METHODOLOGY OF FORECASTING AND FORECAST OF DEMAND FOR ENERGY CARRIERS BY LORRIES IN POLAND UP TO THE YEAR 2020 (PART I)

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Abstract

Discussed methodology of forecasting and forecast of demand for energy carriers have been presented in two parts. In this part has been give forecast of freight road transport volumes up to the year 2020, estimated structure of the fleet in the initial period of the forecast and variant forecast of the fleet size and its structure according to categories and age. In second part has been given forecast of demand for energy carriers by lorries. The forecast of freight road transport volumes has been developed through an innovative application of the expert cross-influence method. It was assumed that economic and social events exerting a particularly strong influence on the future development of freight road transport volumes in Poland currently are and will continue to be in the future as follows: economic development of the state, changes in the structure of GDP production, development of the international exchange of goods, increase in investment and domestic consumption, decrease in material consumption and energy consumption of the production, development and modernization of road infrastructure and rail transport, internalization of transport external costs, changes in spatial arrangement of production, storage and consumption. The forecast of transport included two variants. The pace of growth of freight road transport in 2020 should fall within the range of 147 - 152% in comparison to figures recorded in 2004. As far as absolute values are concerned that would correspond to about 190 - 196 billion tonne - kilometers.

Keywords: *Motor transport, lorries, forecast*

1. Introduction

Each and every modern transport policy has to take into account, besides the undeniable advantages, the problem of a destructive impact motor transport has on the environment. In search for a rational compromise, transport policy makes references to the principles of the so called sustainable development (French: development durable), understood, in the broadest possible terms, as meeting current needs in such a way so as not to inhibit future generations from satisfying their needs.

What poses a threat to sustainable development understood as referred to above, a threat generated by motor transport in the first place, is increasing use of oil-based fuels as well as contamination of the atmosphere due to pollutants emitted from combustion engines. (Motor transport is responsible among others for the vast portion of the estimated 30% of greenhouse gas emissions).

One of the basic challenges facing transport policy is limiting energy consumption by the road transport as well as curbing the level of emissions resulting from such consumption. Forecasting energy and ecological results of road transport development is significant in arriving at comprehensive evaluations pertaining to further development of this branch of transport, especially in view of current and future undertakings of the transport policy pursued by the state.

Hence, ITS (Motor Transport Institute) had developed a research and forecasting methodology pertaining to measuring the demand for energy carriers in connection with the expected development of freight road transport. ITS has also developed means of verifying such methodology under specific domestic conditions.

The developed methodology of forecasting and a variant forecast up to the year 2020 refers to the following:
- freight road transport volumes,
- number of lorries in the fleet and structure of the fleet according to category and age.

2. Forecast of freight road transport volumes

The forecast of freight road transport volumes has been developed through an innovative application of the expert cross-influence method (also referred to as mutual influence of events). It is an expert method which bases the forecast on the evaluation of the impact certain events have on the future shape of transport.

It was assumed that economic and social events exerting a particularly strong influence on the future development of freight road transport volumes in Poland currently are and will continue to be in the future as follows:
- economic development of the state,
- changes in the structure of GDP production,
- development of the international exchange of goods,
- increase in investment and domestic consumption,
- decrease in material consumption and energy consumption of the production,
- development and modernization of road infrastructure and rail transport,
- internalization of transport external costs,
- changes in spatial arrangement of production, storage and consumption.

The dynamics of predicted changes in transport devised by experts and probability of mutual events laid foundations for developing a forecast of the pace of freight road transport volume up to the year 2020.

The forecast of transport included two variants. Variant “min” takes into account eight events mentioned above which have influence on the future freight road transport volumes. Variant „max” omits internalization of transport external costs.

The pace of growth of freight road transport in 2020 should fall within the range of 147-152% in comparison to figures recorded in 2004. As far as absolute values are concerned that would correspond to about 190-196 billion tonne - kilometres (Tab. 1.).

The dynamics of predicted growth in the years 2004-2020 should amount to an annual average of 3.6% (pursuant to the „min” version). It is expected to be lower than the dynamics recorded in the period 1990-2003 (an annual average of 7.2%).

