European Research Studies Journal
Volume XXVI, Issue 1, 2023

pp. 203-221

An Analysis of the Current Structure of Means of Transport in Poland in Terms of Emission Performance

Submitted 20/01/23, 1st revision 11/02/23, 2nd revision 21/02/23, accepted 15/03/23

Mariusz Pyra[1]

Abstract:

Purpose: *This study analyses the current structure of the means of road transport in Poland in the context of emission performance and transition to sustainable mobility. Its main aim is to present numerical data for key categories of vehicles from the decarbonisation perspective, i.e. buses and trucks, as well as to formulate conclusions concerning the presence or absence of a qualitative improvement in these means of transport, as well as the nature of these qualitative changes, if any.*
Design/Methodology/Approach: *This study is based on secondary data sources, mainly the literature of the subject, statistical data from SAMAR reports with regard to the automotive market as well as statistical information from EUROSTAT. It employs a method involving the analysis of the structure and dynamics of phenomena related to the Polish road transport stock.*
Findings: *Statistical analysis allowed us to conclude that the structure of the means of transport in the Polish road transport sector has seen a noticeable qualitative improvement over the past 10 years, which involved the introduction of vehicles that comply with stricter exhaust gas emission standards, as well as vehicles with other sources of propulsion than internal combustion engines. Still, high-emission vehicles prevail in the sector. The scale of qualitative changes in the structure of the means of road transport in terms of emission performance (types of propulsion) is not permanent.*
Practical Implications: *The analyses carried out in this study reveal the condition of the Polish road transport sector in the context of zero-emission and low-emission transport. This type of study may provide a clear signal for decision-makers that the current steps are insufficient to achieve the set decarbonisation targets.*
Originality/Value: *The overall picture emerging from the analysis is not optimistic. The stock of vehicles in Poland's road transport is dominated by long used or old vehicles, which means that these vehicles have been in service for a long time and that they have poor emission performance, which is disadvantageous in the context of road transport decarbonisation targets.*

Keywords: *Road transport, decarbonisation, emission performance.*

JEL Classification: *C1, Q5, R4.*

Paper type: *Research article.*

---

[1]*Ph.D., Faculty of Economic Sciences, John Paul II University of Applied Sciences in Biala Podlaska, Poland, ORCID ID 0000-0001-8246-851X, m.pyra@dyd.akademiabialska.pl;*

1. Introduction

The Polish road transport sector, especially its commercial section, is a vitally important part of Poland's economy. In every domestic economy transport plays a key role in ensuring conditions for the efficient transport of goods, materials and raw materials. The same is true for the Polish transport sector and its high significance, also in the context of transport in the EU. To cite transport industry websites, in 2018 alone, of all 4.3 million trucks registered in the EU, about 680,000 (ca. 16%) were registered in Poland. Estimates also show that the Polish road transport sector handles 22.6% of the entire international transportation, hence its importance for both domestic and EU economy.

Both increased environmental awareness and the increasingly pressing problem of environmental pollution have forced the EU to look more stringently at the question of CO2 and other pollutant emissions. Consequently, the EU took a number of legislative steps and initiatives to cut the emission of pollutants by its member states. The last few years have seen increasingly frequent weather anomalies in Europe, which translated into tangible and quantifiable losses in the economies of the countries which have been the most affected (especially the south of Europe).

This led to a higher pressure from the public opinion to address the need to stop and limit the consequences of climate change and eliminate its causes. The issues related to the environment and its protection became an important part of public and political debate, increasingly focusing on factors shaping future investments and plans in areas subject to the EU's sector policies.

Vehicles are responsible for a considerable portion of the emission of pollutants negatively impacting the natural environment and quality of human life and health. For many years, the European Union has made efforts to restrict of harmful effects of transport operations. Particular importance is attached to the tightening of the Euro standards and the implementation of the "polluter pays" principle under Directive 2004/35/EC (Kamińska, 2021).

The Green Deal, the EU's flagship initiative, has seen updated CO2 emission targets for road transport. According to EU data, road transport is responsible for 22.3% of greenhouse gas and airborne pollutant emissions in the entire EU. Road transport alone accounts for 21.1% of all emissions, so it is hardly surprising that the pursuit of a faster reduction in total emissions has translated into stricter road transport reduction targets. The previous set of targets, which anticipated a 15% reduction in CO2 emitted by trucks by 2025, has been updated, and is currently set at 25%.

This allowed setting a new target for 2035 at a level of 50% (instead of the previously agreed 31%). Another important change was the modification of reference points for the targets. Current reference points are based on data collected from June 2019 to July 2020. This makes for a significant change, which in practice means tightening CO2 emission targets.

A justified question as to the feasibility of the newly accepted reduction targets encourages an analysis of the current state of the road transport sector in the context of the vehicle fleet at the disposal of businesses operating on the market.

The structure of road vehicles in Poland by age and drive system was analysed on the basis of data from SAMAR for 2010-2019 (a 10-year period). The analysis allowed for general categories assumed in SAMAR reports, i.e., buses, trucks and passenger cars.

However, in the context of the analysis, passenger cars constitute background rather than foreground, with main focus on trucks and buses as the predominant vehicles used in road transport to provide professional transport services (buses for passengers and trucks for goods). Of note is the fact that the truck category includes vehicles with a GVW in excess of 3.5 t, i.e., commonly used in medium- and long-distance cargo transport. This category also includes agricultural tractors.

