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ENERGY CONSUMPTION IN THE TRANSPORT IN BULGARIA IN THE CONTEMPORARY CONDITIONS

In the present paper, the author aims to theoretically highlight the transport in logistics and to focus on some options for optimal solutions and based on analysis of the dynamics in the development of the final energy consumption in the transportation sector of Bulgaria, to reveal the role of technologies as a means of improving energy efficiency in the country's transport. In order to achieve this goal, transport is theoretically defined in the context of the overall reproduction process, its role in the supply chain is highlighted, and in this relation, the system approach is reviewed as a way of optimizing transport costs. The different modes of transport are compared, as the comparative characteristic is one of the approaches that will allow to be taken transport solutions in line with the current requirements of economic efficiency and environmental friendliness.

The analytical part follows the dynamics in the development of the final energy consumption in the transport sector of Bulgaria for the period 2001-2017, differentiated by type of transport, in order to be able to highlight the specifics of the different transport alternatives with regard to the used energy sources. On the basis of the analyses made, conclusions are drawn that emphasize the established trends and the localized problems.

In the third part, the technological achievements in the field of the automotive industry are presented as the main sources for improving the energy efficiency in the transport of Bulgaria.

JEL: L62 ; L91 ; Q01 ; Q49

Introduction

Current issues in modern economies are closely linked to energy efficiency issues, given the increasing intensity of the different sectors and their dependence on energy sources. The reason for the necessity for research in this direction is the limited possibilities for securing the economic processes in the conditions of increasing economic dynamics. This requires finding alternatives to conventional resources in the form of multiple non-standard solutions.

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In this regard, arises the idea of tracking the development of these transport processes as an important logistic function, accounting for serious levels of energy consumption in the performance of its tasks in the context of the basic logistics principles known as the 7R rule or as a logistical mix – to deliver the exact product, in the right quantity and quality, in the right place, at the right time, to the exact customer, with the exact cost.

The aim of the present paper is to theoretically highlight the transport in logistics and to focus on some options for optimal solutions and based on analysis of the dynamics in the development of the final energy consumption in the transportation sector of Bulgaria, to reveal the role of technologies as a means of improving energy efficiency in the country's transport.

In order to achieve the stated goal, three main tasks are drawn, and namely:

1. Revealing the role of transport in logistics and opportunities for optimal solutions.
2. Analysis of the dynamics in the development of final energy consumption in the transport sector of Bulgaria.
3. Exploring technologies as a means to improve energy efficiency in Bulgaria's transport.

The methods to be used are: method of comparison and synthesis, dynamic statistical analysis, graphical method.

The period covered by the analysis of the development of the final energy consumption in the transport sector in Bulgaria is from 2001 to 2016/2017. The choice of the period is dictated by the changes in the new millennium which affect both the Bulgarian economy as a whole and the transport sector in particular, given the full Bulgarian membership in the European Union and the resulting prior and subsequent synchronization processes.

Tracking the evolution of final energy consumption, totally and differentiated by modes of transport, will reveal the extent of implementation of the currently set parameters. By final energy consumption should be understood the total energy consumption in transport, excluding fuel losses for marine bunkering (National Statistical Institute, 2019).

The main limitation of the empirical study is the lack of unified official statistical information published by the National Statistical Institute, which to be systematized for the entire period under review. This also predetermines the existence of certain differences in the length of the surveyed period by different modes of transport, which does not reduce the qualities of the paper.

The actuality of the chosen subject is a prerequisite for conducting research that is relevant both for the development of the theory and the practice.

1. The role of transport in logistics and opportunities for optimal solutions

Transport ensures the normal flow of the entire reproduction process by promoting the rhythmical movement of material flows from raw material sources through the manufacturing area to consumers, whether they are end users or industrial buyers, using "means of transport and a number of other machinery and equipment, which are consumed in the production process... and fuels, lubricants and other materials are consumed" (Nikolov, 2013, p. III-114). It is precisely the role that transport performs throughout the supply chain and the costs it accumulates that place it at the centre of business logistics. Regardless of whether we will adopt the definition of S. Blagoeva for a supply chain such as "Three or more economic units (legal or natural persons) directly involved in the movement of internal or external flows of production, services, finances and/or source information to the user" (Blagoeva, S., Kehayova-Stoicheva, M., 2008, pp. 168-206) or that by M. Rakovska et al as a "system of organizations involved in the process of creating and realizing the products and services from their generation at the stage of extraction of the raw materials to their delivery to end users" (Rakovska, etc. , 2014, p. 21), we will highlight transport as a strategically significant function that implements the objectives of "material and related flows through all phases and stages of movement as a whole (system)" (Dimitrov, etc., 2010, p. 17). It is the system approach that implies "integrated management of incoming, internal and outgoing flows" (Rakovska, 2011, p. 17), which optimizes transport costs and leads to desired levels of customer satisfaction.

Achieving these goals in transport requires a comparison between different modes of transport, as the comparative characteristic is an approach that will allow for transport solutions to meet modern requirements for economic efficiency and environmental friendliness.

In this connection Hr. Nikolova notes that "only in rail transport is currently possible the massive use of electricity as a driving force, while in all other modes of transport, deficient liquid fuels are used" (Nikolova, 2010, p. 23). The author adds that rail transport "offers the lowest cost for transporting one tonne of cargo per 1 km compared to other types of land transport, with lower energy consumption, lower labour costs and higher environmental friendliness of transportation" (Nikolova, 2018, p. 10). This statement certainly focuses the interest on this transport option, as it very much meets the modern requirements and expectations of the organization of freight transport. On the one hand, large volume shipments at a favourable cost, that is, at low unit costs, correspond to the economic efficiency postures where the main goal is to achieve high results at relatively low-cost levels. On the other hand, the choice of rail transport accumulates some of the lowest energy costs in carrying out the transport activity, which should be highlighted as a strategic advantage over other options in the context of a shortage of energy resources.

Another important land-based opportunity for freight transport in compliance with environmental parameters provides pipeline transport, which is considered one of the most technologically advanced options in the sector. In addition to being highly mechanized, reliable, ensuring a continuous transport process, it is distinguished by high throughput and high labor productivity, it also has three very important advantages: it does not consume much energy, does not pollute the environment and is relatively silent and safe. Therefore, we can join to the statement of Al. Dimitrov, that transportation via oil pipelines and gas pipelines is much more economical and faster than other modes of transport (Dimitrov, 2013, p. 7).

Undoubtedly, these distinctive features in conducting transport via pipelines confirm the claim that the future of freight transport belongs precisely to this alternative, as humanity must abandon the "transport" of the engines and the fuel they need (Cosmos, 1975, p. 36).

Inland road transport also includes the vehicles which, in terms of environmental parameters, does not stand out as a possible competitive solution, given the specificity of the rolling stock it operates at this stage, but it is an optimal solution for relatively short distances, where it is economically unreasonable to use the other modes of transport. They have their advantages over long distances and then are recommended mainly water (sea and river) and air transport (Nikolova, 2010, pp. 27-29):

- Water transport because the cost of fuel per unit of transport is much lower than in rail, road and air transport.
- Air transport because the speed of traffic is many times higher than other modes of transport and the transport is done directly in the air space, which shortens the routes.

Knowing the specificities of the different modes of transport requires the research of optimal transport solutions to reduce energy costs and, consequently, reduce irrational transport through (Nerush, Yu, Sarkisov, 2016, p. 114):

- improving the geographical distribution of the transport network based on the construction of new railway lines, motorways, the use of new waterways;
- making the most of the capability of the routes on the shortest possible route;
- the most efficient distribution of freight traffic between modes of transport;
- maximum use of water transport for the carriage of bulk and road vehicles for short haul;
- continued development of mixed transport involving different modes of transport;
- improving transportation planning.