The forecast increase in the transport volume is going to influence the rolling stock of the maximum total weight of more than 3.5 t; including but not limited to the rolling stock the maximum total weight of which exceeds 16.0. It is assumed that in 2020 about 95% of the transport volume will be performed by lorries of more than 3.5 t of the maximum total weight. In 2020 an estimated 88% of the entire freight road transport volume will be carried out by the rolling stock of the maximum total weight exceeding 16.0 t (about 84,8% in 2004). The transport volume scheduled for 2009 for vehicles of the maximum total weight of more than 3.5 t, should fall within the range between 180.7 and 186.6 billion tonne-kilometres, and out of that amount the rolling stock of the maximum total weight of more than 16.0 t would be responsible for 167.4 to 172.8 billion tonne - kilometers (Tab. 2).

According to estimates, in 2020, transport volumes performed by lorries of the maximum total weight of up to 3.5 t will amount to 9.5 – 9.8 billion tonne - kilometers.

3. Estimated size of the fleet of lorries

The future number of lorries and the structure of the fleet depends on the size and structure of the vehicle fleet in the period prior to that in which the forecast was conducted, on the expected amounts of transport, on average transport efficiency of a vehicle (in each of the specified categories), as well as on the predicted replacements in the rolling stock. The estimated future

number of lorries was split into the following categories: groups of GVW, types of energy carriers, vehicle production periods (characteristic of the technical level of construction).

The total number of lorries and truck-tractors registered in Poland in the initial period of the forecast (end of 2004) amounted to 2392 thousand. (Tab. 3).

Tab. 1. Forecast of freight road transport volumes

Year	Variant "min"		Variant "max"	
	Forecast dynamics of changes	Freight transport volumes	Forecast dynamics of changes	Freight transport volumes
	%	mln tkm	%	mln tkm
2004		110481		110481
2005		119740		119740
2006	100,0	129000	100,0	129000
2007	102,5	132173	102,6	132341
2008	105,0	135476	105,3	135811
2009	107,7	138894	108,1	139436
2010	110,4	142455	111,0	143190
2011	113,3	146144	114,0	147112
2012	116,6	150362	117,6	151678
2013	120,0	154774	121,3	156451
2014	123.5	159367	125,2	161444
2015	127,3	164153	129,2	166668
2016	131,1	169158	133,4	172125
2017	135,0	174098	137,8	177788
2018	139,0	179246	142,4	183696
2019	143,1	184625	147,2	189888
2020	147,5	190249	152,2	196351

Source: Main Statistical Office, Transport - results of activity in 2004, p. 96
Research task No 1 at ITS No 9537/ZBE, Warsaw, 2006

Tab. 2. Forecast freight road transport volumes up to 2020 under different variants (billion tone - kilometers)

Specification	2004	2010		2015		2020	
		min	max	min	max	min	max
Total	110,5	142,5	*143,2*	164,2	*166,7*	190,2	*196,4*
Including:							
- up to 3.5 t GVW	7,6	8,0	*8,1*	8,6	*8,8*	9,5	*9,8*
- Above 3.5 t GVW including:	102,9	134,5	*135,1*	155,6	*157,9*	180,7	*186,6*
- From above 3.5 to 16.0 t of GVW	9,2	10,0	*10,2*	11,5	*11,8*	13,3	*13,8*
- Above 16.0 t of GVW	93,7	124,5	*124,9*	144,1	*146,1*	167,4	*172,8*

Source: Research Task No 3 "Forecast of the number vehicles in the freight fleet and its structure according to categories and age" at ITS No 9537/ZBE, Warsaw, 2006

The rolling stock of the GVW of up to 3.5 t accounted for about 75% of the lorries in the fleet structure (1830 thousand). Since late 1980`s Poland has seen a growing tendency towards an increased share of light lorries in the fleet structure. A significant share of light vehicles in the fleet of lorries is a characteristic feature of the majority of economically developed countries. There were about 381 thousand lorries of the GVW of more than 3.5 t and up to 16.0 t , whereas the number of those the GVW of which exceeded 16.0 t equaled 181 thousand. A growing tendency in the latter fleet category has been noted. In 2004 the heaviest rolling stock (vehicles of the GVW of more than 3.5 t in the fleet) made up about 32% of the total number of vehicles in Poland (about 26% in 2002).