2. Buses as a Vehicle Group

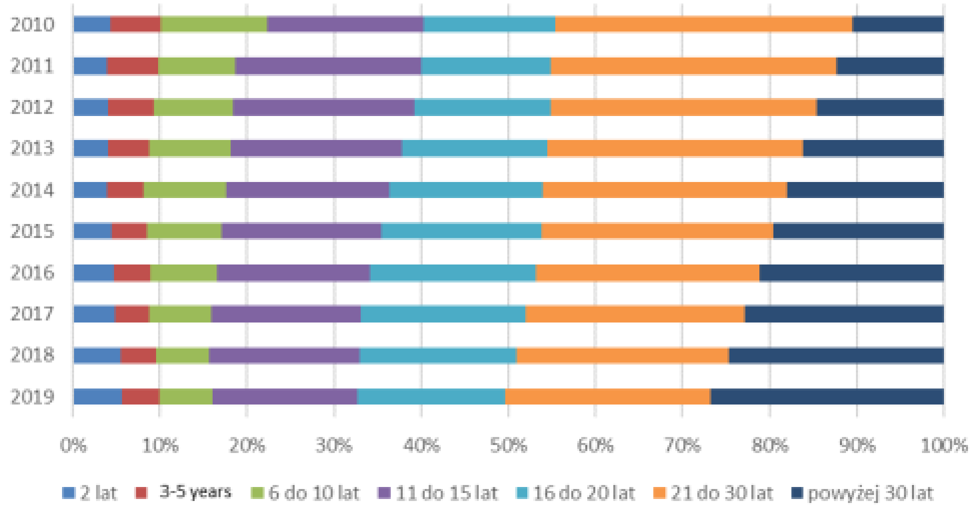
Buses were categorised as a separate group, mainly comprising vehicles operating in a municipal public transport network but also buses carrying passenger between cities, to and from suburban areas, and long-distance coaches. Buses are a significant group in the context of the present study.

In the years 2010-2019, the age structure of the bus stock in Poland (see figure below) improved noticeably. The proportion of vehicles aged up to 2 years in the structure was relatively constant almost throughout the analysed period, ranging from 4 to 4.6%. The only exception is data from 2018-2019, when their share in the structure rose by more than 5%. The proportion of 3-5-year-old vehicles in the bus stock is subject to a greater variation. In 2010, they accounted for 5.78% of all vehicles, to drop even below 4% in the subsequent years (in 2017).

Although in 2010-2014 the percentage of 6-10-year-old vehicles ranged from 9 to 12% of all buses, the trend started to reverse in 2015 and the following years brought even a more radical change. The proportion of 11-15-year-old vehicles also fell, albeit slightly less noticeably.

This could be observed by a shift in the trend’s appearance in this group and its slightly lower magnitude than in the previous category (a decrease from 21.38% in 2011 to 16.6% in 2019). Similar changes are manifested in the group of vehicles ages from 16 to 20, with the difference that there is a more consistent growing trend peaking in 2016.

Figure 1. *Bus stock structure by vehicle age in Poland in 2010-2019*



Source: *Author's own study based on data from SAMAR.*

The group of vehicles in use for 21 to 30 years also saw a change (decline) in their share in the overall structure. In 2010, it equalled 34.12% and dropped to 23.36% in 2019. Meanwhile, the proportion of vehicles older than 30 years had grown. In 2010, such vehicles made up 10.46% of the entire bus stock; in 2019, their share was as high as 26.82%.

Judging by the above data, we may notice that the stock of buses in service in Poland in the years 2010-2019 strongly relied on long-used vehicles (i.e. older than 10 years), with vehicles older than 30 years being the dominant group. This implies that, once commissioned, buses are often used for 20 and more years, provided that their technical condition allows.

Hence, there is no indication of any pre-planned and coordinated bus stock replacement scheme. Both the analysis of the dynamics of the number of vehicles in the 2-year-old category and the dynamics of the total number of buses reveal certain inconsistencies (particularly in 2010-2011, when the dynamics of the number of vehicles in the 2-year-old group was lower than the dynamics of the total number of buses) which suggest that vehicles older than 2 years (i.e., imported used buses – Euro 3/Euro 4 and lower) were commissioned.

Therefore, the increase in the total number of buses over in the two years was due to the growing number of buses in the 3-5-year-old, 11-15-year-old and 21+ groups. In the remaining periods (i.e. 2012-2019) the number of buses aged up to 2 years rose every year, and its dynamics was often higher than the dynamics of the total number of buses. Nevertheless, one should note that in this comparison there are two different bases – for buses aged up to 2 the base is lower than for the total.

Thus, comparable increases in the dynamics will translate into numerical growth in an wholly different manner, so we should consider nominal increments in every single group.

A comparison between nominal changes in vehicle quantities in each group offers a better insight into the nature of changes in the bus stock structure over the analysed period. First, we find that only in 2012 did the nominal total number of buses fall by 441 (which is how many more buses were decommissioned than commissioned).

Another important observation is the fact that changes in nominal increases/decreases in the number of buses in all groups, except for buses older than 30 years, were variable. The latter category was the only group which expanded in each year in the course of the year-to-year analysis. This corroborates an earlier conclusion and finding – i.e. that the bus stock is becoming older, which translates into a constant and nominally high growth in the quantity of 30-year-old and older vehicles. In addition, the bus stock is growing nearly each consecutive year subjected to the present analysis (on average by 3,600 vehicles)[2].

Attempting to determine the “rate of replacement” in the bus stock, one may rely on the relationship between nominal growth/decline in the number of vehicles aged up to 2 years (in the y/y approach) and the corresponding value of nominal growth/decline in the number of buses (in the same approach) – see table below.