Rational transport solutions are also directly related to modal transport, such as the intermodal, where "most of the shipment is by rail, inland waterway or sea transport, and the start and end of the road where road transport is used, are the shortest possible" (Dybskaya, etc., 2008, p. 528). The author specifies the organization of transport, which, when traveling over significant distances, provides for the use of these modes of transport, which are characterized by the fact that they leave the smallest environmental footprint in the environment and have capacity of the rolling stock for the transport of mass cargo, which reduces the cost of energy resources per unit load. Logically, in overcoming relatively short distances connecting infrastructure points and destination of the cargo, is recommended the most flexible transport that is avoided over a long distance due to two main deficiencies: its operating costs are much higher than rail and water transport per tonne-kilometre and its carrying capacity is less than that of other modes of transport, which also determines higher capital inputs for delivery and repair divided into one tonne carrying capacity.

Optimization processes in transport are directly related to new technologies and, to a very large extent, intelligent transport systems (ITS), defined as applications that create prerequisites for the use of information and communication technologies in transport, the main innovation that these systems offer is the integration of existing technologies for the creation of new services (Nikolova, 2017, p. 79).

Their development is based on the 12 basic principles envisaged in Directive 2010/40/EU of the European Parliament and of the Council of 7 July 2010 on a framework for the deployment of Intelligent Transport Systems in the field of road transport and for interfaces with other modes of transport, which can be systematized in the following order (The European Parliament, 2010, p. 13):

1) *The principle of effectiveness*, which in practice is associated with reducing congestion, lowering emissions, improving energy efficiency, achieving higher levels of safety and security, including of the vulnerable road users.
2) *The principle of economic benefits*, which helps to achieve an optimal cost-to-end result ratio in terms of achieving the goals.
3) *The principle of proportionality* envisaged to achieve different levels of service quality and deployment, taking into account the specificities of local, national and European level.
4) *The principle of continuity of services* ensures ITS deployment without interruption.
5) *The operative compatibility principle (inter-operability)* ensure the availability of data sharing capacities and the sharing of information and knowledge that will enable the effective provision of ITS services.
6) *The principle of backwards compatibility* ensures the ability of ITS to work with the existing systems.
7) *The principle of respecting the existing characteristics of national infrastructures and networks* takes into account the differences inherent in the characteristics of transport networks.
8) *The principle of promoting equal access opportunities* provides for non-discrimination of vulnerable road users when accessing ITS applications and services.
9) *The principle of reaching maturity* requires that the deployment plans for the relevant systems demonstrate the stability of the innovative ITS, after an appropriate risk assessment.
10) *The principle of provision of qualitative determination of the time and location* is based on the use of satellite-based infrastructures or any technology providing equivalent levels of accuracy for ITS applications and services.
11) *The principle of facilitating intermodality* implies, after ITS deployment, improved coordination of different modes of transport.
12) *The principle of consistency* concerns the implementation of ITS deployment projects between the EU Member States.

Compliance with these principles in the development of ITS is mandatory in order to achieve higher levels of stable entry of the technology into transportation, the role of which is further enhanced by the single digital market, which guarantees the free movement of people, services and capital, and where individuals and businesses can seamlessly perform and engage in online activities in the conditions of fair competition and a high level of consumer and personal data protection regardless of their nationality or place of residence (European Commission, 2018).

The new market configurations place high expectations on technology and to a large extent on information and communication technologies as a means of improving energy efficiency in transport, and their potential for energy savings in the transport sector is estimated at 26% of their total primary energy consumption in 2020 (Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, 2008, p. 7).

This requires surveys to track the development of energy consumption in the transport sector.

2. Analysis of the dynamics in the development of final energy consumption in the transport sector of Bulgaria

The analysis of the energy consumption in the country as a whole, and in particular in the transport sector, is of strategic importance, given that "Bulgaria is a net importer and a poor of energy resources (except for coal)" (Center for the Study of Democracy, 2014, p. 1).

From the beginning of the 21st century until 2017 we see a serious decline in the final energy consumption in Bulgaria's rail transport, which in relative terms reaches 44,196%. The highest levels were reported in the first year of 71.5 thousands toe and the lowest in 2014 (25.7 thousands toe) (see Table 1).

The low energy consumption in 2014 can be related to stopping the reforms related to changes in the business model applied in the Bulgarian railways, which has an impact on the economic activity. Efforts focus on optimization measures regarding the irrational empty carriage and human resource engagement.

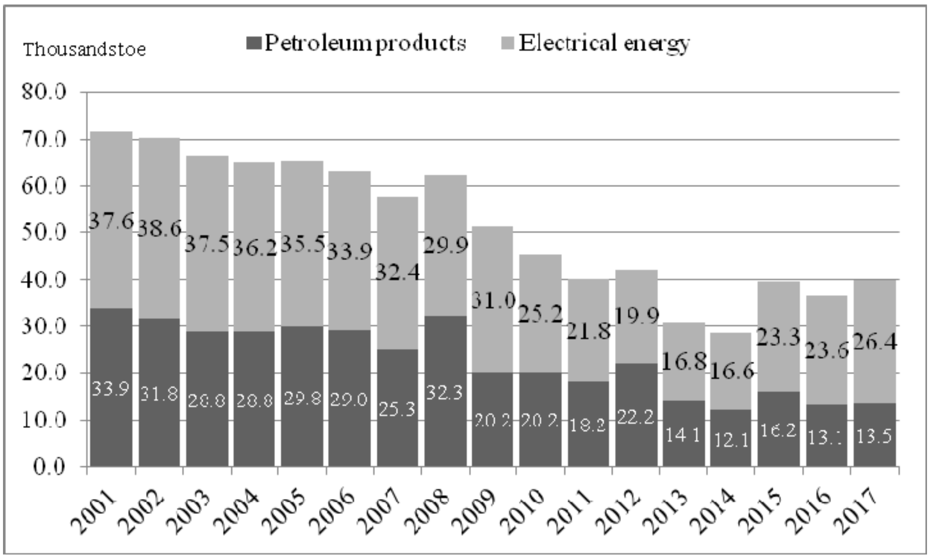
Traditionally, rail transport uses electric power as a driving force and, to a lesser extent, uses petroleum products. In this transport sector, natural gas and renewable fuels are not applicable. In a comparative plan, electricity occupies a priority position over petroleum products. The consumption of both energy sources is definitely reduced, but for oil products, the levels at which consumption is established are 13.5 thousands toe (2017), or 60.177% less than in 2001. (33.9 thousands toe). For electricity, it is noted that final consumption in 2017 is almost twice as high as that of petroleum products (see Figure 1).

Table 1
Final energy consumption and performance in the railway transport of Bulgaria for the period 2001-2017

Years	Total (thousands toe)	Natural gas (thousands toe)	Petroleum products (thousands toe)	Renewable fuels and wastes (including non-renewable waste) (thousands toe)	Electrical energy (thousands toe)	Transport performance (mln. tkm)
2001	71.5	-	33.9	-	37.6	4904.2
2002	70.4	-	31.8	-	38.6	4627.4
2003	66.3	-	28.8	-	37.5	5273.8
2004	65.0	-	28.8	-	36.2	5211.6
2005	65.3	-	29.8	-	35.5	5163.3
2006	62.9	-	29.0	-	33.9	5396.2
2007	57.7	-	25.3	-	32.4	5241.4
2008	62.2	-	32.3	-	29.9	4693.3
2009	51.2	-	20.2	-	31.0	3144.5
2010	45.4	-	20.2	-	25.2	3063.5
2011	40.0	-	18.2	-	21.8	3291.2
2012	42.1	-	22.2	-	19.9	2907.6
2013	30.9	-	14.1	0.9	16.8	3246.0
2014	28.7	-	12.1	-	16.6	3439.2
2015	39.5	-	16.2	-	23.3	3649.8
2016	36.7	-	13.1	-	23.6	3433.7
2017	39.9	-	13.5	-	26.4	3931.0

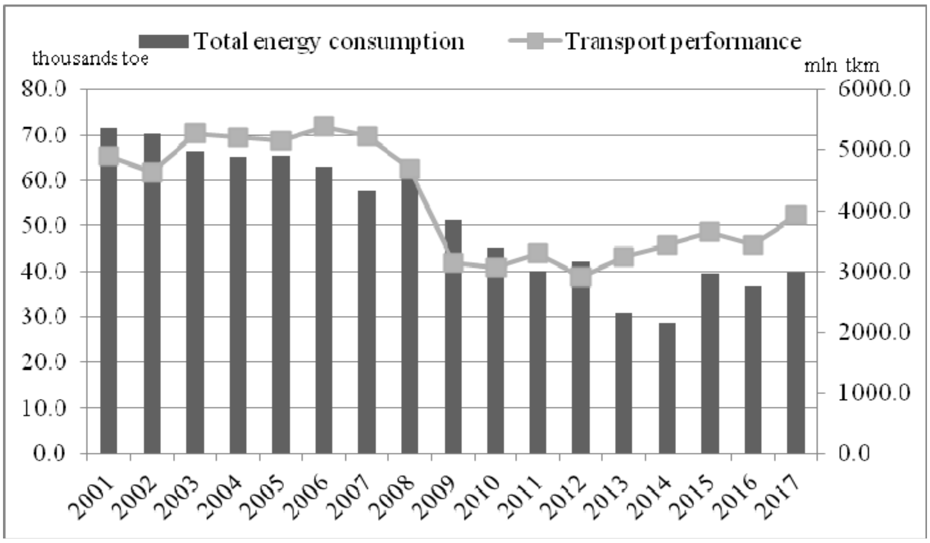
Source: National Statistical Institute, 2019.

