POLITYKA ENERGETYCZNA – ENERGY POLICY JOURNAL
2016 ✦ Tom 19 ✦ Zeszyt 2 ✦ 23–46
ISSN 1429-6675

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A review on energy consumption and CO_2 emissions in the Polish transport sector

ABSTRACT: Transport has been crucial for the global economic development. It is one of the key drivers for the improvement in mobility, urbanization and trade. Nowadays, transport is the second-largest energy consuming sector in the world and one of the major sources of greenhouse gas emissions. Since the accession of Poland to the EU, the transport sector has become pivotal for the economic growth of the country. Rail and road network systems have been modernized and the total number of passenger cars has nearly doubled. Moreover, there has been an increase in road freight and logistic services, making Poland one of the largest road transport service providers in the EU. On the other hand, all the aforementioned developments have contributed to an increase in the total final energy consumption and CO_2 emissions of the Polish transport sector. Gasoline, diesel, LPG and jet fuel consumption has increased sharply over the last decades. CO_2 emissions from the transport sector have gone from approx. 20 million tons of CO_2 in 1990 to 46 million tons in 2013. This paper aims to present an overview of the energy consumption and CO_2 emissions of the Polish transport sector and give a detailed account of the sector development over the last two decades.

KEYWORDS: transport, emissions, fuel consumption, Poland, energy consumption

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Introduction

For decades, the transportation sector has been crucial for the global economic development. It has been one of the key drivers for the improvement in mobility, urbanization and trade. Moreover, the transportation sector has made possible the connection between cities, countries and distant regions around the world. It has created millions of jobs and it has increased the productivity of various sectors of our global economy (Kopp et al. 2013). Unfortunately, all these benefits have come at a considerable cost to the environment. Over the last thirty years, transport has become the second-largest energy consuming sector in the world and consequently one of the major sources of greenhouse gas (GHG) emissions (EIA 2014). Fig. 1 shows the global final energy consumption by sector type while Fig. 2 presents the global CO_2 emissions by sector type in 2013.

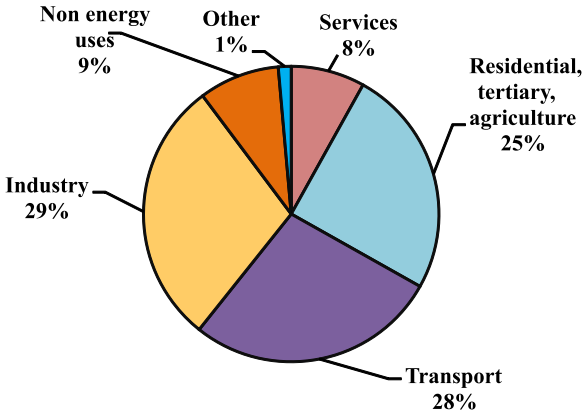

Fig. 1. Global final energy consumption by sector type (2013) Source: IEA, 2016

Rys. 1. Zużycie energii finalnej na świecie według sektorów (2013)

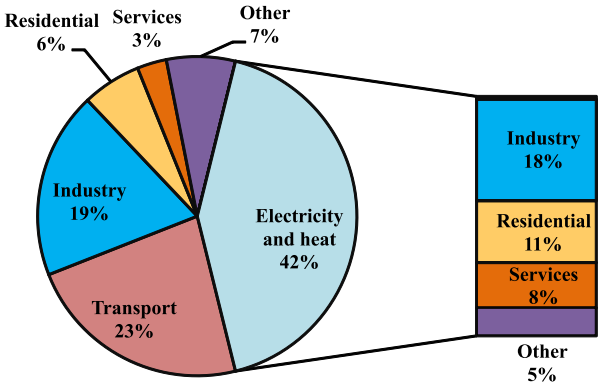

Fig. 2. World CO_2 emissions by sector type (2013)
Source: IEA, 2015a

Rys. 2. Emisje CO_2 na świecie według sektorów (2013)

Driven by the rapid global economic development that took place between the years 1996 and 2007, as well as the fast global motorization rate particularly in developing nations such as China, India and other non-OECD countries, the transportation sector nowadays consumes approximately 2564 Mtoe (IEA 2015b; IEA 2015c). This represents a twofold increase in energy consumption compared to the 1022 Mtoe that was consumed in 1973 (IEA 2015c). Moreover, the International Energy Agency (IEA) estimates that the transportation sector accounts for 27.5% of the global final energy consumption, a figure that has raised serious concerns among researchers and policy makers and has prompted the development of new methods for the reduction of energy consumption in the transport sector (see de Haan et al. 2007).

As previously stated, one of the main reasons for the growth in energy consumption in the transportation sector has been the international economic development and the increasing number of vehicles that are in use globally. In 2005, there were an approximate 892 million vehicles around the world, but that number has climbed to 1.18 billion vehicles in 2013 (OICA 2013).

Moreover, the extreme weather events that have taken place over the last several years and have been linked to carbon dioxide emissions (see Solomon et al. 2009), have attracted the attention of policy makers and researchers to study the environmental impact of the transportation sector GHG emissions (see Kopp et al. 2013). The IEA reported that the transport sector is one of the largest producers of global CO_2 emissions, being responsible for approximately 7384 million tons of CO_2 or 23% of the total carbon dioxide emissions in 2013. Since 1990, the road transport sector has increased by over 68%, becoming one of the main drivers for the growth of CO_2 emissions in the transport sector (IEA 2015a; IEA 2015b; IEA 2016).

Currently, the transportation sector of the United States (1700.8 million tons CO_2), European Union (861.2 million tons CO_2) and China (760.2 million tons CO_2) are the largest sources of CO_2 emissions (IEA 2015b). It is worth noting that in the case of the EU, the transport sector in 2013 contributed approximately 24.4% of the total EU GHG emissions; becoming the only main sector in the EU economy to increase its GHG emissions (EEA 2015a). Fig. 3 shows the global CO_2 emission for the years 1971–2013 and Fig. 4 shows the fuel consumption by sector in the years 1990–2013.