Table 1. *Structure of nominal increase/decrease in the number of buses in Poland in 2010-2019 by vehicle age (y/y in %)*

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
2 years and less	-14.5	-6.6	-5.2	3.9	1.2	17.6	14.9	8.9	27.4	12.4
3 to 5 years	7.8	8.7	145.8	-13.8	-12.4	2.2	5.1	-4.7	11.9	11.5
6 to 10 years	-36.5	-92.7	-69.8	18.9	10.8	-15.8	-21.6	-12.4	-32.6	5.9
11 to 15 years	37.1	122.3	153.1	-24.5	-5.7	5.8	-6.7	0.4	20.8	-5.9
16 to 20 years	-89.2	5.7	-173.2	53.5	47.8	38.2	39.8	12.6	-12.5	-24.5
21 to 30 years	120.1	-6.0	543.1	13.0	-12.8	-11.0	-6.6	4.9	-3.0	-5.0
More than 30 years	75.3	68.6	-493.7	75.0	71.0	62.8	75.1	90.3	87.9	105.8

Source: *Author’s own study based on data from SAMAR.*

The number of buses up to 2 years old in the entire analysed period was between 14.5% and 1.2% (in absolute values) of the overall change in the total number of

[2]*The mean does not include data for 2012, when the total number vehicles dropped by 441. Allowing for this figure, the mean is 3259 a year.*

buses in Poland. Consequently, relatively new buses commissioned in subsequent years made for a relatively small fraction of the change in the total number of buses in service in a given year. What is more, like for buses aged 2 years or less, the relationships discussed for other age groups are also highly variable.

Therefore, it appears that there are no repeatable patterns or regularities in the structure discussed in this study. Nominal changes in the number of buses in subsequent years in the groups defined in proportion to the total number of buses are subject to an elevated level of fluctuation. This is confirms the conclusion on the absence of any concerted and planned bus stock exchange or upgrade in Poland.

Another finding based on the above data is that a change in the number of buses older than 30 years in the y/y approach in relation to the total number of buses in Poland (y/y) in 2013-2019 constitutes over half of the total – frequently above 2/3. The increase in the number of oldest buses exceeds the total increase in the other groups. In 2019, the number of buses aged 30 years and more grew by 3,314. In the 0-2, 3-5, 6-10-year-old groups, it rose by a total of 931.[3]

Vehicles aged 30 years and more are the fastest and most dynamically growing category. Consequently, the "rate of replacement" is very low, as for every new bus (up to 2 years old) commissioned in 2019 there were 9 buses in the oldest category still in service. Hence, there are no conditions to reverse or balance out the aging trend reported for the bus stock.

Another important characteristic of buses as a group of vehicles is the share of various propulsion systems. One should expect that buses will mostly be powered by diesel engines, which is currently the standard for commercial vehicles (because of the unique features of the diesel engine)[4] – see Figure 2.

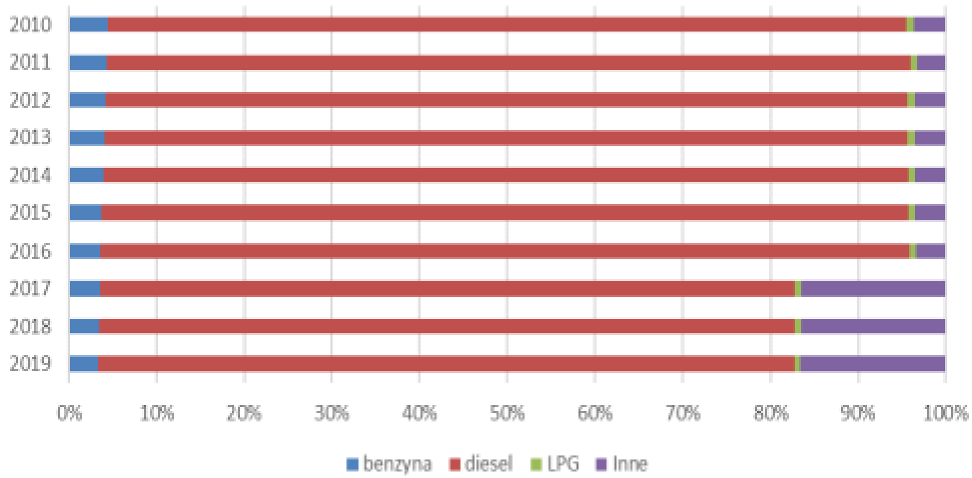
Propulsion system structure is in line with expectations: the diesel engine remains the dominant type of propulsion for buses. In addition, there is a noticeable rise in the proportion of propulsion systems defined as "other" (since 2017). In 2017, the number of vehicles with other propulsion systems increased from 3,849 to 19,175.

Such an abrupt change without a rapid increase in the total number of buses implies a alteration in the way in which these vehicles were categorised as belonging to the "other" group. The reason for this is that their quantity did not grow in 2018 at such

[3]*This concerns total values for each group, i.e. in the group of buses aged 30 years and more, allowing for vehicles which had entered the group and which had left the group (by virtue of being decommissioned), the total number of buses in service in the group increased (nominally) by 3,314.*
[4]*Diesel engines offer greater torque compared to petrol engines of similar capacity, as well as better durability.*

a rate and the increase in their number in 2019 is a mere 3.13% y/y. Therefore, we need to use a different set of data.

Figure 2. *Bus propulsion type structure (main groups) in Poland in 2010-2019*



Source: *Author's own study based on data from SAMAR.*

Unfortunately, identifying the causes for the aforementioned surge in the number of buses with "other" propulsion systems based on the EUROSTAT database proved impossible. Besides, available detailed data for a more precise classification of propulsion systems are incomplete, resulting in inconsistent total quantities. However, the approximate status as of 2020 was successfully determined – see figure below.

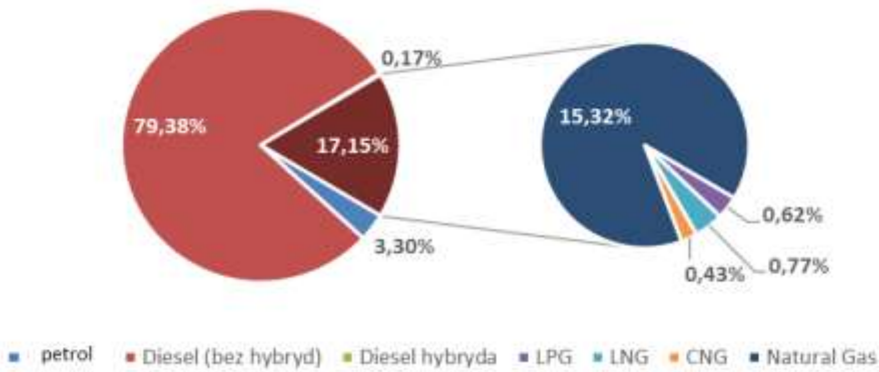
In 2020, buses in Poland were mainly propelled by diesel engines. Petrol engines made up only 3.3% of all vehicles, and diesel engines operating in a hybrid propulsion system accounted for merely 0.17%. Other alternative propulsion types were used only in approx. 17.15% of all vehicles. This category was dominated by buses fuelled by "natural gas".