Figure 1
Final energy consumption in the railway transport of Bulgaria for the period 2001-2017



If we follow the dynamics of total final consumption in rail transport and the transport performance indicators in tkm, we will notice that these indicators move relatively unidirectionally (see Figure 2).

Figure 2
Dynamics in the development of final energy consumption and performance in the cargo rail transport of Bulgaria for the period 2001-2017



The causal link is embedded in the complexity of the "transport performance" indicator, which in the transport relates for a certain period of time, the volume of the goods carried and the average distance travelled. Logically, with changes in the volume of goods carried and the distance, the final energy consumption is intensified or reduced. In rail transport, we find that for the period 2001-2017 the curve of the transport performance follows that of the goods transported, and the average transport distance is 246 km. The real operational parameters of the Bulgarian railways do not correspond to the fundamental characteristics of this transport, designed to transport bulky and heavy goods over long distances at favourable costs.

The period, which is close to 18 years, is characterized by dynamics in the Bulgarian railway transport sector, which however does not increase the interest of the economic operators in it. In 2007, with the country's accession to the European Union, this market segment is being liberalized and the railway carriers currently are 14, and the most active players on the market are 5 ("BDZ Freight Transport" EOOD, 2019).

The downward trend in the sector, regarding the final energy consumption and performance, are indicators of the existence of problems that arise from:

- The pace of development in industrial production in Bulgaria.

- The cessation of Kremikovtzi's activity in 2009, resulting in the loss of 1/4 of the freight transport volume.
- Competition of the road transport.
- The limited volumes of business activity of enterprises, which prevent them from benefiting from the main advantage of rail transport associated with the lower cost per unit of freight.

Reasons can also be sought in infrastructure provision of railways and rolling stock, which require major modernization, as well as criticism of the railways in relation to the unused opportunities that are revealed on the basis of intermodal and multimodal transport. The participation of the railways in overcoming the main length of the routes in these transport solutions is expected to be active. The advantage of the Bulgarian railway carriers is the possibility of combining rail and sea transport via the ferryboat complex in Varna, connecting Europe and Asia through regular trips to Ilychovsk (Ukraine), Poti / Batumi (Georgia) and Caucasus (Russia).

The enormous competition in road transport by freight transport can also be ascertained on the basis of the volumes of final energy consumption (see Table 2).

Table 2

Final energy consumption and performance in the road transport of Bulgaria for the period 2001-2017

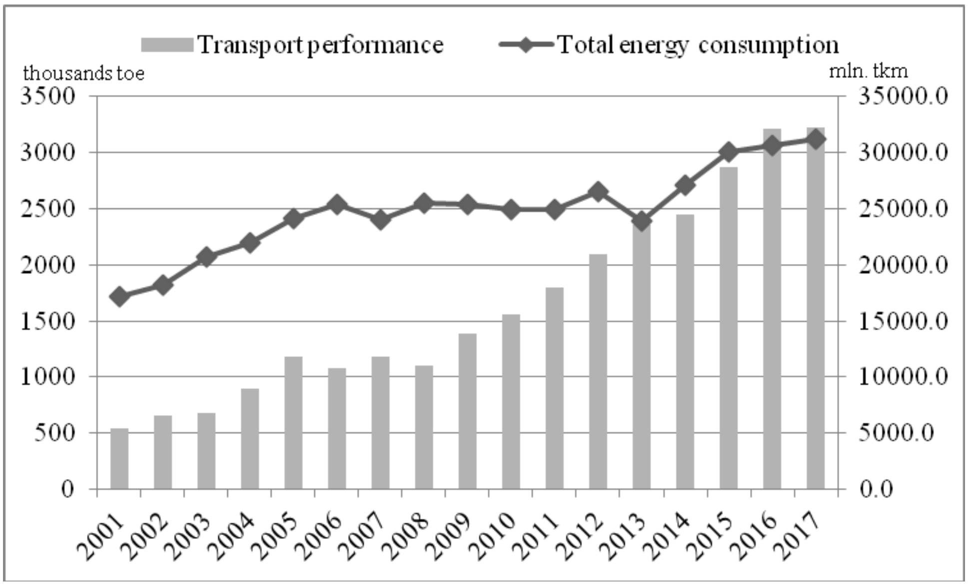
Years	Total (thousands toe)	Natural gas (thousands toe)	Petroleum products (thousands toe)	Renewable fuels and wastes (including non-renewable waste) (thousands toe)	Electrical energy (thousands toe)	Transport performance (mln. tkm)
2001	1723.6	-	1723.6	-	-	5423.0
2002	1826.6	-	1826.6	-	-	6603.0
2003	2066.3	-	2066.3	-	-	6840.0
2004	2198.6	5.8	2188.2	-	4.6	9015.0
2005	2418.4	19.1	2395.1	-	4.2	11843.0
2006	2538.6	25.3	2503.5	5.4	4.4	10793.0
2007	2404.4	37.0	2360.5	2.3	4.6	11795.0
2008	2548.4	35.0	2504.7	4.2	4.5	11027.0
2009	2539.5	49.1	2480.0	3.7	6.7	13871.0
2010	2490.5	65.9	2404.6	13.4	6.6	15641.0
2011	2492.1	60.7	2407.0	17.2	7.2	17943.0
2012	2654.4	64.8	2500.7	85.9	3.0	20994.1
2013	2392.1	70.9	2213.2	103.4	4.6	23530.3
2014	2708.2	78.6	2511.5	110.7	7.4	24454.7
2015	3009.7	77.8	2781.1	146.2	4.6	28741.5
2016	3065.0	74.1	2823.1	163.1	4.7	32069.7
2017	3115.4	75.0	2869.7	166.2	4.5	32187.1

Source: National Statistical Institute, 2019.

The growing interest in road transport over the years has been accompanied not only by criticism due to the footprints it leaves in the atmosphere but also by positive trends due to the increasing efficiency measured on the basis of work (effect) and total energy consumption (resource) (see Figure 3). There is a nearly six-fold increase in indicators measured in tonne-kilometres at 1,807 times or nearly double the increase in final energy consumption.