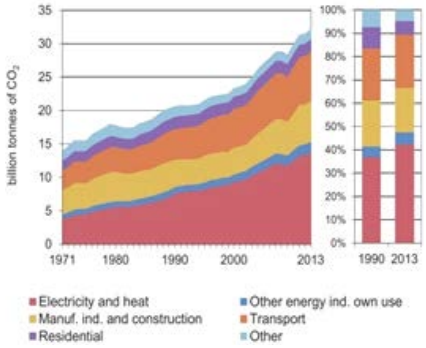

Fig. 3. CO_2 emissions by sector (1971–2013)
Source: IEA, 2015a

Rys. 3. Emisje CO_2 według sektorów w latach 1971–2013

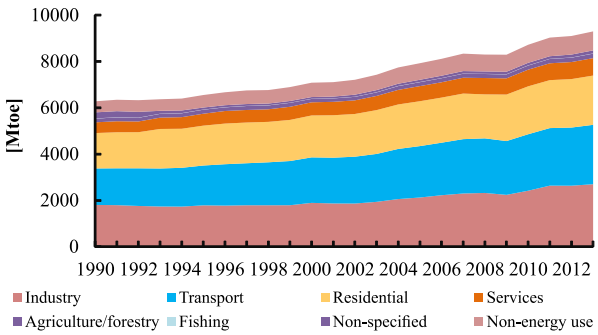

Fig. 4. Fuel consumption by sector (1990–2013)
Source: IEA 2016

Rys. 4. Zużycie paliw według sektorów w latach 1990–2013

The EU has been one of the major supporters for climate action and a reduction in CO_2 emissions. It has set targets for renewable energy, GHG emissions and energy efficiency for the years 2020, 2030 and 2050. The European Environment Agency (EEA) estimates that the EU-28 may achieve its GHG reduction and energy efficiency targets by 2020 if it continues with the current policies and measures in place (EEA 2015b). Yet, in order to ensure that member states achieve the planned GHG emissions mitigation, energy consumption reductions, and energy efficiency improvements set by 2030 and 2050, it is imperative that each member state performs a periodical assessment, at the national level, of the current status of each economic and industrial sector.

Historically, the transport sector of Western Europe has been intensively studied; however, only a small number of papers have focused on the transportation sector of Central and Eastern European (CEE) countries. With this scope in mind, the aim of this paper is twofold. Firstly, this paper aims to present an overview of the energy consumption and CO_2 emissions of the Polish transport sector, the largest economy in Central Europe. Secondly, the paper aims to give detailed account of the Polish transport sector development over the last two decades.

1. An overview of the Polish transport sector

1.2. Road Transport

In 2015, Poland was the sixth largest economy in the EU and the largest economy in Central Europe (WB 2015). Since 1990, Poland has experienced an unprecedented economic development, having an average annual growth (in real GDP growth rate) of 2.7% between 1989 and 2005. This represented that Poland's GDP in 2005 was 153% higher than the GDP recorded in 1989 (Myant and

Cox 2008). Furthermore, since its accession to the European Union in 2004, Poland's GDP grew at an annual rate of 3.9% per year, becoming one of the few EU member states that achieved an economic growth even during the global economic crisis of 2009 (Ministry of Foreign Affairs 2014).

Over the last twelve years, the road transport sector has become a crucial component of the Polish economy. The improvement of the Polish labor market and the increase in gross national income (GNI) per capita from $6260 (2004) to $13690 (2014), have had a significant impact on the number of motor vehicles (WB 2015). The total number of passenger cars has nearly doubled (2003–2014), and according to the published estimates of the statistical office of the European Union, Poland had the largest increase in passenger cars in the EU between 2003 and 2012 with an increase of 65.3% (Eurostat 2015a). Furthermore, motorization rate, which is the number of registered passenger cars per 1000 inhabitants has gone from 294 in 2003 to 520 in 2014 (GUS 2004–2015). Previous studies show that there is a strong interdependence between per capita income and the motorization level of a country (Ingram & Liu 1999). Moreover, motorization and energy consumption increase at a higher rate when per capita incomes reach $5,000–$10,000 (Kopp et al. 2013). Fig. 5 shows the motorization rate in Poland in 2003–2014 and Fig. 6 the relation between motorization and GDP per capita around the world.

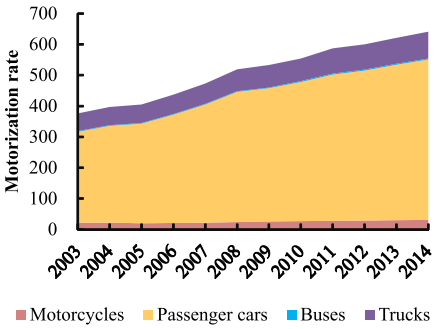

Fig. 5. Motorization rate in Poland, 2003–2014
Sources: GUS 2004–2015

Rys. 5. Liczba samochodów na 1000 mieszkańców w Polsce w latach 2003–2014

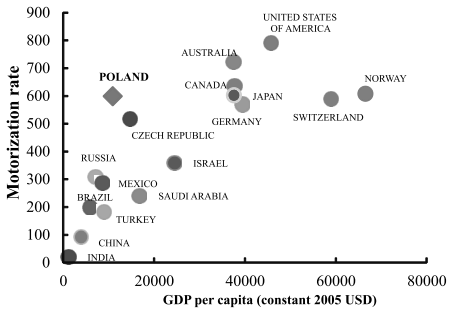

Fig. 6. Relation between motorization rate and GDP per capita in selected countries
Source: WB, 2015 and OICA 2013

Rys. 6. Zależność pomiędzy liczbą samochodów na 1000 mieszkańców a PKB *per capita* w wybranych krajach

In regard to the bus transport, the total number of registered buses has increased at an average annual rate of 2.3% between 2003–2014, and in 2014 there were approximately 106,057 buses. In the last fourteen years, there has been a radical change in the ownership structure of intercity passenger buses. Over 70% of the intercity bus services are privately owned, compared to the 9% that were privately owned in 2000, as shown in Fig. 7. Even though there has been a change in the ownership structure, the intercity bus services carried a total of 431.5 million passengers in 2014. The number of transit buses has not changed over the last 11 years, but the number of intercity buses has increased from 71.2 to 94.5 thousand (GUS 2004–2015) (Fig. 8).