3. Trucks as a Vehicle Group

Trucks are a relatively large and varied group. They include special-purpose vehicles (e.g., ambulances, fire engines, etc.) as well as cargo vehicles for carrying specific goods (e.g., refrigerator trucks) and multi-purpose vehicles with replaceable trailers (semi-trailer trucks). Trucks perform the majority of haulage operations according to Poland's Central Statistical Office (GUS).

In the years 2010-2019, truck stock age structure in Poland (Figure 4) improved noticeably. The change is similar to the one identified for buses but its structure is slightly more balanced. Trucks aged up to 2 years accounted for 6% to 10% of the structure. In 2010, 9.38% of all vehicles in service belonged to this group. In 2011-2014 the proportion declined, reaching 5.23% in 2013. This was obviously related to the nominal decrease in the number of these vehicles. Ultimately, their share stabilised in 2015-2019 at a level around 6.5%.

Figure 3. *Bus propulsion types in Poland in 2020 according to EUROSTAT*



Source: *Author's own research based on data from EUROSTAT.*

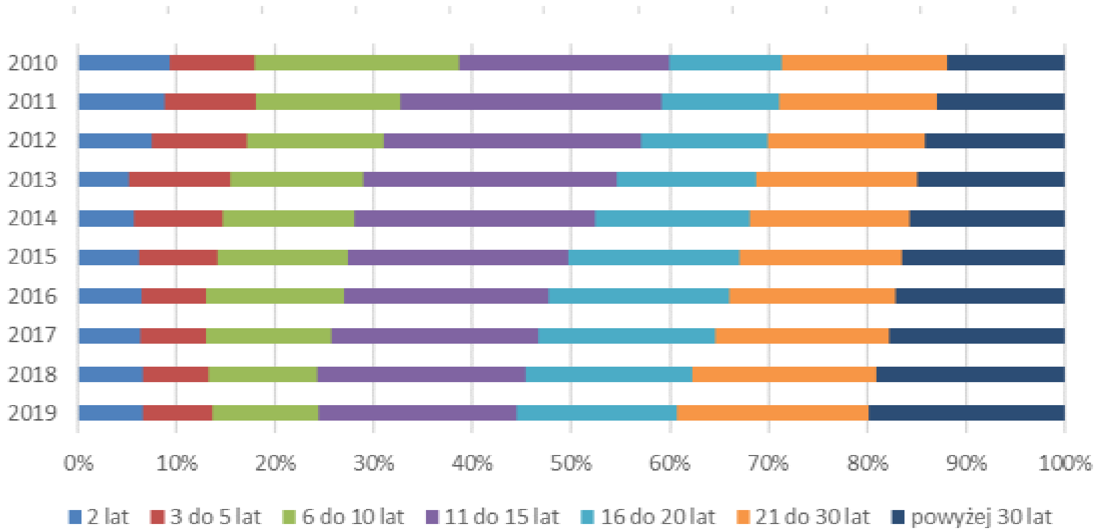
Vehicles in the 3-5-year-old group still accounted for 8.11% of the entire truck stock in the analysed period. The value changed throughout the ten years analysed in the study. Afterwards, it successively grew in 2010-2012 to finally reach 10.26% in 2013. Later years saw a consistent decrease down to 6.5% in 2016. In 2019, the value was recorded at 7.01%.

The group of 6-10-year-old vehicles made up over 10% of the entire truck stock. It should be emphasized that in 2010 their proportion rose to 20.65% and over the period of 10 years investigated in the study it went down to 10.79%. The drop was relatively gentle, albeit consistent throughout the period.

Trucks from the 11-15-year-old group were the most numerous in the entire analysed period. Obviously, this meant that they had the largest share in the structure. From 2010 to 2019, on average, they made up 22.92% of the entire truck stock in service. Their proportion peaked in 2011 (26.4%) and reached its lowest point in 2019 (20.12%).

Vehicles aged 16-20 years increased their proportion in the age structure of the vehicle stock from 2010 to 2019. In 2010, they accounted for 11.52% of the structure, reaching a proportion of 16.16% in 2019. Still, it was not the maximum value, which was reported in 2016 at 18.24%.

Figure 4. *Structure of truck stock by vehicle age in Poland in 2010-2019*



Source: *Author's own study based on data from SAMAR.*

Vehicles aged 21 to 30 years are another group with a significant share in the structure. Also, they constitute another category whose participation rose in the analysed period. In 2010, this group of vehicles accounted for 16.69% of all trucks in service. Nine years later, in 2019, their share reached 19.49%.

The last age group includes trucks older than 30 years. The share of this group in the structure was rather similar to the vehicles from the previously mentioned group. In 2010, they made up 11.91% of all trucks, so significantly less than vehicles aged 21-30 years. In comparison, in 2019 their proportion in the structure equalled 19.85%, hence slightly more than vehicles aged 21-30 years. This structure allows us to draw a similar conclusion like in the case of the analysis of the age structure of buses, namely that the truck stock in service in Poland is becoming older and is not being replaced by new vehicles at a sufficient rate.

As for the truck stock, one can hardly see any pre-designed and expediently executed resource upgrade plan. What can be seen, however, is a certain degree of stability in the structure. Changes taking place in the structure are far less surprising than in the case of buses. The expected "movement" of vehicles between age groups is also noticeable. As a process, the use of vehicles is disrupted to a lesser extent, and the use itself appears to be predictable, somewhat stabilizing the vehicle stock's age structure.