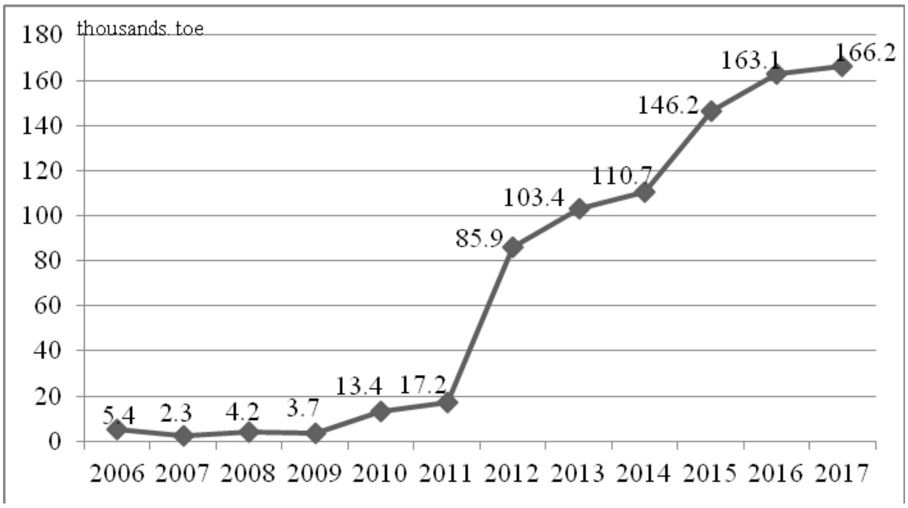
Figure 3

Dynamics in the development of final energy consumption and performance in the cargo road transport of Bulgaria for the period 2001-2017



We should also reflect the fact that the levels of consumption of natural gas and of renewable fuels and waste are the most serious. Of all renewable energy sources reported by the National Statistical Institute: water, wind, solar (photovoltaic) energy, solar thermal, geothermal, renewable landfill waste, wood burning, wood waste and other vegetable waste, wood-coal, landfill biogas, biogas from sewage sludge, other types of biogas, liquid biofuels (biogasoline and biodiesel), only data on biofuels used in road transport from 2006 on is registered (see Figure 4).

Figure 4
Dynamics in the consumption of biofuels in road transport of Bulgaria for the period 2006 - 2017



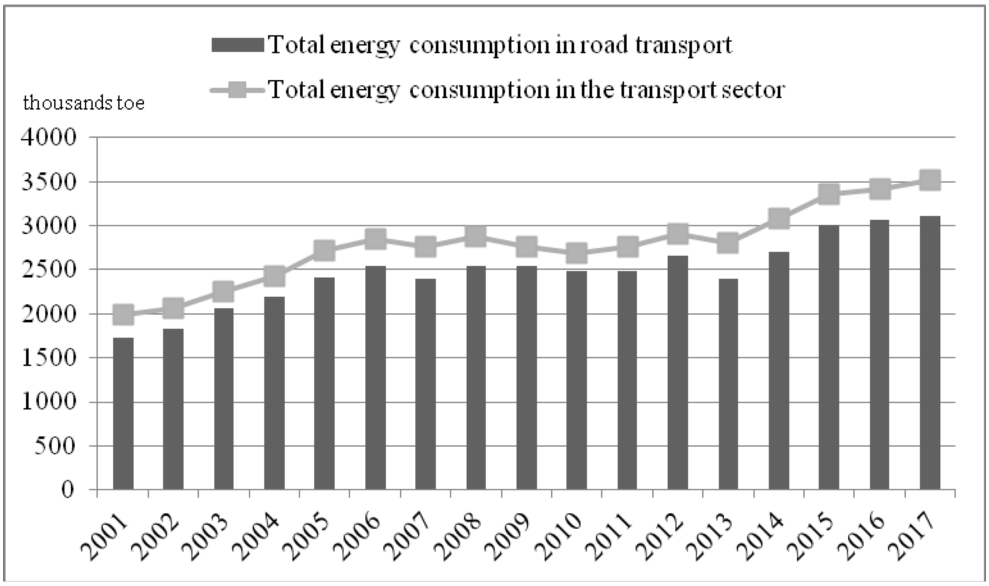
The established growth in biofuel consumption in Bulgaria's road transport is in line with the long-term objective, which requires an upward growth in energy efficiency compared to the growth of energy consumption and an increase in the share of electricity from renewable sources (Executive Environment Agency, 2015). However, we should not ignore the growing consumption of petroleum products. Only with electricity, fluctuations are unstable with declines and increases over the years ranging from 3.0 (2012) to 7.2 (2011) thousands toe. This is an indication of the still unstable penetration of electric-powered vehicles in the transport of goods. Indeed, particularly in this market segment, the future is associated with a re-routing of carriers from the use of internal combustion engines to electric trucks, which will reduce oil consumption in the sector.

Compared to the overall energy consumption in the transport sector, there is a tendency towards unilateral development, which shows that in practice on the Bulgarian transport market, the road transport is an indisputable leader and the other transport solutions are not its real competition (see Figure 5).

Therefore, levers should be sought to shift goods to transport solutions which either completely exclude the participation of vehicles, such as rail transport or to seek modal solutions involving the use of vehicles in the initial and final stages of the route. In this direction, priorities should focus on innovations in railways and in water transport, which have been neglected in recent years, despite the benefits they have in terms of efficacy and efficiency of transport. This is a solution with serious long-term consequences for the country's economic development and losing postions in the European transport area.

Figure 5

Final energy consumption in the transport sector and road transport of Bulgaria for the period 2001-2017



The third land alternative involves the rhythmic movement of cargo (gaseous, liquid, dust, slurries, sludge from waste materials, etc.) through pipelines, which reflects positively on the variable costs associated with transported volumes of material flows.

During the period 2001-2017, Bulgaria's pipeline transport increased the final energy consumption by 2,378 times, with a reported growth of 1,737 times the performance indicators (see Table 3, Figure 6).

Data shows some inefficiency based on energy consumption (resource) and performance (effect). The reasons for the relatively low dynamics in the development of this transport could be related to the discontinuation of the "South Stream" marine gas pipeline, an element of the "South Stream" gas transmission system, which would have finished with more than 2300 km in length. The Black Sea section of the pipeline had to consist of four parallel pipelines, about 930 km in length, from the Russian coast near Anapa, pass through the Turkish exclusive economic zone and reach the Bulgarian coast 11 km south of Varna.

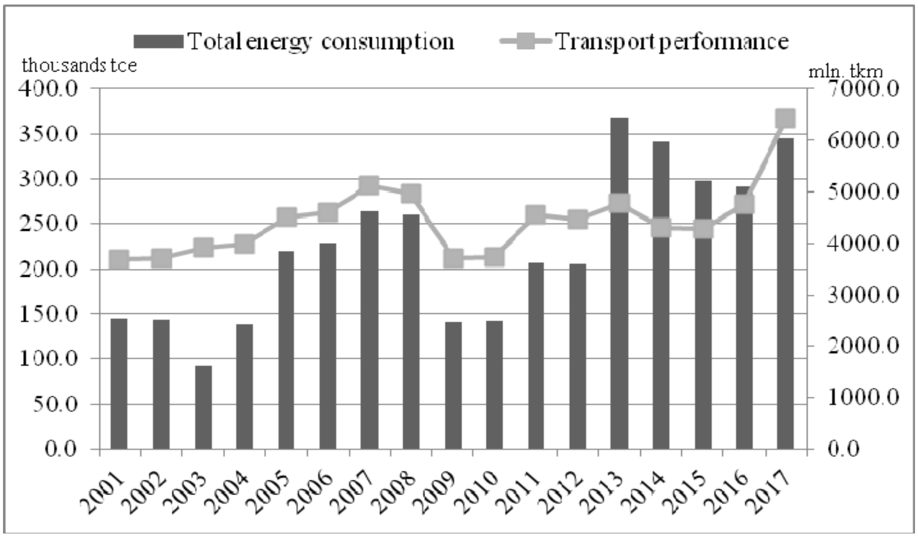
Expansion of Bulgaria's national gas transport network from the Turkish to the Serbian border is currently expected, which means that the second pipeline of the "Turkish Stream" gas pipeline will be directed to the Bulgarian rather than the Greek border (Stanchev, 2018).

Table 3
Final energy consumption and performance in the pipeline transport of Bulgaria for the period 2001-2017

Years	Total (thousands toe)	Natural gas (thousands toe)	Petroleum products (thousands toe)	Renewable fuels and wastes (including non-renewable waste) (thousands toe)	Electrical energy (thousands toe)	Transport performance (mln. tkm)
2001	145.3	138.0	1.9	-	5.4	3692.0
2002	144.3	139.0	1.9	-	3.4	3720.0
2003	91.5	87.5	1.9	-	2.1	3910.0
2004	138.5	134.5	1.9	-	2.1	3977.0
2005	220.3	216.0	1.0	-	3.3	4515.0
2006	229.6	227.8	-	-	1.8	4602.0
2007	263.8	262.1	-	-	1.7	5129.0
2008	260.2	258.1	-	-	2.1	4968.0
2009	142.0	139.6	-	-	2.4	3716.5
2010	143.3	140.8	-	-	2.5	3735.5
2011	206.3	203.7	-	-	2.6	4559.8
2012	206.1	203.5	-	-	2.6	4472.3
2013	368.4	181.7	-	-	2.5	4772.7
2014	340.5	167.9	-	-	2.3	4301.1
2015	298.0	146.7	-	-	2.3	4285.7
2016	291.5	143.6	-	-	2.1	4759.6
2017	345.5	171.0	-	-	1.8	6413.9

Source: National Statistical Institute, 2019.