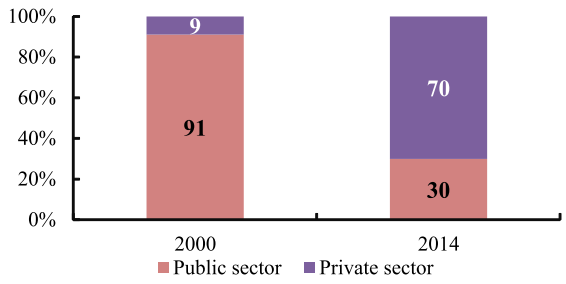

Fig. 7. Ownership structure of buses
Source: GUS 2004–2015

Rys. 7. Struktura właścicielska autobusów

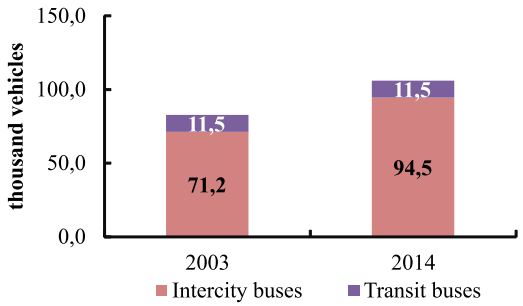

Fig. 8. Number of intercity and transit buses
Source: GUS 2004–2015

Rys. 8. Liczba autobusów międzymiastowych oraz miejskich

Since its accession to the EU, the passenger car fleet has seen an accelerated ageing due to the high number of imported second-hand vehicles (aged 4 years or over). The average age of passenger cars has been reported to be 14 years and approximately 75% of the car fleet is over 10 years old (PZPM 2015). In 2014 the import of used passenger cars reached 748,863, compared to the 373,285 new passenger cars registered in the same year (PZPM 2015; GUS 2004–2015). Fig. 9 shows the age structure of the passenger vehicle fleet and other transport vehicles for the years 2005 and 2013.

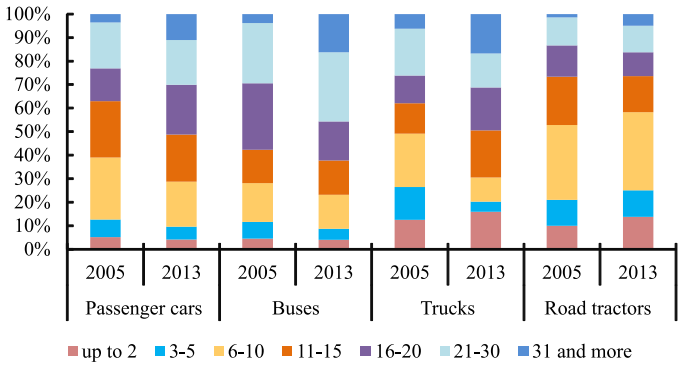

Fig. 9. Age structure of road vehicles in Poland
Source: GUS 2015a

Rys. 9. Struktura wiekowa pojazdów drogowych w Polsce

The economic growth over the last decade has also caused a rapid increase in the number of commercial vehicles. Commercial vehicles include light, medium and heavy good vehicles. Poland has become the second largest road freight transport service provider in the EU. Polish haulers transported (national and international) a total of 250,931 million tonne-kilometre (tkm) in 2014 (Eurostat 2016b). Furthermore, according to the Polish Automotive Industry Association, the majority of the road freight services are being carried out by the newest share of commercial vehicles; approximately 81% of the transport operations are being performed by commercial vehicles that are 6 to 10 years old (PZPM 2015).

1.2. Rail Transport

Between 1989 and 2011, the Polish railway network saw a steep decline in the number of local railway lines. This was mainly due to the poor state of its infrastructure, "low importance" of the lines, lack of funding from local governments who had the responsibility to run the lines, and the trial and error of the liberalization policies that have been implemented since 2000 (Taczanowski 2012).

With the accession to the European Union and the financing of various institutions such as the European Investment Bank (EIB) and the European Bank for Reconstruction and Development (EBRD), there has been a major modernization of the national railway system and railway stations. For instance, between 2007 and 2013, Poland received significant funds from the Infrastructure and Environment – EU Cohesion Fund for the modernization of rail lines and purchase of 20 high-speed trains (European Commission 2016e; European Commission 2016c; European Commission 2016d).

Poland, in 2014, had a total of 19,240 km of operated railway lines, out of which 11,830 km were electrified lines (GUS 2004–2015). Fig. 10 shows the length of operated railway lines in Poland from the year 2002 to 2014.

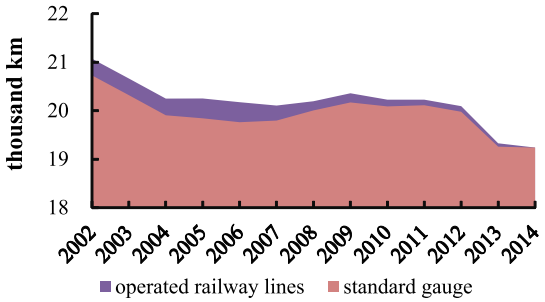

Fig. 10. Length of operated railway lines in Poland
Source: GUS 2004–2015

Rys. 10. Długość linii kolejowych eksploatowanych w Polsce

The Polish railway transport carried approximately 268.2 million passengers in 2014. Over the last decade, the number of passengers has varied from 291.4 million in 2006 to a low of 200.8 million in 2009, shown in Fig. 11 (GUS 2004–2015). The Polish Central Statistical Office (GUS) reported in 2014 that the train passenger transport accounted for almost 38% of the total movement of passengers (GUS 2004–2015).