Another observation based on the data referred to above is that the group of vehicles aged 11-15 years is very significant to the structure of the truck stock in Poland. The group is most the most numerous, with EURO 4 compliant vehicles being the majority of vehicles in service. The problem, however, is that the group of older vehicles is not much smaller in terms of quantity.

An analysis of chain dynamics indicators shows that the nominal number of 2-year-old vehicles dropped in 2011-2013. The fact may be construed as a sign of halted fleet upgrade investment processes in transport companies. Over the next few years, the number of vehicles in this group grew on an annual basis. The maximum increase (113.5%) was reported in 2014, which is hardly surprising, since it occurred immediately after the third consecutive year of the declining number of vehicles.

Subsequently, the dynamics of the growth of the number of vehicles in this group was falling successively from 2015 to 2017 (still remaining above 100%) to bounce back to 112.5% in 2018. Ultimately, even by 2019 (269,786 trucks), the number of vehicles aged up to 2 years had not reached the level reported back in 2010 (i.e., 279,619).

The group of vehicles aged 3 to 5 years underwent a similar change, with the difference that the declines in the dynamics of changes in the number of vehicles occurred in 2014-2016, so in accordance with the expected “offset” from the previous age group. In the remaining periods, the number of vehicles in the group increased. The level reported in 2010 (255,550) was soon exceeded, with the maximum value (332,553) reached in 2013.

The group of vehicles aged 6-10 years reveals a slightly dissimilar picture. The chain dynamics of the change in the number of vehicles in this group was positive only from 2014 to 2016 and in 2019. The level as of 2010 (615,763 vehicles) was never reached again in the analysed period.

From 2014 to 2016 and in 2019, the group of vehicles aged 11-15 saw a drop in terms of chain dynamics below 100%. In other periods, the dynamics was maintained above 100%, hence the increase in the number of vehicles y/y. As a result, the level reported in 2010 (634,494) was quickly surpassed, and the value from 2019 (825,040) is approx. 30% higher.

Only in 2019 did the group of vehicles aged 16-20 achieve chain dynamics in excess of 100%. In 2010-2018, the number of vehicles in the group increases. In 2010, the group comprised 343,622 vehicles, and their number rose by 92.8% in 2019 (662,525).

Over the entire analysed period, the chain dynamics for the group of 21-30-year-old vehicles was at a level above 100%. In other words, the group expanded with every year. Juxtaposing the value at the start of the analysis (497,582 in 2010) with the value from the end of the analysed period (799,201 in 2019), we see a 60% increase in the number of vehicles.

The last age group (vehicles aged 30 years and more) was characterised by similar chain dynamics as the group described above, with the number of vehicles growing throughout the analysed period. A comparison between the value recorded in 2010 (354,986) to the value as of 2019 (814,096) shows a 130% increase. This constitutes the greatest change of this kind across all age groups. In the analysed period the most significant increase was reported for the number of the oldest vehicles.

An analysis of changes in nominal values shows a noticeable drop in the group of vehicles aged up to 2 years. Although in 2010 the increase in the number of vehicles in the group amounted to 77,766[5], over the course of the next three years nominal increases declined at a very high rate (dynamics). The period from 2014 to 2019 saw a recovery in the number of vehicles in the group.

Nevertheless, nominal increases were low and became even lower year by year. In 2014, the number of vehicles in this group rose by 22,904 year-to-year. In contrast, in 2019 it increased by a mere 6,793. A conclusion which can be drawn from this is that fewer and fewer new vehicles are being commissioned each year and that their number grows at an increasingly slower rate y/y.

The status of the group of 3-5-year-old vehicles was slightly different. The rate of change in the nominal number of vehicles y/y in the periods when the number grew (i.e. 2011-2013 and 2017-2019) is slightly more stable. In 2010, there were 47,143 vehicles in the group; this number rose by 31,964 in 2011. In 2017, there were 7,639 more vehicles in the group and 26,493 more a year later. A total of 23,449 vehicles became part of the group in 2019, i.e. 3.45 times as many as in the group of vehicles aged up to 2 years.

In six out of the ten years analysed in the study, the number of vehicles aged 6 to 10 years fell. Nominally, the declines were highly varied: in 2011 they totalled 155,337, which was due to a considerable number of vehicles moving to the subsequent age group. In contrast, in 2012 the number of vehicles in this group fell only by 15,160. Consequently, there were quite significant nominal differences in changes year to year. A similar situation took place in the later years subjected to the present analysis. Eventually, 2019 saw the addition of 6,219 vehicles to the group.

In terms of nominal change in quantity y/y, vehicles aged 11-15 years also displayed high variability. In 2010-2011, their number increased by 156,870 and 191,866 respectively, the steepest growth over the entire period. Another significant change in the nominal number of vehicles took place in 2015, when the total dropped by 48,722 (and a year later, when it fell by a further 31,298). Later, in 2018, 72,602 trucks were added to the group. Finally, 2019 saw a nominal decline in the number of vehicles in the group by 13,348 (year to year).

---

[5] *Compared to the value in 2008.*

Vehicles aged 16-20 years show a more consistent distribution of nominal increases in vehicle number, which reached its peak (70,678) in 2015. In 2019, the number fell nominally by 2,818 y/y.

From 2010 to 2017, there was a very consistent nominal y/y increase in the number of vehicles aged 21-30 years. 2018 was a year in which the maximum value of 102,994 was reached. A year later, in 2019, 57,787 vehicles entered the group.

Vehicles aged above 30 years displayed the most consistent rate of change with regard to the nominal y/y growth of the number of vehicles. Except for 2010 (when their number rose by 97,179) and 2018 (when their number rose by 108,539), the annual increase in their number fluctuated around 42,000. This was the only group of vehicles with such a stable and large nominal y/y growth in size.