Figure 6
Dynamics in the development of final energy consumption and performance in the pipeline transport of Bulgaria for the period 2001-2017

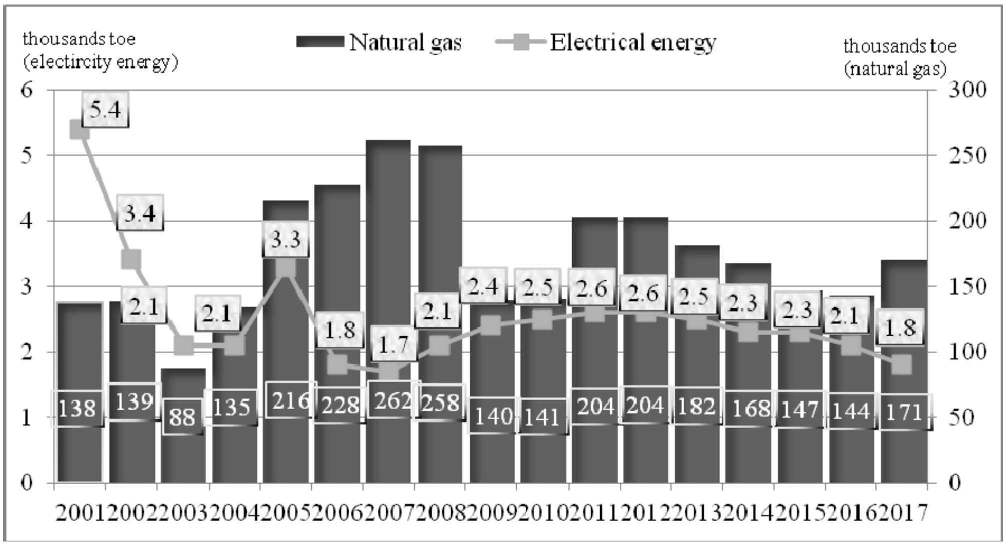


Following the shown in Figure 6 the dynamics in the development of final energy consumption and performance in the pipeline transport of Bulgaria for the period 2001-2017, we establish, that empirically measured both indicators follow an unstable trend. Energy consumption in the sector sets minimum levels in 2003, which is a consequence of the increase in excise duties this year in order to reduce fuel consumption. In 2001, 2002, 2004 and 2009, 2010, pipeline transport energy consumption was resistant to levels below 150 thousands toe.

Bulgaria's preparations for entry into the European Union requires harmonization of the legislative framework and of the existing mechanisms within the single European market, which implies the imposition of certain requirements by the EU on the legislation on excise duties, the most important of which is the mandatory nature of excise duties on certain goods which cannot be lower than the minimum levels laid down in the directives. Specifically, such energy products are motor fuels and heating fuels – gasoline, diesel, electricity, natural gas, coal and coke. Consequently, given the purpose of pipeline transport and the use of mainly natural gas in its operation (see Figure 7), we can link the outlined trends and the country's adaptation processes to the one created in 1993 Common European Market.

Figure 7

Final energy consumption of natural gas and electricity in the pipeline transport of Bulgaria for the period 2001-2017



Pipeline transport spends two types of energy products – natural gas and electricity, which are one of the most environmentally friendly sources of energy. Priority is given to the consumption of natural gas, which is logical given that "In Bulgaria, the natural gas price for corporate customers is times lower than that of traditional energy sources – 0.227

BGN/kwh for electricity, BGN 0.242 per kwh for gas oil, 0.160 BGN / kwh for LPG and 0.070 BGN / kwh for natural gas" (Overgas, 2019).

On the other opposite is the structure of final energy consumption in Bulgaria's air transport, where the only energy source is petroleum products (see Table 4).

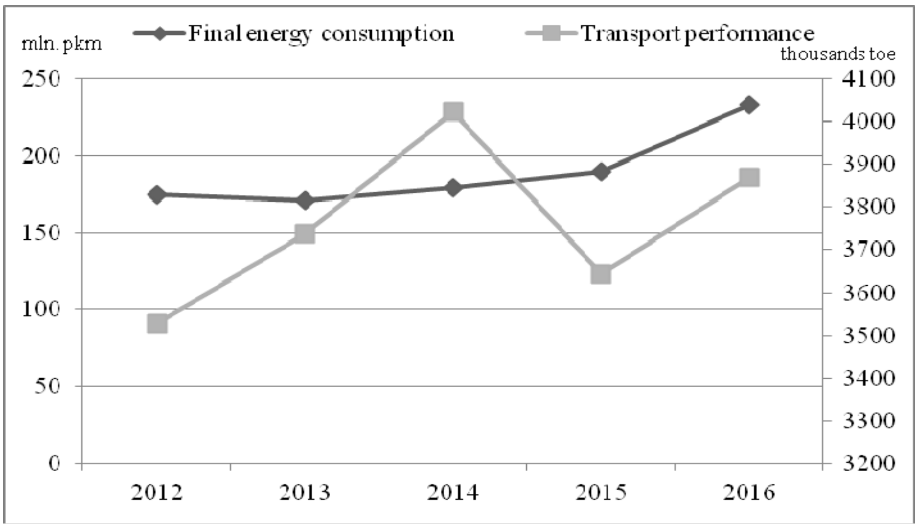
Table 4
Final energy consumption and performance in air transport of Bulgaria for the period 2012-2016

Years	Total (thousands toe)	Natural gas (thousands toe)	Petroleum products (thousands toe)	Renewable fuels and wastes (including non-renewable waste) (thousands toe)	Electrical energy (thousands toe)	Transport performance (mln. pkm)
2012	175	-	175	-	-	3528
2013	171	-	171	-	-	3738
2014	179	-	179	-	-	4023
2015	190	-	190	-	-	3644
2016	233	-	233	-	-	3869

Source: National Statistical Institute, 2019.

The comparatively narrow timeframe of reporting final energy consumption data does not create prerequisites for tracking sustained trends, but outlines the dynamics of the performance indicator in the passenger segment, which is significantly more active in air transport compared to the transportation of loads (see Figure 8).

Figure 8
Dynamics in the development of final energy consumption and performance in air passenger transport of Bulgaria for the period 2012-2016



It is important to draw in parallel the final energy consumption and the performance curves in order to assess the levels of efficiency. On a comparative plan, the energy consumed shows that it maintains relatively constant levels from 2012 to 2015 and reaches the highest levels in 2016 while at the same time the work done increases in 2013 and 2014 compared to the beginning of the period, then the trend turns for one year, and in 2016 there is a certain upturn in air transport. An interesting divergence between the two indicators is found in 2014, when the performance is positioned at the highest levels and the final energy consumption at the lowest and precisely in this time range of the survey period the efficiency reaches maximum values. The reasons for these results can be related to the increase in absolute figures: passenger numbers and length of distance.

Domestic flights account for some fluctuations in final energy consumption over the period 2001-2017, with the highest figures being measured in 2001 and the lowest in 2014 (see Table 5).

Table 5

Final energy consumption and performance in domestic aviation in Bulgaria for the period 2001-2017

Years	Total (thousands toe)	Natural gas (thousands toe)	Petroleum products (thousands toe)	Renewable fuels and wastes (including non-renewable waste) (thousands toe)	Electrical energy (thousands toe)	Transport performance (mln. pkm)
2001	46,4	-	46,4	-	-	10,1
2002	27,4	-	27,4	-	-	10,4
2003	24,2	-	24,2	-	-	17,3
2004	19,6	-	19,6	-	-	17,3
2005	13,4	-	13,4	-	-	18,9
2006	24,7	-	24,7	-	-	22,0
2007	41,1	-	41,1	-	-	32,0
2008	13,4	-	13,4	-	-	56,0
2009	23,6	-	23,6	-	-	45,0
2010	15,4	-	15,4	-	-	44,0
2011	21,6	-	21,6	-	-	70,0
2012	11,3	-	11,3	-	-	70,0
2013	12,3	-	12,3	-	-	62,0
2014	9,3	-	9,3	-	-	57,0
2015	13,4	-	13,4	-	-	55,0
2016	19,5	-	19,5	-	-	-
2017	20,6	-	20,6	-	-	-

Source: National Statistical Institute, 2019.