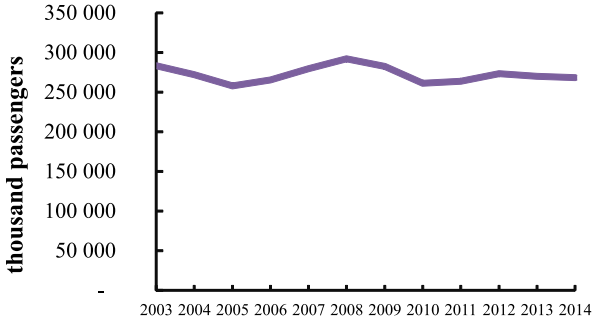

Fig. 11. Rail passenger transport
Source: GUS 2004–2015

Rys. 11. Przewóz pasażerów transportem kolejowym

With respect to the rail freight, Poland was the second largest market for rail freight transport in the EU in 2014. Poland transported 227.8 million tons of freight, only surpassed by Germany with 365 million tones (Eurostat 2016b). Fig. 12 shows the total amount of cargo transported via rail. After the global economic crisis of 2009, there has been a reduction in rail freight volume across the Central and Eastern European countries. Just in a decade, between 2000 and 2010, Poland has experienced an absolute variation of rail modal share of approximately –18.7% (CER 2013).

The largest-volume commodity transported in the Polish rail freight is coal, with a 40.48% of market share. It is followed by metal ores, sand, gravel and clays with a 26.80% market share

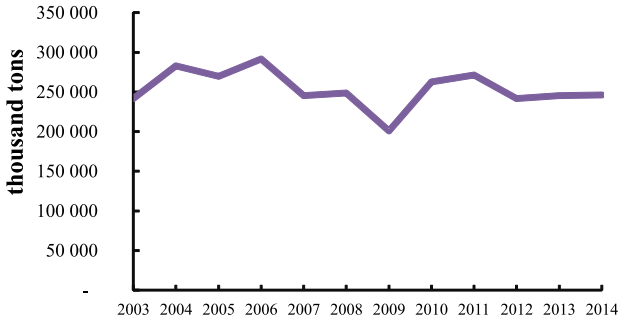

Fig. 12. Rail freight transport
Sources: GUS 2004–2015

Rys. 12. Przewóz ładunków transportem kolejowym

(CER 2013). Moreover, it has been estimated that for the past twelve years, the average transportation distance of one ton of rail freight is 208 km (GUS 2004–2015).

1.3. Air transport

Since the market liberalization and the accession of Poland to the EU, and similarly to the road and rail transport, the Polish air transport sector has experienced a growth in traffic volume. With the increase in disposable income and the privileged geographical location, connecting the eastern areas of Europe to the West, Poland nowadays has the largest number of active commercial airports and the largest number of air passengers among all the CEE countries (Jankiewicz & Huderek-Glapska 2015). The air transport system consist of over 103 air routes including 17 domestic and 96 international destinations. Furthermore, 13 airports were in use in 2014, which

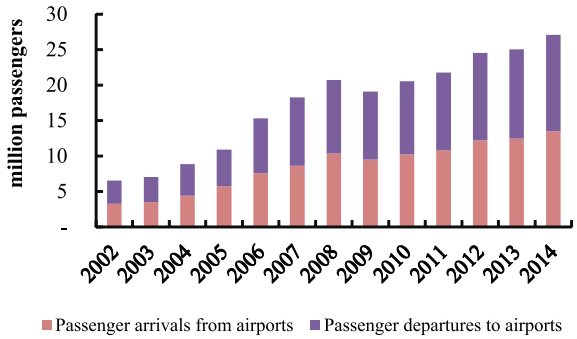

Fig. 13. Air passenger transport
Sources: GUS 2004–2015

Rys. 13. Przewóz pasażerów transportem lotniczym

served an absolute passenger volume of over 27 million passengers, 2.9 million in domestic flights and 24.2 million in international flights (GUS 2004–2015) (Fig. 13).

In addition, the market liberalization and the EU-US Open Skies agreement encouraged the entry of foreign EU carriers to the Polish aviation market (ICAO 2013). In 2014, low cost carriers (LCC) had the largest market share as shown in Fig. 14 (ULC 2014). Moreover, the growing number of passengers has promoted competition between LCC and has provided access to lower air fares. Likewise, it has incentivized national and international investment in the Polish aviation sector (Jankiewicz & Huderek-Glapska 2015). The total number of aircrafts increased from 1064 (2004) to 1216 (2014) (Fig. 15) and the number of jet planes almost doubled during the same period, going from 42 to 81 (GUS 2014).

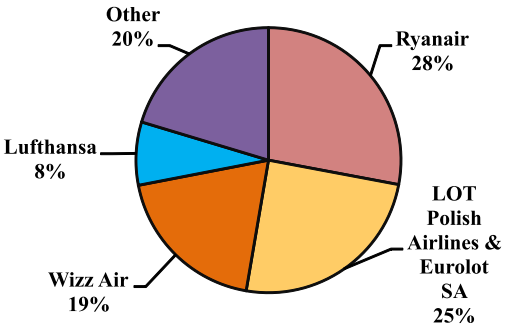

Fig. 14. All airlines market share (2014)
Source: ULC, 2014

Rys. 14. Udział w rynku poszczególnych linii lotniczych

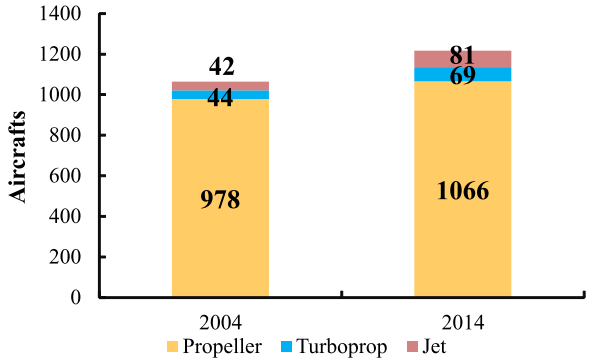

Fig. 15. Number of aircrafts in Poland in 2004 and 2014
Sources: GUS 2004–2015

Rys. 15. Liczba samolotów w Polsce w roku 2004 i 2014

Regarding air freight, its market share is just a fraction of a percent of the total freight transport (see Fig. 16). However, the total cargo volume, mail and freight loaded and unloaded increased from 55,581 tons in 2002 to 86,137 tons in 2014. Approx. 90% of the total fre-

ight volume was international freight transport (GUS 2004–2015). Fig. 17 shows total freight transported via air.