Analysing nominal changes in the total number of trucks from 2010 to 2019, we may notice a clear rising trend with a relatively constant dynamics. Throughout the analysed period, the number of trucks in Poland rose, on average, by 139,113.

In an attempt to determine the "rate of replacement" in the truck stock, one may rely on the relationship between nominal growth/decline in the number of vehicles aged up to 2 years (in the y/y approach) and the corresponding value of nominal growth/decline in the number of trucks (in the same approach) – see table below.

Table 2. *Structure of nominal increase/decrease in the number of trucks in Poland in 2010-2019 by vehicle age (y/y in %)*

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
2 years and less	28.6	-1.0	-85.8	-105.6	23.3	22.2	15.3	4.7	9.0	5.0
3 to 5 years	-17.3	21.4	37.7	42.2	-36.7	-27.6	-37.4	7.7	8.1	17.3
6 to 10 years	-12.3	-104.8	-32.1	-10.9	9.9	9.2	36.8	-32.3	-8.8	4.6
11 to 15 years	57.7	128.7	2.0	9.0	-18.7	-55.8	-27.6	31.5	22.3	-9.8
16 to 20 years	4.1	20.3	71.9	75.9	68.1	80.9	45.4	5.6	4.3	-2.1
21 to 30 years	3.1	0.2	15.7	35.6	15.1	23.0	33.0	38.4	31.7	42.6
More than 30 years	36.1	35.2	90.5	53.9	38.9	48.0	34.5	44.2	33.4	42.5

Source: *Author's own study based on data from SAMAR.*

The proportions to the aforementioned change in the total number of trucks were determined by referring the values of rises/falls in the number of trucks in each age group to the overall change in the number of trucks in a given year (Table 2). This provided basis for drawing conclusions on the significance of changes in individual vehicle age group for the overall change in the number of trucks.

For vehicles younger than 2 years, nominal increases/decreases in their number in the subsequent analysed years fluctuated to a very broad extent, i.e. from 28.6% to 4.7%[6]. In 2010, the rise in the number of vehicles aged up to 2 years corresponded to 28.6% of the increase in the total number of trucks in service in Poland. In comparison, in 2019, the rise in the number of vehicles in this group made up 5% of the increase in the total number of trucks.

High vehicle number growth ratios in the group occurred only in the period from 2014 to 2016. Starting from 2017, their proportion plummeted, never to exceed 10% again. This invites a conclusion that from 2017 onwards, the number of vehicles aged up to 2 years was no longer as noticeable in terms of increasing the total size of the truck stock as it had once been.

In the group of vehicles aged 3-5 years, the nominal growth in 2011-2013 rose very dynamically in proportion to the increase in the total number of trucks. In comparison to the aforementioned total, the scale of growth in the group becomes increasingly larger (starting at 21.4% and finishing at 42.2%).

In 2017- 2019, when the trend is reversed and the vehicles in this age group again increase in number, their growth in proportion to the total number of trucks increases from 7.7% (in 2017) to 17.3% (in 2019). These values, however, are relatively low if one considers 21-30-year-old vehicles or vehicles older than 30 years.

The increases in the number of vehicles in these groups relative to the total increase in the number of trucks in a given year normally exceed 20-30% and are often even higher. For the 21-30-year group, the mean is 23%; for the >30 group it equals 45.7%. In other words, a change in the number of 21-30-year-old and more than 30-year-old trucks in the y/y perspective in relation to the total change in the number of trucks in Poland (y/y) from 2010 to 2019 usually corresponds to 1/5-1/2 of the latter value.

This means that the number of vehicles in the two groups rises so steeply in nominal terms that these increases account for a very significant portion of the growth in the total number of trucks. Vehicles aged 21-30 and above 30 years constitute a dominant group contributing to the expansion of the total number of trucks in service in Poland.

Attempting to determine the rate of replacement, we notice that the ratio between the rise in the number of vehicles aged up to 2 years and the increase in the number of

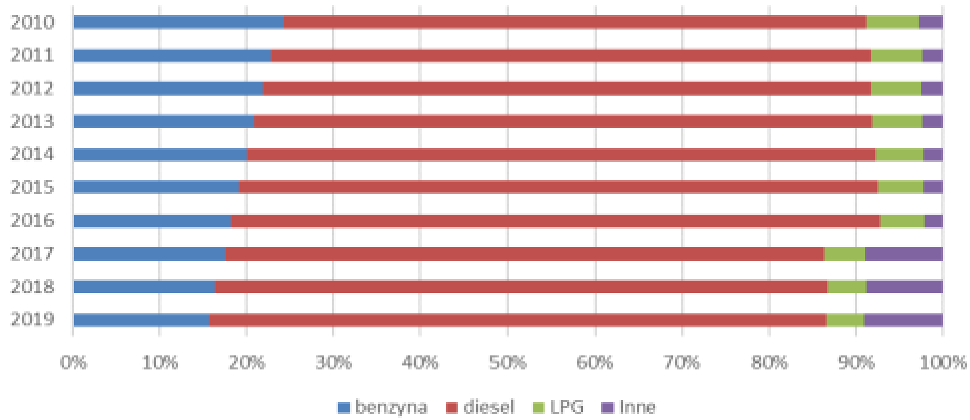
---

[6]*The value -1% from 2011 was omitted, since this study focused on increases rather than falls in the number of vehicles year to year.*

vehicles aged more than 30 is fairly low and not constant. Such a rate is therefore insufficient to replace all "old" trucks, which would halt the overall process of the truck stock becoming older.

A second important characteristic of trucks as a group of vehicles is the share of various propulsion systems. As with buses, one may expect trucks to be mostly powered by diesel engines, currently the standard solution applied in commercial vehicles (Figure 5).

Figure 5. *Truck propulsion type structure (main groups) in Poland in 2010-2019*



Source: *Author's own study based on data from SAMAR.*

Propulsion system structure is as expected: the diesel engine remains the dominant type of propulsion for buses. Please note, however, that the share of LPG in truck propulsion systems throughout the analysed period makes up a sizeable proportion. Like for buses, we also see a stepwise change in the quantity (and, at the same time, the proportion in the structure) of vehicles categorised as having "other" propulsion systems.