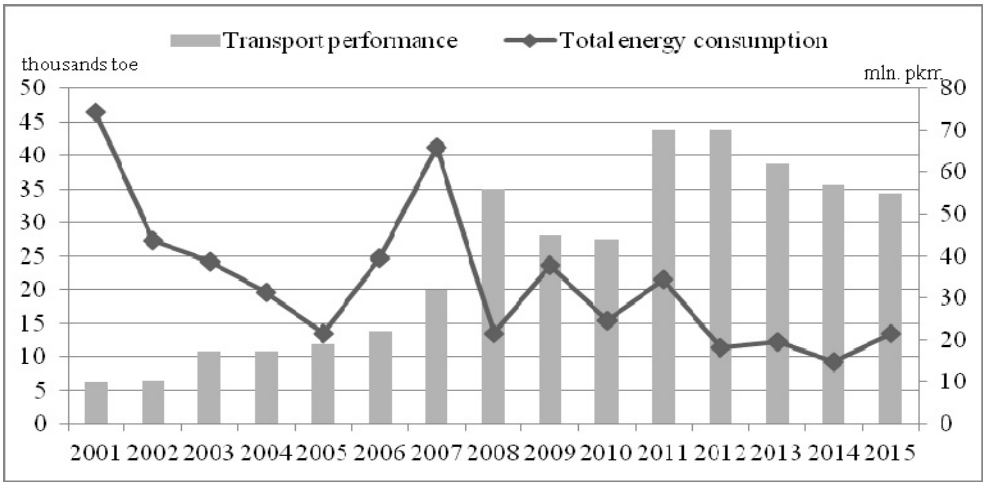
Domestic flights have been developing more intensively since 2006, when "Fraport Twin Star Airport Management" won a 35-year concession at the airports in Varna and Burgas, with an option to extend it. The airport operator has invested nearly BGN 368 million at the two Black Sea airports, its priority being the opening of new destinations (Chipilski, 2018).

This is impossible within the country, as the main traffic is borne by 4 airports in Sofia, Burgas, Varna and Plovdiv, but on an international scale, this is a reality.

If we follow the movement of the indicators for final energy consumption and performance on the domestic lines of the country there is a sharp border between their directions after 2007 (see Figure 9).

Figure 9

Dynamics in the development of final energy consumption and performance in the domestic aviation of Bulgaria for the period 2001-2015



In 2008 the effective operation of the flights performed in the country is clearly expressed as the trends we witness are in changed directions compared to the period 2001-2007. With slight fluctuations, total energy consumption has been steadily decreasing over the years, while at the same time there is an unsteady increase in performance, but at steadily higher levels than in the early millennium. While the decline in the first indicator is a consequence of the entry of companies operating in the country's domestic airspace airplanes with lower fuel costs, the dynamics of the second indicator is due to the increased interest of passengers in domestic flights, as a result of which their number jumped from 26,000 in 2001 to 156,000 in 2015, with two spikes in 2011 (199 thousands) and 2012 (197 thousands).

To sum up, we can say that air transport is developing in a positive direction in terms of energy costs and reported results. These trends are expected to be maintained, as in this sector the concession of Sofia Airport will be particularly influential as the biggest air transport infrastructure in Bulgaria. The conditions of the concession presume the airport to be held for 35 years, with a total prime cost of around 3.9 billion euro. The concessionaire will be required to build a third terminal, which will have to be done within a period of 10 years from the date of contract. Also his investments will have to be at least 600 million euro (Stoycheva and Boneva, 2018).

Also interesting are the structural indicators of the final energy consumption in transport of Bulgaria, which reveal the lack of balance in the sector (see Table 6 and Figure 10).

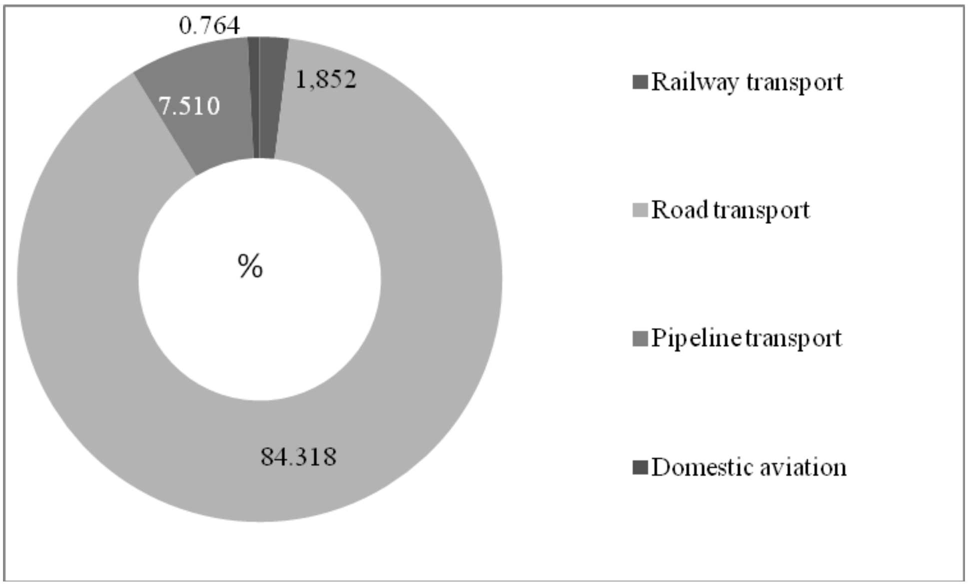
Table 6

Structure of final energy consumption in Bulgarian transport for the period 2001-2017 (%)

Years	Total	Railway transport	Road transport	Pipeline transport	Domestic aviation
2001	100	3,599	86,753	7,313	2,335
2002	100	3,403	88,297	6,975	1,325
2003	100	2,949	91,905	4,070	1,076
2004	100	2,684	90,787	5,719	0,809
2005	100	2,403	88,997	8,107	0,493
2006	100	2,203	88,893	8,040	0,865
2007	100	2,085	86,896	9,534	1,485
2008	100	2,157	88,357	9,022	0,465
2009	100	1,858	92,134	5,152	0,856
2010	100	1,685	92,426	5,318	0,572
2011	100	1,449	90,293	7,475	0,783
2012	100	1,445	91,094	7,073	0,388
2013	100	1,102	85,319	13,140	0,439
2014	100	0,930	87,738	11,031	0,301
2015	100	1,175	89,558	8,867	0,399
2016	100	1,075	89,812	8,542	0,571
2017	100	1,133	88,470	9,811	0,585

Figure 10

Average relative share of the final energy consumption in the transport of Bulgaria for the period 2001-2017



The unbalanced structure of final energy consumption is an indicator of the lack of effective and environmentally friendly solutions in the Bulgarian transport sector, given the high relative share of road transport. This focuses our attention on the fact that petroleum products are the main energy source used in the country's transport system. Conceptually this means that the pollution in the atmosphere is at significant levels. In a positive light, we are looking at the results reported by air transport (0.762% average final energy consumption over the whole period) that are adequate to the "green" development strategies, because in practice the overcoming of air distances means 100% consumption of petroleum products. At present, environmentally friendly technologies related to the use of natural gas or electricity are not being used in this transport segment.

In the 2001-2017 survey, two years were highlighted, configuring extreme energy consumption, which accounted for the highest percentages for pipeline transport and one of the lowest for road haulage. We highlight this finding, given the priority position to be taken by pipeline transport, based on the used energy sources – natural gas and electricity, i.e. two environmental solutions.