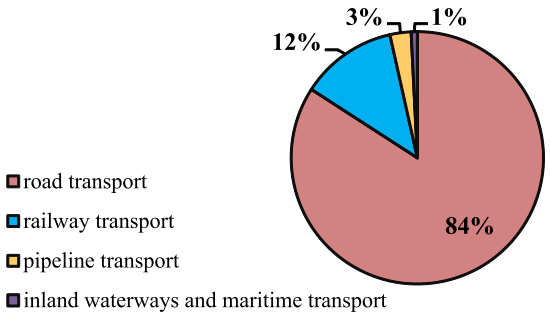

Fig. 16. Freight transport – modal split
Source: GUS 2004–2014

Rys. 16. Przewóz towarów według rodzajów transportu

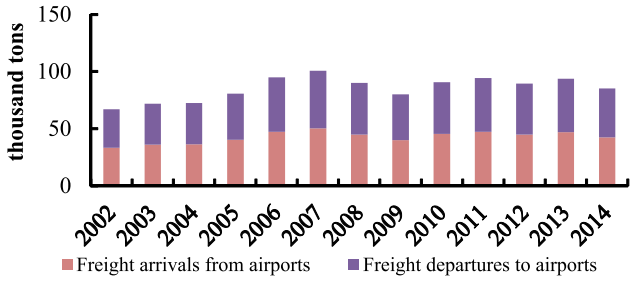

Fig. 17. Air freight transport
Sources: GUS 2004–2015

Rys. 17. Przewóz towarów transportem lotniczym

2. Energy consumption in the transport sector

The EIA estimated that the total final energy consumption in Poland was 66.98 Mtoe in 2014. This was an increase of approximately 13% when compared to 2003. The growth in total final energy consumption was mainly due to a 54% increase in the amount of energy required by the transportation sector and 27% increase in the commercial and public sector (Fig. 18).

As mentioned in Section 2, the dynamic economic growth of the country and the development of the transport sector have led to a surge in energy consumption (GUS & KAPE 2015). Nowadays, the road transport and the rail transport sector consume nearly 30% of the total energy consumption, taking the second largest share only after the household sector (see Fig.

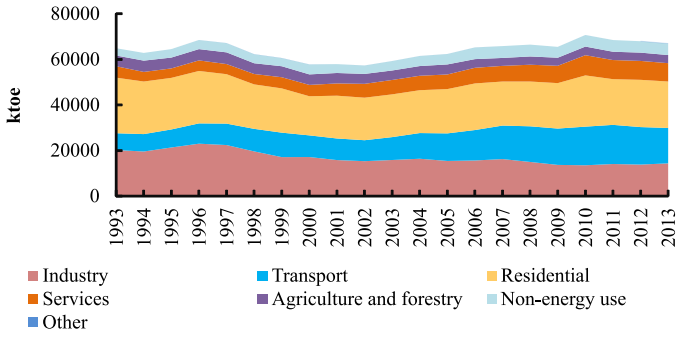

Fig. 18. Total energy consumption in Poland, by sector
Source: IEA 2016

Rys. 18. Całkowite zużycie energii w Polsce według sektorów

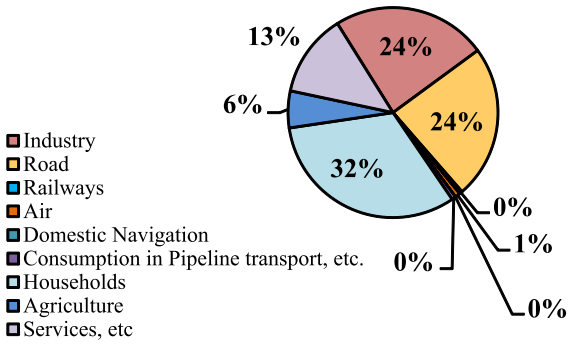

Fig. 19. Total energy consumption in Poland, by sector Source: European Commission, 2015

Rys. 19. Zużycie całkowite energii w Polsce w podziale na sektory

19) (European Commission 2015). Furthermore, it is estimated that 94% of the total energy consumption of the transport sector is due to the road transport (GUS 2015a) (see Fig. 18).

Additionally, the growth in the total number of vehicles has led to a rapid increase in the demand of petroleum derived fuels (Fig. 21). In 2013, the largest majority of buses, trucks and tractors were predominantly diesel-powered (Fig. 22). For passenger cars, the improvement in engine efficiency and the national strategies to gradually replace fossil fuels with alternative fuels have made a significant impact on the number of passenger vehicles powered by diesel and liquefied petroleum gas (LPG) engines. Gasoline cars dominate the transport sector, followed by diesel-powered cars; however, Poland has the second largest fleet of LPG-fueled passenger cars in the European Union (retro-fitted) (Eurostat 2015b).

During the 1990s, gasoline and diesel were the only two fuels used for the road transport. Between 2003 and 2012, the popularity of diesel-powered cars rose leading to an increase in the consumption of diesel from 2841 ktoe in 2004 to a peak consumption of 10200 ktoe in 2011. This represented a twofold increase in just seven years. Table 1 shows the final consumption of

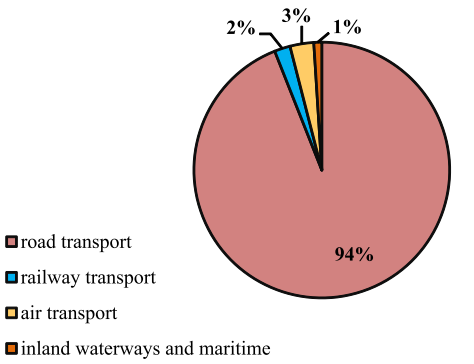

Fig. 20. Energy consumption by transport mode
Source: GUS 2015a

Rys. 20. Zużycie energii w sektorze transportowym

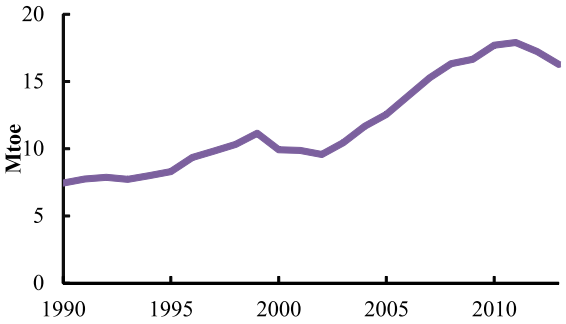

Fig. 21. Polish transport sector final energy consumption
Source: European Commission 2016b