Recent years have seen changes in the fuel structure of vehicles of the maximum total weight of up to 3.5 t. Particularly dynamic changes have been observed in the vehicles equipped with compression-ignition engines as well as with dual-fuel engines.

The age structure of the fleet of lorries registered in Poland is undergoing positive albeit slow changes. Import of second-hand vehicles of the maximum total weight of more than 16.0 t has contributed to an increased number in the structure of the Polish fleet of vehicles manufactured in the period from 1991 until 2000.

Tab. 3. Estimated number of lorries registered in Poland according to specified categories and production periods (as of the end of 2004)

No	Vehicle category	Number of registered vehicles (thousand)				
		Total	Including vehicles produced in years:			
			until 1990	1991-1995	1996-2000	2001-2004
	Total	*2392*	*940,8*	*341,2*	*629,8*	*480,2*
1.	Lorries of up 3.5 t GVW	1830	585	253	547	445
1.1.	Including: positive ignition	901	427	97	188	189
1.2.	compression ignition	758	137	132	303	186
1.3.	LPG	150	0	24	56	70
1.4.	two stroke	21	21	0	0	0
2.	Rolling stock of more than 3.5 t GVW	562	355,8	88,2	82,8	35,2
2.1.	Including: compression ignition from over 3.5 to 16.0 t GVW	380,9	289,3	40,4	39,5	11,7
2.2.	compression ignition over 16.0 t GVW	181,1	66,5	47,8	43,3	23.5

Source: Research Task No 2 entitled: "Estimated fleet structure in the initial period of the forecast" of project No 4 T 12C 037 28; Warsaw, 2006

Bearing in mind major diversification in the specificity of transport tasks carried out by the rolling stock of the GVW of up to 3.5 t and by the rolling stock of the GVW exceeding 3.5 t, a variant-based approach was applied as regards the issue of the future condition of an average annual transport efficiency of the discussed category of lorries.

Taking into account premises pertaining to the average annual transport efficiency of a statistical lorry in the period until 2020 (according to variant I) there are reasons to expect that the above-mentioned figures of 25 thousand tonne-kilometres in case of the rolling stock of the maximum total weight ranging from 3.5 to 16.0 t GVW, and of 520 thousand tonne-kilometres in case of the rolling stock of the GVW in excess of 16.0 t, will fall into variant I (Tab. 4). Pursuant to variant II of the average annual transport efficiency of a lorry, an increase in the above-mentioned figure in the range of 50% up the year 2020 is expected. This translates into about 36 thousand tonne-kilometers/vehicle in case of a fleet composed of vehicles of the maximum total weights ranging from more than 3.5 to 16.0 t GVW. Whereas in case of a fleet made up of vehicles of the maximum total weights exceeding 16.0 t GVW, we arrive at the number of 770 thousand tonne-kilometers/vehicle.

Tab. 4. Average annual efficiency values of transport volumes by a statistical lorry of the GVW exceeding 3.5 t, in the forecast period up to 2020 (thousand tonne - kilometers/vehicle)

Specification	Variant	Thousand tkm/vehicle in year				
		2004	2005	2010	2015	2020
from more than 3.5 t GVW	I	24,2	24,2	25	25	25
	II	24,2	24,2	27	31	36
exceeding 16.0 t GVW	I	517,4	517,4	520	520	520
	II	517,4	517,4	580	660	770

Source: Research Task No 3 entitled "Forecast of the number of vehicles in the fleet of lorries and structure of the fleet according to categories and age" at ITS No 9537/ZBE, Warsaw, 2006

A far as a fleet of lorries of the GVW of up to 3.5 t is concerned, which currently carries out less than 7% of the freight road transport volumes, it is assumed that the average annual transport efficiency of such fleet in the forecast period will remain at broadly the same level as in the pre-forecast period (about 4.2 thousand tonne-kilometers/vehicle/year).