On this basis, we can make the conclusion that Bulgaria has conditions for the restructuring of the final energy consumption in transport on the basis of the higher activity of the ecological transport options, i.e. by increasing the operating levels of the railway and pipeline transport alternatives. They should be developed as a matter of priority in view of their underlying characteristics relating to energy consumption and the volumes of transported goods.

Another possibility for changes in the structure of final energy consumption is the transformation of the energy sources used in the most widely used transport option, such as road transport, by stimulating the development of technologies that consume natural gas and electricity.

An important player in the transport services market and respectively a significant fuel user are the municipal transport companies operating in all geographic regions of the country which requires the monitoring of the change in fuel consumption in municipal transport by economic planning regions in Bulgaria during the last reporting period 2017 compared to 2016 (see Table 7).

Following the dynamics of the change in fuel consumption by country, we find that the quantities of diesel fuel used have decreased most seriously. These processes respond to the European initiatives aimed at limiting diesel-powered vehicles. The reasons for taking these measures are the harmful emissions of nitrogen oxides (NOx), which are released into the air. The European Union applies a system of standards for normative emissions, differentiated according to the type of vehicles, which are updated periodically. Effective as now are: from 31 December 2013, the Euro VI standard for high power diesel engines and from 1 September 2014 Euro 6 standard for light commercial vehicles.

The objective of the Euro VI standard is to set the exhaust emission limit values for high-power diesel engines, i.e. heavy-duty vehicles, which typically include diesel-powered trucks and buses. These norms have the following empirical expression: carbon monoxide

(CO) to 1.5 g/ kwh, hydrocarbon (HC) to 0.13 g/kwh, nitrogen oxides (NOx) to 0.4 g/kwh, fine particulate matter) to 0.01 g / kwh and smoke to 8.10 umh^{-1}.

Table 7

Change in fuel consumption in municipal transport by economic planning regions in Bulgaria in 2017 compared to 2016 (liters)

City	Total diesel fuel	Impurity biodiesel (6%)	Total gasoline	Impurity bioethanol (7%)
North-East region				
Varna	-562292,0	-33737,1	-7675,0	-543,3
Dobrich	-90377,3	-5422,3	-31159,8	-2181,0
Targovishte	82150,8	4928,6	61395,4	-10002,4
Shumen	-164855,4	-10429,9	42991,5	-88,2
Total	-735373,9	-44660,7	65552,1	-12814,9
Southeastern region				
Burgas	-95339	-5711	1730	121
Sliven	-48611	-2917	4326	303
St. Zagora	-51497	-2090	-28466	-1992
Yambol	-42893	-2574	-11883	-764
Total	-238340	-13292	-34293	-2332
Northwestern region				
Vidin	5 116	307	1 431	102
Vratsa	-401 418	-24 085	-6 340	-443
Lovech	-128	-8	-2 675	-179
Montana	-70 268	-4 216	-22 731	-1 591
Pleven	42 169	2 529	38 890	2 725
Total	-424 528	-25 473	8 575	613
Southwestern region				
Blagoevgrad	-123 097	-7 256	-38 784	-2 716
Kyustendil	-34 104	-2 047	251 181	17 551
Pernik	-12 517	-801	8 058	559
Sofia	-10 550 794	-633 047	-70 693	-4 948
Total	-10 720 512	-643 151	149 762	10 446
South Central Region				
Kardzhali	10 859	651	9 809	687
Pazardzhik	-92 657	-5 560	2 690	188
Plovdiv	-75 047	-4 502	6 853	479
Smolyan	5 658	339	12 329	864
Haskovo	-65 437	-3 926	-42 733	-2 992
Total	-216 624	-12 998	-11 053	-774
North Central Region				
V. Tarnovo	65 339	321	-3 475	-243
Gabrovo	-913 238	-54 795	-15 321	-1 073
Razgrad	84 419	2 066	-948	-66
Ruse	-23 389	-1 404	-3 001	-210
Silistra	-13 589	-846	22 731	1 592
Total	-800 458	-54 658	-13	0

Source: Agency for Sustainable Energy Development, 2016 and 2017.

In only five Bulgarian cities there is an increase in the consumption of diesel fuel in municipal transport and these are Targovishte, Vidin, Kardzhali, Smolyan, Veliko Tarnovo and Razgrad. The most serious decline in diesel consumption is reported in Sofia related to the commissioning of new gas and electric buses, renewal of tramways and trolleybuses, which reduces the average age of the rolling stock and the amount of exhaust gases in the atmosphere.

Parallel to the reduction of the total diesel fuel used in the municipal transport of the country, the decrease of about 6% and the quantities of biodiesel is reported, as according to Art. 47 of the Renewable Energy Act, diesel fuel should contain 6% of biodiesel (Renewable Energy Act Effective, 2018). Similarly, within the meaning of the same law, gasoline fuel should contain 7% bioethanol. This is also the reason to observe unidirectional dynamics of movement of reported data - when reducing petrol consumption, it drops by approximately 7% and the amount of bioethanol mixtures. Only in the Northeast region this rule is not met and the growth in total petrol consumption is accompanied by negative amounts of bioethanol mixtures.

The main conclusions that can be systematized on the basis of an analysis of the dynamics in the development of the final energy consumption in the transport sector of Bulgaria are:

1. The final energy consumption in rail transport is reduced for the period 2001-2017, by changing the structure of fuels used in favour of electricity at the expense of petroleum products. In regard to the relation between the total energy consumption and the work performed by the railway transport, there is a downward trend on both indexes.
2. Road transport shows a progressively increasing positive trend in terms of efficiency measured on the basis of work (effect) and total energy consumption (resource), with reported growth in biofuel consumption over the period 2001-2017.
3. Pipeline transport has shown inefficiencies when comparing energy consumption and performance. The indicators, that take into account the priority consumption of natural gas are positive and, the ones using electricity to a lesser extent, which are one of the most environmentally friendly sources of energy.
4. In air transport, there is a certain instability in performance indicators over the period 2001-2017 and a relatively steady trend in total final energy consumption growth. Specifically for domestic flights, the market situation has changed since 2007, which to some extent we associate with the concessions of the airports in Varna and Burgas.
5. The structure of final energy consumption in Bulgaria's transport sector is unbalanced, as road transport consumption ranges between 85,319% (2013) and 92,426% (2010). This in practice means that in Bulgaria's transport system the most widespread applications have the petroleum products, as they are the major source of energy for the motor vehicles in the country.
6. At the municipal level, fuel consumption is evolving towards a reduction in diesel fuel, which corresponds to European initiatives aimed at limiting and completely decommissioning diesel-powered vehicles.

The analysis of the dynamics in the development of the final energy consumption in the transport sector of Bulgaria and the main conclusions objectively focus on the search for new opportunities for its restructuring, in order to increase the levels of energy efficiency and preservation of the natural resources.

3. Technologies as a means of improving energy consumption in Bulgaria's transport

Technology development is one of the factors that is expected to make the biggest contribution to protecting the living environment. In the practice new technologies that influence the energy consumption of rolling stock in transport are known. "As it does not matter for the grid, what kind of energy is used to generate electricity, in the same manner, the means of transport and the fuel distribution system must be open to a diverse mix of fuels. This is in the spirit of the emerging neo-industrial era, and there is already movement in that direction, though it is only at the beginning – pure electric vehicles, hybrid electric vehicles, methanol vehicles, etc." (Milina, 2013, p. 58), as well as the so-called technological "communication" road transport.

Definitions that are recognized by European and Bulgarian law are defined according to Art. 3 of Regulation (EC) № 168/2013[2] and they are:

"Hybrid vehicle" means a motor vehicle which is equipped with at least two different energy converters and two different energy storage systems (in-vehicle) for driving.

"Hybrid electric vehicle" means a vehicle which, for the purpose of mechanical propulsion, draws energy from the following two energy storage/power sources in the vehicle:

(a) fuel for consumption;

(b) a rechargeable battery, a condenser, a flywheel/generator or other device for storing electricity or power.

This definition also includes vehicles that draw energy from fuel for consumption only for the purpose of recharging an electrical energy / power storage device.