Rys. 21. Zużycie energii finalnej w sektorze transportowym w Polsce

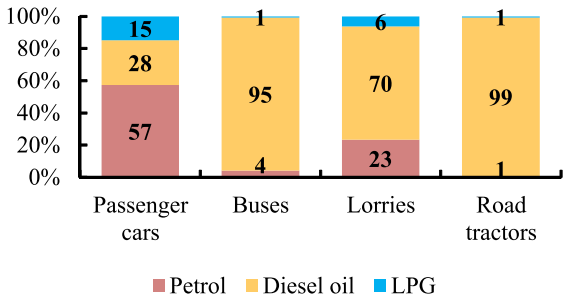

Fig. 22. Proportion of vehicles by fuel type
Source: GUS 2015a

Rys. 22. Pojazdy samochodowe według rodzaju paliwa

petroleum products in Poland from 1990 to 2013. By 2013, the share of fuels used in the road transport sector looked very different to 1990 (European Commission 2016b) (Fig. 23). Nowadays, the transport sector is responsible for approximately 98% of the gasoline, 78% diesel, and 66% LPG consumed in Poland (CSO 2014).

TABLE 1. Polish transport fuel consumption (1990–2013)

TABELA 1. Zużycie energii w transporcie według paliw, 1990–2013

	Motor Gasoline	Gas/Diesel Oil	LPG	Natural Gas	Biogasoline	Biodiesel
1990	3252	3259	0	0	0	0
1991	3793	3129	0	0	0	0
1992	4023	3094	0	0	0	0
1993	4110	2841	27	0	0	0
1994	4548	2711	78	0	0	0
1995	4610	2796	193	0	0	0
1996	4819	3506	278	1	0	0
1997	5204	3548	369	1	0	0
1998	5306	3914	385	1	0	0
1999	5903	4063	513	0	0	0
2000	5319	3396	467	60	0	0
2001	4935	3530	644	78	0	0
2002	4519	3382	911	84	0	0
2003	4316	4094	1176	126	28	0
2004	4382	4973	1473	176	13	0
2005	4230	5657	1702	236	34	15
2006	4338	6575	1868	308	55	35
2007	4333	7872	1923	283	72	24
2008	4280	8555	1889	321	127	308
2009	4295	8869	1816	265	168	468
2010	4243	9737	1824	221	170	698
2011	4013	10200	1767	222	161	755
2012	3841	9715	1764	258	138	669
2013	3660	8930	1750	368	144	603

Source: European Commission 2016b

Several direct and indirect factors have been related to the change in final energy consumption in the transport sector. For instance, in road transport sector, direct factors such as the number of vehicles, transport infrastructure and vehicle fuel economy. Furthermore, in the case of the road and rail freight transport (see Fig. 24), direct factors have been divided and further expanded into logistical, technical and operational (García-Álvarez et al. 2013).

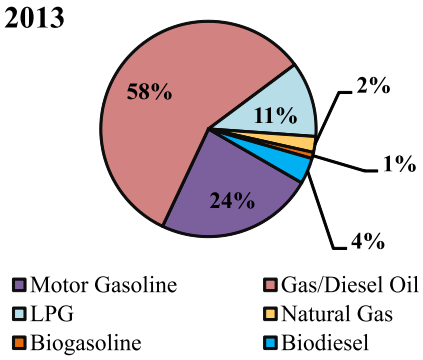

Fig. 23. Share of fuels used in the Polish transport sector (2013)
Source: European Commission 2016b

Rys. 23. Udział poszczególnych paliw wykorzystywanych w polskim sektorze transportowym, 2013

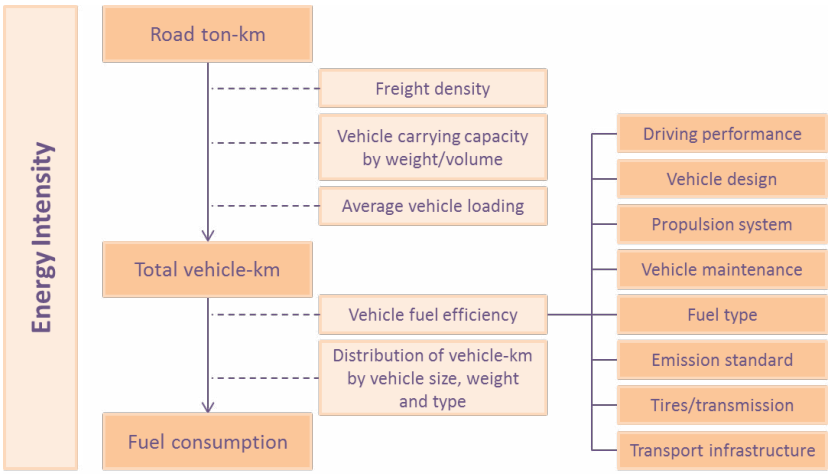

Fig. 24. Direct and indirect factors that affect the energy consumption in the road transport sector
Source: Adapted from (Piecyk & Mckinnon 2009)

Rys. 24. Bezpośrednie i pośrednie czynniki wpływające na zużycie energii w transporcie drogowym

A main technical factor that has directly influenced the energy consumption and the environmental impact of the Polish road transport sector is the improvement of the fleet average fuel consumption. In 2000, the average car fuel consumption in Poland was 8.17 liters per 100 km (12.2 km/l) and in 2013 the fuel consumption was down to 7.65 liters per 100 km (13.07 km/l). Even though the vehicle fuel consumption has decreased and for the most part is due to the fuel economy standards imposed after the accession to the EU, the average car fuel consumption is still behind the 5.37 liters per 100 km (18.62 km/l) in the U.K, or 6.03 liters per 100 km (16.58 km/l) in Italy (see Fig. 25) (Enerdata 2016).