The forecast of the number of lorries according to groups of GVW was developed in variants which resulted from two variants of the forecast transport volume and from two variants of the forecast average annual transport efficiency of a statistical vehicle (in respect of the rolling stock of the GVW exceeding 3.5 t). Out of four forecast variants pertaining to the number of lorries and covering the period up to 2020, it is two extreme ones that constitute basis for further deliberations. They were given the following names: a „developmental" variant and a „non-developmental" variant.

The „developmental" variant of the forecast includes: the „min" variant of the forecast transport volumes and variant II of the forecast average annual transport efficiency of the respective categories of lorries. The „non-developmental" variant covers: the „max" variant of the transport volumes and variant I of the forecast average annual transport efficiency of the respective categories of lorries.

According to the developmental variant, the total number of lorries in 2020 should amount to about 2849 thousand, whereas, pursuant to the non-developmental variant, it should amount to about 3218 thousand (Tab. 5).

Tab. 5. Forecast number of lorries in Poland until 2020 according to groups of GVW under different variants (thousands)

Specification	2010		2015		2020	
	dev. variant	n-d variant	dev. variant	n-d variant	dev. variant	n-d variant
Total	2720	2577	2637	2848	2849	3218
Including:						
- up to 3.5 t GVW	1905	1929	2048	2095	2262	2333
- Above 3.5 t GVW including:	585	648	589	753	587	884
- From above 3.5 to 16.0 t of GVW	370	408	371	472	369	552
- Above 16.0 t of GVW	215	240	218	281	217	332

Source: Research Task No 3 "Forecast of the number vehicles in the freight fleet and its structure according to categories and age" at ITS No 9537/ZBE, Warsaw, 2006

In 2020 the number of lorries of the GVW of up to 3.5 t in Poland should be between 2262 and 2333 thousand, whereas the number of those of the GVW exceeding 3.5 t, between 587 and 884 thousand. The share of lorries of the maximum total weight of up to 3.5 t would amount to about 79% and 73% respectively.

Compared to the total size of the fleet of lorries in the initial period of the forecast, we would observe an increase of 19-34%. In case of vehicles of the GVW of up to 3.5 t, the expected increase would amount to 24-27%, whereas that of the rolling stock of the GVW exceeding 3.5 t, from 5 to 57%, depending on the forecast variant. In case of a fleet including vehicles of the GVW in excess of 16.0 t, the change referred to above would be 20% and 83% respectively.

When estimating the number of vehicles forming part of the fleet of lorries according to production periods, the process of replacement of the Polish fleet was taken into account. That process would include both, new vehicles entering the market and import of second-hand vehicles. It is probable that due to the economic situation in the coming years, a considerable number of small carriers will not be able to renew their fleet exclusively through obtaining new rolling stock. Hence, especially in the domestic transport, imported rolling stock will be partly replacing the old, worn out vehicles. It was assumed that the vehicles from the earliest production periods will be withdrawn from usage and signed off, including but not limited to those makes and models characterized by low production quality (low durability). Up to the year 2020 an expected increase of up to 57-58% in vehicles equipped with compression-ignition engines is envisaged in the structure of lorries of the GVW of up to 3.5 t (25% in 1995, more than 41% in 2004). This is going to result from the trends observed in recent years (Tab. 6-7).

Future share of vehicles equipped with engines adapted to LPG fuel is an estimated 10%. It is further assumed that the second half of the forecast period will already see a tangible share (about 2%) of lorries powered by natural gas (CNG).

Taking into account the above-mentioned assumptions, supplies of both new and second-hand lorries in the forecast period should contribute to the improvement of the age structure of the Polish rolling stock. For instance, among lorries of the GVW of up to 3.5 t, the share of vehicles of up to 10 years of age should increase to the level of 62-63% in 2020 (less than 55% in 2004). One further assumption is a considerable "rejuvenation" of the fleet of lorries of the maximum total weight exceeding 3.5t. In 2004 the share of the rolling stock of up to 10 years of age was barely 21%. An estimated increase to the level of 50-60% in 2020 is expected.