Hybrid cars are a new and at the same time already proven opportunity to reduce fuel consumption and emissions of harmful substances in the atmosphere (Selifonov, etc., 2007, p. 31). The hybrid vehicle engine delivers significant fuel savings, reduced environmental emissions, reduced overall engine running time, especially in areas where urban driving is stopped, which has a positive effect on the performance of such vehicles compared to conventional ones.

Under the meaning of the law, "All-electric vehicle" means a vehicle driven by:

(a) a system of one or more electrical energy storage devices, one or more electrical power control units and one or more electrical machines for converting stored electrical energy into mechanical energy to be transmitted to the vehicle drive wheels;

[2] With Ordinance № 117 for the type approval of new L category vehicles, March 2018, it is ensured that Regulation (EU) № 168/2013 of the European Parliament and of the Council of 15 January 2013.

(b) an auxiliary electric drive mounted on a vehicle powered by pedals;

For the purposes of Regulation (EU) № 168/2013, the following categories and subcategories shall apply:

(a) a category L1e vehicle (light-duty two-wheeled motor vehicle);

(b) a category L2e vehicle (three-wheel moped);

(c) a category L3e vehicle (two-wheel motorcycle);

(d) a category L4e vehicle (two-wheel motorcycle with sidecar)

(e) a category L5e vehicle (three-wheel motor vehicle);

(f) a category L6e vehicle (light four-wheeled);

(f) a category L7e vehicle (heavy four-wheeled).

In creating energy-efficient vehicles, much attention is paid to reducing energy consumption to overcome movement resistance, focusing primarily on the strength of rolling resistance, the inertia of the vehicle during acceleration and the strength of aerodynamic drag. Given the operating conditions of an electric vehicle in modern high traffic density cities and frequent "acceleration-delay" cycles, the presence of a large battery is ineffective in terms of these losses. A positive feature of an electric vehicle is the absence of harmful emissions in its use, which defines electric vehicles as an environmentally friendly mode of transport suitable for use as personal, commercial or public transport (Bakhmutov, etc., 2015, pp. 4-5).

Also interesting are the technologies forming the basis of the hydrogen economy, due to several advantages of hydrogen over other fuels, which can be reduced to (Petrov, 2019, pp. 465-466):

- the high availability of hydrogen in the universe (according to the astrophysicists, 75% of the mass and 90% of the number of atoms consists of hydrogen);
- the conversion of hydrogen into electricity is done quickly and efficiently (fuel cell efficiency reaches 60-70% or more) (Tawfik, H., 2003);
- products using hydrogen and hydrogen itself at the exhaust do not harm the environment;
- high lightweight and diffusion lead to a relatively low explosion hazard (hydrogen is ignited at concentrations much lower than in an explosion). At the same time, the strength of a hydrogen explosion is 22 times less than that of petrol vapour, and the hydrogen output of the hydrogen flame is 7% lower than that of gasoline;
- there are already pipelines to transport hydrogen over long distances. In addition, the theoretical energy losses during the transport of hydrogen are estimated to be half of those in electricity transmission to power lines. Also, pipelines can be cheaper, easier to deploy, and safer than ground high-voltage power lines (Lovins, 2003, pp. 8-9).

At present, the legislative framework does not cover the technological "communication" vehicle, also called a non-pilot vehicle or automated controlled vehicle, which is self-driven and, after an initial moment, management decisions are taken without human intervention. Therefore, the main distinctive feature of conventional vehicles is related to the exploitation of artificial intelligence that partially or completely replaces the human factor in management with its rational and emotional solutions.

The development of self-driving technology in freight transport can lead to radical improvements in fuel efficiency, emission reduction and pollution reduction. This is possible when heavy truck convoys move, which accelerate, stop and run synchronously with each other and according to other vehicles.

With a view to improving energy consumption in transport, the state should take measures to motivate consumers to target so-called "green" transport solutions. To this end, the purchase and use of green cars and electric motorcycles, mopeds and electric vehicles of categories L1e-L7e should be encouraged as they are related to electric and hybrid transport when driven by an electric or hybrid engine, by exempting owners from paying an annual local tax, taking into account their characteristics and ecological parameters.

One of the incentives to promote sales of environmentally friendly cars can be financial levers with which to exempt partially or completely from tolls, the owners of such cars, who are correct payers to the state and municipal budgets, have no violations within the meaning of the Road Act, and in the case of company vehicles, apart from the driver's integrity, account should also be taken of the profile of the economic operator who owns the vehicle.

This is fully possible after the introduction of an electronic toll collection system, as it will provide data, which is to be a platform for deploying applications based on intelligent transport systems, ranging from data collection for traffic management to providing mobile services to road users. In Bulgaria, the toll system is of mixed type, which means that passenger traffic uses electronic vignettes, and cargo traffic is charged on a real-distance basis, which can be done in two ways: on-board units, which will not be mandatory and by purchasing, online or by special machines, a routing ticket that will take into account the distance travelled and the selected roads – highway, first-class, second-class, third-class.

Local authorities should also join environmental policy, besides tax incentives, they can provide some privileges to environmental vehicle owners such as free parking spaces in central city areas, reserved parking spaces in other urban areas, increased public transport fleets driven by gas and electricity in the populated areas.

Mobile applications should also be developed to encourage people to re-orientate from passenger cars to more intensive use of public transport services. These applications need to monitor the frequency of public transport and the distance travelled by car. On this basis, assessment scales can be configured to take account of these indicators, compare them with the results of the other participants, with a view to drawing up a weekly, monthly and yearly ranking, and on this basis to provide preferences for payment of dues to the municipality for the citizens with the highest ecological parameters during the year. The idea of the application should be encouraging on the basis of mutual competition between citizens, with the idea in the long term to build awareness of personal responsibility to environmental problems and the involvement of everyone in their solution.

For the purpose, a number of technologies must be put in place, as this will require, for example, the purchase of an electronic ticket, which will take into account the use of public transport. Such a work platform algorithm has been developed in Varna and includes the following steps ("Urban Transport" EAD Varna, 2019):

Each passenger must first download the TICKEY mobile app from the respective e-shop. For users with Android operating system the application is from Google Play, and for iOS operating system users, it's from the App Store. The app is free for users.

As a second step, the passenger must have registered in the system with his name, email, password, and bank card. Debit and credit cards, as well as PayPal, are accepted.

TICKEY mobile application for electronic ticket purchase works only when the passenger is in a vehicle equipped with proximity sensors. Every vehicle must therefore be equipped with such sensors. When the passenger boards the vehicle and the application starts, a connection is established between the proximity sensor and the mobile application. At the passenger's leaving the vehicle the connection is respectively interrupted.

With only one click on the screen of your mobile device on the "BUY" sign, the passenger confirms the purchase transaction and pays the price displayed on the screen, then receives an "Electronic Ticket" with all the requisites. The ticket is validated with a correct and valid date and time. The payment is made by transferring the specified amount to the bank account of "Tickey Mobile Solutions" Ltd. from the bank card entered upon registration.

All actions described above are recorded on a server designed specifically for the purpose of the project in Varna and can be controlled by authorized employees of "City Transport" EAD Varna.

In the worldwide practice, the principle of buying an electronic ticket does not imply a need to place the buyer in the vehicle, as this can also be done through a remote platform, and in order to stimulate the purchase of such a travel document by electronic means rather than conventional ones, discounts are also envisaged.

Therefore, the technological progress reveals the potential for finding environmental solutions that engage both state and local government resources, as well as economic operators and Bulgarian citizens.

Conclusion

Satisfying unrestricted needs with limited resources is a major economic problem that has reached high levels of relevance in recent years. The reasons for this are mainly the consumer's attitudes of the society, which are expressed in the ever-wider and varied needs of the modern individual. In turn, they also give rise to the pursuit of business agents, operating in a competitive environment, to offer a diversified product portfolio in the widest possible market.

It is these supply and demand characteristics that drive the market mechanism at faster speeds and directly or indirectly find a tangent to the transport sector. In this respect, the role of transport operators, which seek to respond adequately to their expectations, is also strengthened. The high intensity of demand for transport services reflects directly on the final energy consumption and forms a new rank of needs, satisfied in a fundamentally new way, based on the environmental and equity considerations in the exploitation of transport alternatives.

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