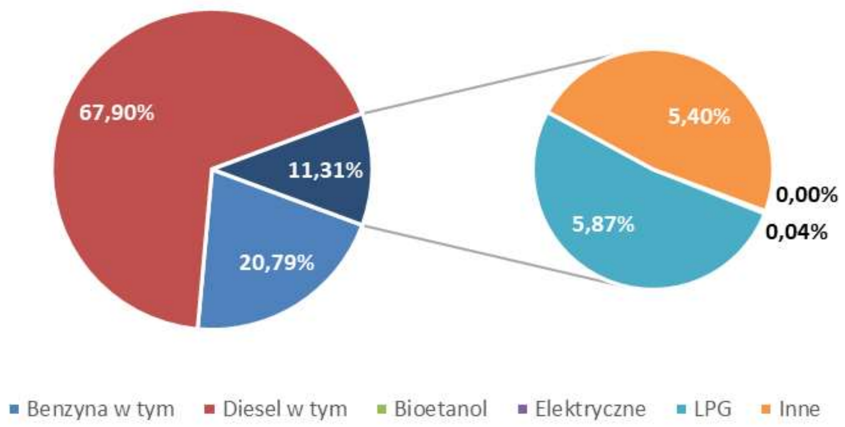
Therefore, we need to use a different set of data. EUROSTAT data provide a basis for a more in-depth analysis of the propulsion systems in each vehicle group (trucks with a mass of up to 3.5 t, trucks with a mass above 3.5 t and semi-trailer trucks/road tractors). Unfortunately, such detailed information is available for 2014-2020, so a period slightly shorter than the one analysed on the basis of SAMAR data. However, it offers a very useful insight into the structure of propulsion systems in each group of trucks.

Diesel engines prevail in trucks with a GVW of up to 3.5 t, being 3 times as numerous as petrol engines. An analysis of the aforementioned ratio in the years

2014-2020[7] reveals a decrease in the number of vehicles with petrol engines with along with a rise in the number of diesel-powered vehicles. This means that there is a noticeable diminishing trend in the proportion between petrol and diesel engines, albeit its dynamics is very low.

Meanwhile, there is considerable dynamics in the case of vehicles with alternative propulsion systems. From 2014 to 2020, their total number went up from 229,156 to 320,149, which accounts for an approx. 40% increase in the number of vehicles over the space of six years.

Figure 6. *Truck propulsion types in Poland in 2020 according to EUROSTAT*



Source: *Author's own research based on data from EUROSTAT.*

Of all alternative propulsion systems, 51.58% vehicles are fuelled by LPG and 47.4% are categorised as trucks with "other" propulsion systems. It is worth noting that in 2020 electric cars were the only type of vehicles with alternative propulsion which grew in 2020 (from 775 in 2019 to 1,088 in 2020). Still, their share in the alternative propulsion group is merely 0.34%.

The situation was entirely different in the group of trucks with a GVW above 3.5 t without semi-trailer trucks: diesel engines prevail over other types of propulsion. Trucks with petrol engines constitute a smaller group than trucks with alternative propulsion. This ratio between diesel and petrol-fuelled vehicles was maintained throughout the period from 2014 to 2020. However, starting from 2017, vehicles with alternative propulsion systems outnumbered petrol vehicles.

The number of trucks with petrol engines in the aforementioned group remained on a relatively constant level from 2014 to 2012, with a slight falling trend (in terms of

[7] *The period for which Eurostat data are available.*

dynamics). In contrast, the number of diesel-powered vehicles is highly variable. It grew in 2014-2016, to drop markedly in 2017.[8] In the subsequent years (i.e.. 2018-2020), it grew again, clearly and dynamically (mean dynamics 2.5% y/y).

From 2018, vehicles with alternative propulsion systems (when analysed as a whole group) increased in number with a mean dynamics of 0.7% y/y (rather negligibly). This group of vehicles is dominated by LPG-fuelled trucks (8,186 vehicles), with electric propulsion present only in 641 vehicles.

Diesel engines are the most numerous propulsion type in the semi-trailer trucks/road tractors. The proportion of petrol-fuelled vehicles in this group is very marginal. The number of vehicles with a diesel engine in the period 2014-2020 was almost constantly growing, with mean dynamics of 6.1% y/y (see table below). The only exception was the year 2017, when the number of these vehicles dropped by 0.82%.

***Table 3.** Truck structure (semi-trailer truck/road tractor) by propulsion type (EUROSTAT) in Poland in the years 2014-2020*

	2014	2015	2016	2017	2018	2019	2020
Petrol	1,621	1,618	1,629	1,608	1,608	1,601	1,618
Diesel, including	295,745	322,100	354,112	351,200	379,157	401,890	420,694
Non-hybrid diesel	295,745	322,100	354,112	351,200	379,157	401,890	420,694
Hybrid diesel	0	0	0	0	0	0	0
BIO-diesel	0	0	0	0	1	7	8
Alternative energy	5,823	5,871	5,940	37,637	39,242	43,822	47,139
Bioethanol	0	0	0	2	2	2	2
Electric	62	61	61	61	61	61	60
LPG	1,966	2,021	2,087	1,998	2,043	1,956	1,920
CNG	72	75	82	78	177	n/a	n/a
LNG	0	0	2	9	35	n/a	n/a
Other	3,723	3,714	3,709	35,489	36,923	39,735	40,143

Source: *Author's own research based on data from EUROSTAT.*

Semi-trailer trucks with alternative propulsion systems constitute a highly significant group. The years 2018-2020 saw a rapid, noticeable growth in their number (mean dynamics 7.8% y/y), which caused their total quantity to increase by 25.24% over three years. Of note is the fact that in this group electric vehicles have a marginal share in the alternative propulsion systems.