Tab. 6. Forecast of the number of lorries registered in Poland in 2020 according to groups of GVW and production periods (developmental variant)

No	Vehicle category	Number of registered vehicles (thousand)						
		Total	Including vehicles produced in years:					
			1991 - 1995	1996 - 2000	2001 - 2004	2005 - 2010	2011 - 2015	2016 - 2020
	Total	3217	30	97	385	697	1060	948
1.	Lorries of up 3.5 t GVW	2333	0	32	317	529	756	699
1.1.	Including: positive ignition	549	0	11	118	104	151	165
1.2.	compression ignition	1479	0	18	136	357	508	460
1.3.	LPG	250	0	3	63	68	75	41
1.4.	CNG	55	0	0	0	0	22	33
1.5.	two stroke	0	0	0	0	0	0	0
2.	Rolling stock of more than 3.5 t GVW	884	30	65	68	168	304	249
2.1.	Including: compression ignition from over 3.5 to 16.0 t GVW	552	13	32	30	103	218	156
2.2.	compression ignition over 16.0 t GVW	332	17	33	38	65	86	93

Source: Research Task No 3 entitled "Forecast of the number of vehicles in the fleet of lorries and structure of the fleet according to categories and age" at ITS No 9537/ZBE, Warsaw, 2006

4. Conclusions

- Development of the Polish economy and its international connections are going to generate further increase in transport tasks of freight road transport. A decrease in energy consumption by the economy as well as the expected development of rail transport will stop the growing trend. The dynamics of growth of freight road transport in the period of 2004-2020 will amount to 170-180%. An increase in freight road transport volumes will concern firstly and most importantly lorries of the GVW exceeding 3.5 t, including but not limited to the heaviest rolling stock - of the GVW of more than 16.0 t.
- Forecast dynamics of the number of lorries in the period: 2004-2020 fluctuates around 119-134% and depends on the adopted assumptions. The forecast dynamics of the number of lorries of the GVW of up to 3.5 t, fluctuates around 124-127%, whereas that of vehicles of the GVW exceeding 3.5 t - around 105-157%.
- Further switching to diesel fuels also in the area of light lorries rolling stock is expected. In the group of lorries of the GVW of up to 3.5 t, the number of vehicles equipped with compression-ignition engines is going to double in 2020 compared to 2004. The share of the rolling stock equipped with engines adapted to LPG will remain at broadly present-day level (10 %). As far as the available alternative energy carriers used for powering vehicles are concerned, the authors of this paper assume wider use of natural gas, especially in the vehicle group of the GVW of up to 3.5 t.
- In the forecast period a renewal of lorries fleet is expected. It should come about as a result of the improvement of vehicles` age structure, especially in the heaviest vehicle group, where the share of vehicles of less than 10 years of age should increase to the level of 50-60% in 2020.

References

[1] Menes, E., Waśkiewicz, J., Gis, W., Research project supervised by dr Edward Menes entitled, *Sustainable development of motor transport in Poland*, Research project No. 4 T12C 037 28; Motor Transport Institute, September, Warsaw 2006.

[2] Dorosiewicz, T., Dorosiewicz, S., *Construction of the detailed method of cross-influence (method of mutual influence of events)*, ITS; Research project of the Scientific Research Committee (KBN) reg. No. 8 T12C 038 21 entitled, Connections between economy and road transport - methods, evaluation, forecasts, Warsaw 2002.
[3] *GUS (Main Statistical Office)* - Statistical yearbook 2004.
[4] *Main Statistical Office*, Transport - results of activity in 2004.
[5] Waśkiewicz. J., *Estimated make and age structure of motor vehicles in Poland. 2003*, Vol 2 - Lorries, Vol. 3 - Truck tractors; ITS Paper No 6421/ZBE, Warsaw 2004.

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