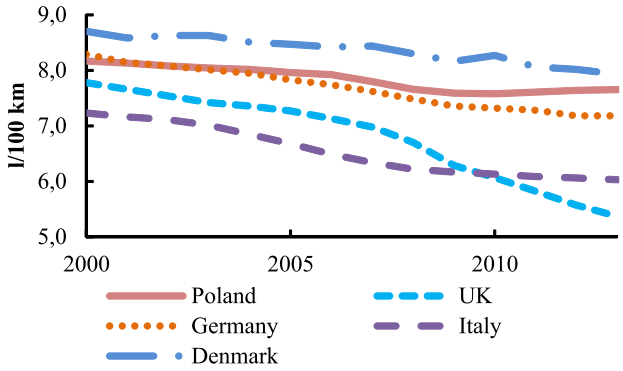

Fig. 25. Fleet average fuel consumption
Source: Enerdata 2016

Rys. 25. Średnie zużycie paliwa przez flotę samochodową

In addition, the significant changes in hydrogen carbon ratio and carbon content in gasoline have had a direct impact on the road transportation fuel consumption. In the 1980s and 1990s, leaded gasoline was used in Poland. During those two decades, regular gasoline had an octane number of 86, 94 and 98 (research octane number). Nowadays, it is lead-free gasoline, commercialized with only 95 to 98 (RON). With regard to the energy consumption of rail transport, both freight and passenger traffic routes, available data only takes into account the amount of fuel combusted such as diesel or hard coal. The rolling stock of steam locomotives (hard coal powered) was phased out in 1990. Furthermore, diesel locomotives consumed as much as 4287 TJ in 2013. This was a significant change from the 6907 TJ consumed in 2003 or the 10425 TJ consumed in 1993 (KOBiZE 2015). Unfortunately, data for electricity consumption of electric locomotives is unavailable. As to the air transport, the publicly available data covers only the domestic passenger and freight traffic. Moreover, the available data of the Polish aviation sector between the years 1988 and 2004 is only a fuel consumption estimation. Therefore, reliable data can be only obtained for the years after the accession of Poland to the EU. In 2013, the domestic air transport consumed 1861.29 TJ of jet fuel and 176 TJ of aviation gasoline (KOBiZE 2015).

3. CO_2 emissions in the Polish transport sector

In 2014, Poland emitted nearly 310 million tons of CO_2 or less than one percent (0.9%) share of the global CO_2 emissions. This ranked Poland as 21st out of the 195 countries, just below the top twenty carbon emitters in the world. It is fourth largest emitter in EU, behind Germany (globally ranked 6), France (17) and Italy (20) (EIA 2015).

CO_2 emissions in Poland reached their highest level in the late 1980s (496 million tons in 1987) and only started to decrease after 1989 (see Fig. 26). This was largely due to economic and political transformation of the country. Since its accession to the EU, Poland has become one of the largest economies in the EU and the largest economy in CEE, but at the same time, the Polish economy remains one of the highest in energy intensity and least carbon efficient from all the EU member states. With 294.1 koe/1000 EUR, Poland in 2013 ranked seventh among all EU members. Countries with highest energy intensity in the EU are: Bulgaria (610.4 koe/1000 EUR), Estonia (512.7 koe/1000 EUR), Czech Republic (353.8 koe/1000 EUR), Romania (335.5 koe/1000 EUR), Slovakia (332.0 koe/1000 EUR) and Latvia (310.6 koe/1000 EUR) (Eurostat 2016a; BP 2015).

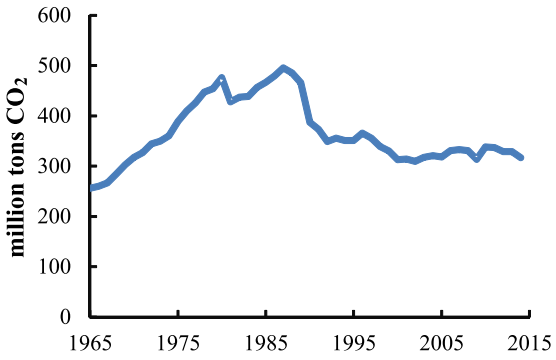

Fig. 26. Poland CO_2 emissions, 1965–2015
Source: BP 2015

Rys. 26. Całkowita emisja CO_2 w Polsce, 1965–2015

The 2020 climate & energy package set by the EU (the 20-20-20 package), has been one of the forcing factors for Poland to cut greenhouse gases emissions from energy-intensive sectors (power sector, refineries, coke ovens, heavy industries – iron and steel, cement, lime, glass, paper) in order to meet the 20-20-20 package targets (European Commission 2016a). It is worth noting that while the package sets key climate and energy targets requiring Poland to decrease its emissions by 21% (compared with 2005), it does not restrict emissions from other sectors, known as non-ETS (Emission Trading System) sectors (such as: transport, services, construction, etc.) and allows emissions from non-ETS to increase even by 14%. According to the World Bank, nearly 60% of CO_2 emissions in Poland were generated by ETS sectors, while the EU's average was approximately 40% (WB 2011).

Even though the industrial sector is considered the main GHG emitter in Poland and is responsible for over half of the 323 million tons of CO_2 generated (2012), the transport sector is the second largest emitter, releasing into the atmosphere approximately 15% percent of the total carbon dioxide emitted by Polish economy (see Fig. 27) (European Commission 2016b). It is expected that without proper regulations, the annual CO_2 emission from the transport sector may

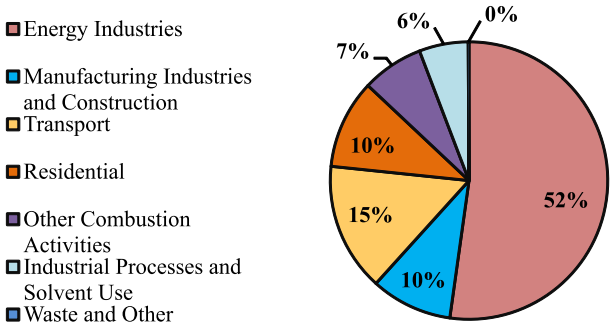

Fig. 27. Contribution of economic sectors to the total CO_2 emissions in Poland
Source: European Commission 2016b

Rys. 27. Udział poszczególnych sektorów gospodarki w całkowitym wolumenie emisji CO_2 w Polsce

double by 2030 (compared to 2005) (WB 2011). Fig. 28 presents Poland's CO_2 emissions from the transport sector between 1990 and 2013.