[8]*Again, we observe what presumably is a consequence of the way in which the vehicles are included in statistics, as this decline is accompanied by a steep rise in the number of "alternative energy" vehicles.*

4. Conclusions

As the deteriorating condition of the natural environment became a focus of public attention in the mid-20th century, governments worldwide started to prioritise raising environmental awareness and countering environmental threats (Bąk and Cheba, 2020). The resulting idea of sustainable growth began to permeate into multiple areas of socio-economic life, also including the transport sector. The priorities of transport policy gradually transformed in the face of new challenges, mainly related to the technological progress in the field of automation and artificial intelligence (Gozdek and Kuciaba, 2021).

There have been postulates concerning structural changes in vehicle stock in the EU member states, including Poland. This was strictly linked to the challenges of decarbonisation and the EU's climate policy. The scale of the degrading environmental impact depends on technology, traffic intensity, branch structure of the transport system and the technological advancement of design solutions applied in the fleet (Wojewódzka-Król and Załoga, 2022).

With regard to buses, of significance is the fact that since 2017 the proportion of alternatives to diesel-based systems has increased. Nevertheless, diesel engines remain the dominant source of propulsion for buses. The dynamics of the implementation of propulsion systems alternative to diesel- and petrol-based systems is still very low. The age structure of the bus stock has worsened over the past 10 years.

The number of buses older than 30 years is increasing, and the group of buses aged 2-5 years is growing at a very slow pace. It is the vehicles aged up to 5 years which meet more stringent emission standards or are powered by alternative systems (fuels). Therefore, we cannot definitely conclude that there is any constant and significant tendency in the change in the quality of the structure of the bus stock in terms of propulsion type (emission performance). However, one may notice first important yet inconsistent changes.

With regard to trucks, one cannot ignore the fact that since 2017 the proportion of alternatives to diesel-based systems has increased, a tendency which was also noticeable in the case of buses. This dynamic growth and change in the structure of propulsion types is a result of a shift in propulsion type categorization criteria in public statistics. We may thus assume that since 2017 we have had access to more detailed information on the subject.

As far as trucks are concerned, this means a better insight on the level of each alternative propulsion system. Unfortunately, we also discover that, like for buses, the diesel engine still remains the prevailing source of propulsion. It is also possible to also access more detailed characteristics of each subgroup of trucks. For vehicles carrying heavy goods on longer routes (semi-trailer trucks/road tractors), the diesel-based propulsion system prevails, and alternative propulsion is still more common than petrol engines (although its share remains below 10% of all vehicles).

The diesel engine also dominates the subgroup comprising commercial vehicles with a GMV above 3.5 t. Nevertheless, alternative propulsion systems have a greater share in this group (above 20% of all vehicles). In the subgroup of light commercial vehicles (with a GMV below 3.5 t), diesel-based propulsion accounts for over half of the systems, whereas petrol-fuelled vehicles constitute 20%, which is more than all vehicles with alternative propulsion taken together. Some characteristics of each group emerge from this picture.

The overall conclusion is that trucks mostly use diesel engines, with vehicles covering the greatest distances and carrying the largest quantities of cargo also being powered by diesel engines.

The age structure of the stock of trucks in Poland has worsened over the past 10 years. The number of long used and old vehicles is growing year by year. Vehicles aged 11-15 years form the most numerous group, quantitatively almost matching the total number of all newer vehicles. The age groups comprising vehicles older than 15 years (i.e., 16-20 years; 21-30 years and more than 30 years) make up a total of 55% of all vehicles in service. Given that vehicles aged below 5 years are those which meet stricter emission standards or feature alternative propulsion types (fuels) more commonly, the age structure of the truck stock also leaves considerable room for improvement.

In addition, one cannot definitely conclude that there is any constant and significant tendency in the qualitative change of the structure of the bus stock in terms of propulsion type (emission performance). The only conclusion which can be drawn from this is that it is not improving and, to make matters worse, it will “fall behind” the acceptable norm once the new emission standards are introduced.

First signs of change are already there, especially within some subgroups, e.g., commercial vehicles up with a GMV of up to 3.5 t. The percentage of alternative propulsion systems is consistently growing and gradually rising in significance in the structure of the entire subgroup. The changes appear to be permanent but their dynamics is quite variable, so we may speak about nothing more than first distinct signs of this trend.

The implementation of ecological solutions in everyday life, promotion of environmentally responsible attitudes, but also the introduction of low-emission (e.g. hybrid or mild hybrid vehicles) or zero-emission (electric vehicles, wherein exhaust emission takes place in a different place than the location of the vehicle) means of transport – these are the goals set for the next few years (Kamiński, 2021).

Accordingly, all discussion on the subject is both desirable and valuable. The succinct analysis of Poland's road transport sector in terms of emission performance presented in this study provides a suitable background for further research on the preparedness of the Polish road transport for decarbonisation and new challenges related to the EU's climate policy.

References:

Bąk, I., Cheba, K. 2020. Zielona gospodarka jako narzędzie zrównoważonego rozwoju. CeDeWu, Warsaw.

Gozdek, A., Kuciaba, E. 2021. Transport w dobie sztucznej inteligencji. In: Mobilność i zrównoważony transport. Poszukiwanie rozwiązań, Gozdek A. (ed.), Wyd. Uniwersytetu Szczecińskiego, Szczecin.

Kamińska, E. 2021. Ekologiczne aspekty działalności transportowej. In: Transport drogowy rzeczy. Zagadnienia organizacyjne i techniczne, Kamiński T. (ed.), Wyd. Komunikacji i Łączności, Warsaw.

Kamiński, T. 2021. Zrównoważona mobilność w aspekcie inteligentnych rozwiązań w transporcie, Wyd. Komunikacji i Łączności, Warsaw.

Wojewódzka-Król, K., Załoga, E. 2022. Transport. Tendencje zmian, Wyd. PWN, Warsaw.