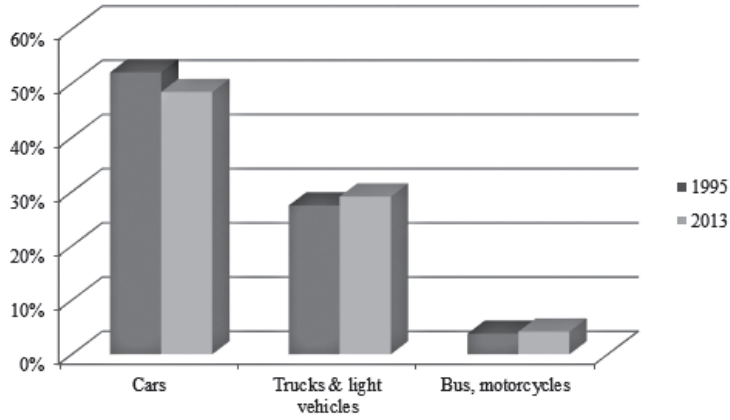
[8] *Energy efficiency trends in the transport sector in the EU*, Lessons from the ODYSSEE MURE project, 2012, p. 13.

[9] *EU energy, transport and GHG emissions. Trend to 2050*, Reference scenario, Directorate-General for Energy and Mobility and Transport, Luxembourg 2013, pp. 38–42.

improvement of 1% per year, an increase of 0.65 percentage points from a similar dynamic characterizes 1990–2000.



Graph 5. Structure of energy consumption in road transport in the EU-28

Source: Own elaboration based on http://odyssee.enerdata.net/database [access: 27.01.2017].

Forecasts developed by the International Energy Agency and experts Warsaw Institute of Economic Studies and Institute for Sustainable Development (Table 3) predict a further decline in unit energy consumption in the road transport sector in the amount of 1.25% per year until 2030 this decline. It leads to the fact that in 2030 the average fuel consumption of passenger cars is expected to be 7.4 l/100 km. At the same time it is expected that the reduction of "occupancy" of passenger cars with 2.38 passenger/car in 2009 to 2.17 passenger/car in 2030 and a significant increase in sales of passenger cars in the EU will contribute to a decline in the rate of the specific energy consumption passenger transport. Total energy consumption will still increase.

Table 3. The energy consumption of cars – a reference scenario

Year	Passenger car		Cars under 3.5 t		Car over 3.5 t		Total energy, Mtoe
	Motors ON (share)	Fuel consumption, l/100 km	Motors ON (share)	Fuel consumption, l/100 km	Motors ON (share)	Fuel consumption, l/100 km	
2010	35%	9.1	68%	11	100%	24.80	15
2020	56%	8.1	78%	10	100%	23.76	20
2030	63%	7.4	82%	9	100%	22.96	22
2040	66%	6.9	83%	8	100%	22.33	22
2050	67%	6.5	84%	8	100%	21.85	21

Source: Elaboration based on 2050.pl journey to a low carbon future, op. cit.

The above regularities are a manifestation of the paradox Jevons'a. The main achievement of the concept of W.S. Jevons'a was the identification of a positive correlation between the increase in the efficiency of use of natural resources and the increase in production and consumption of these resources. In other words, technological progress associated with an increase in the efficiency of use of the resource usually leads to an increase in the consumption of this resource[10]. The transport sector is a very good example of the occurrence of this correlation, which is confirmed still present problems with the introduction of the transport sector on a more sustainable path. Force in the coming decades, global energy and climate trends indicate a key challenge facing the transport system – meet the constantly growing demand for energy. An important issue in achieving the objectives of sustainable transport is not the only technology development, but also human consciousness proper shaping consumer preferences. The future transport will depend on the carriers and the customers.

Discussions

In accordance with the flagship initiative "Europe Resource Efficient" laid down in the framework of the Europe 2020 Strategy, the overriding goal of European transport policy is to help to create a system that offers high-quality mobility services with less use of resources. In practice, this means that the shuttle must consume less energy, use green energy and better use modern infrastructure. How to meet these challenges, while striking a balance between the issues of economic, social and environmental. Restricting mobility is not an option. Personal mobility and, in particular road transport, are issues of global importance. On the other hand – the mobility manages to maintain only if it will be sustainable.

European transport system was made in circumstances where the oil was essentially cheap, the infrastructure is expanded, led Europe in terms of technology, and the limitations of the environment were small. Today, the transport system must adapt to changing conditions. The rapid development of road transport highlighted the negative impact of this mode of transport, among others, on the environment. The resulting, therefore, a contradiction on the line economy – environment. In the literature, many authors postulate raises the issue of accessibility to reconcile with the postulate of his not onerous environment[11].

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[10] D. Pienkowski, *The paradox Jevons'aa energy consumption in the European Union*, "Problems of Sustainable Development" 2012, Vol. 7, No. 1, p. 107.

[11] A. Przybyłowski, *Transport investments as a factor of sustainable development of the regions in Poland*, Publisher Gdynia Maritime University, Gdynia 2013, p. 26.

Can behavioral factors significantly help to solve these contradictions, to improve the quality of life and the environment while maintaining the competitiveness of the European economy and the people's right to movement?

Conclusion

EU enlargement and the increasing integration of world markets led to a significant increase in the amount of transported goods. There was also an increase in the mobility of Europeans, despite the high congestion in many cities. Thanks to its advantages, mainly speed, widespread availability of means of transport, the possibility of direct transport of goods and people, as well as the favorable distribution of the space infrastructure, road transport is today the dominant and most important mode of transport. The analysis shows that road transport now gained a special status in people's daily lives.

The directions of development of transport systems have a direct impact on the energy needs of the transport sector. Transport is still almost entirely dependent on fossil fuels as an energy source. Technical progress has contributed to a more efficient use of energy, but not enough to offset the effects of increasing transport performance in transport. Prospects for further growth in demand for petroleum resources while increasing the market share of diesel cars point to the need to take active measures in terms of creating a competitive and resource efficient transport system.

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Abstract

With quantitative and qualitative data, and knowing, at a glance, goal, it was an attempt to examine the relationship between the development of road transport and the efficiency of resource use. The analysis has shown that road transport now gained a special status in people's daily lives. The increased mobility of European citizens caused the greatest responsibility for the transport of energy. This spite of improving the efficiency of these cars and freight transport growth. The projected continued growth of freight transport will contribute to the further changes in the structure of energy consumption by road transport. Despite the high growth rate of energy efficiency improvement of truck drives, the share of demand for fuel by those vehicles will increase in total fuel demand for road transport sector. At the same time the energy consumption of cars will reduce its share in total fuel needs transport. Improvmrnt of energy efficiency of passenger and truck will not offset the increase in demand for energy in road transport. The above regularities define a key challenge facing the transport system – meeting the ever growing demand for energy.
Keywords: transport, road transport, mobility, transport fuels, energy efficiency, energy consumption of transport