Despite the fact that in the last couple of years there was a slight decline in CO_2 emissions, as shown on Fig. 26, the total motor vehicles emissions in the transport sector have rapidly increased, going from 20 million tons of CO_2 in 1990 to 46 million tons in 2012 (European Commission 2016b). The increase in road transport emissions has triggered, not only in Poland but in all EU member states, the implementation of several EU and national policy measures. Some of these measures are mostly based on the implementation of taxes and pricing motivators in order to reduce passenger car use and limit the number of passenger cars on the roads.

Some policy actions and measures that have been taken to decrease the amount of road transport carbon emissions and that are worth pointing out are: road pricing for highways, fuel tax increase and parking fees in urban areas. Additionally, promotion of public transportation and non-motorized transport, such as walking and cycling; and in the case of the freight transport,

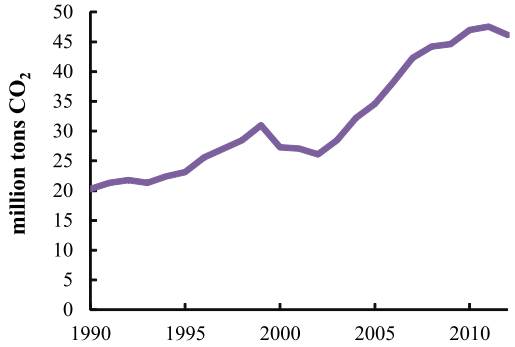

Fig. 28. Transport CO_2 emissions
Source: European Commission 2016b

Rys. 28. Emisje CO_2 z sektora transportu

an improvement in supply chain and logistics efficiency. The last one refers to the road freight transport, which is the second largest emitter of CO_2 in the transport sector (Fig. 29) (WB 2011).

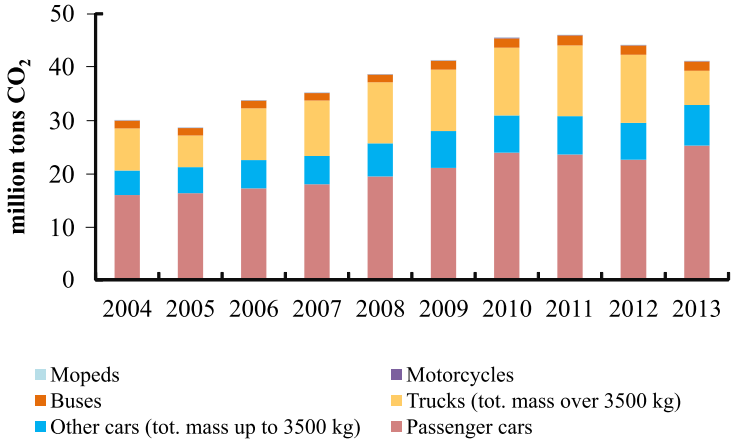

Fig. 29. Road transport CO_2 emissions
Adapted from: GUS 2005–2014

Rys. 29. Emisje CO_2 z sektora transportu drogowego

Passenger cars are responsible for over half of the total road CO_2 emissions in Poland (see Fig. 29). In 2013, passenger cars emitted nearly 51% of the total road transport carbon emissions but just a year later this number went up to 61%. Furthermore, between 2004 and 2013, CO_2 emissions from passenger cars increased by almost 10 million tons. This increase can be linked to the rapid growth in passenger cars, nearly 78% increase from 2003 to 2014, road network development after accessing the EU, and the continuous economic growth for the last two decades. In the road transport sector, GHG emissions are predominantly the result of the combustion of gasoline or equivalent fuels in an internal combustion engine. Factors such as engine type, vehicle age and engine displacement have a direct impact on the amount of greenhouse gases emitted. The combustion of diesel generates over 2 kg CO_{2e} per GJ more than the combustion of gasoline (Department of the Environment 2014). In 2013, approximately 56.4% of passenger cars in Poland were equipped with gasoline-fueled engines, 27.1% are diesel cars and 14.7% LPG powered cars (GUS 2015b).

As previously mentioned, road transport is responsible for almost 95% of the overall CO_2 emissions generated in the Polish transport sector; this implies that 5% or approximately 2 million tons of CO_2 were produced from the aviation, railway and inland waterways transport.

In terms of carbon emissions, the railway transport sector can be considered a direct and also an indirect emitter. Direct emissions arise from the combustion of diesel in an ICE. 53% of the total number of locomotives in service in Poland are diesel-powered locomotives. Diesel locomotives emitted 322 kt of CO_2 in 2013, a decrease of 37% from just a decade before (518 kt CO_2). Additionally, 46% of all the locomotives in the country are electric locomotives.

Electric locomotives are considered indirect emitters since they do not require the combustion of any fuel for their propulsion, they use electricity being generated in power stations (KOBiZE 2015).

With respect to carbon emissions of the Polish air transport sector, publicly available data only reports the CO_2 emissions of civil domestic aviation. The air transport in Poland covers less than 1.1% of the total movement of passengers and a fraction of a percent of goods transported in Poland (GUS 2004–2015). CO_2 emissions in the civil domestic aviation have climbed persistently due to a recent increase in passenger transport. Carbon dioxide emissions, from jet fuel combustion, have gone from 62 kt in 2004 to 149 kt of CO_2 in 2013 (KOBiZE 2015).

Conclusions

Since the accession of Poland to the EU, there has been a major change in the economic performance of the country. The rapid growth of the economy resulted in a significant development in every aspect of the Polish transportation sector. Over the last decade, Poland has experienced a historical increase in motorization rate, going from 294 (in 2003) to 520 passenger cars per 1000 inhabitants in 2013. The growth in road freight and logistic services, which compromise national and international freight services, has placed Poland as one of the largest road transport service providers in the EU. In addition, with the strategic funding from the EU, Poland has been able to modernize its road and rail network systems.

On the other hand, all the aforementioned developments have contributed to an increase in the total final energy consumption and the CO_2 emissions of the Polish transport sector. Gasoline, diesel, LPG and jet fuel consumption have increased sharply over the last decades. CO_2 emissions from the transport sector have gone from approx. 20 million tons of CO_2 in 1990 to 46 million tons in 2013.

This paper presented and discussed the current status of the Polish transport sector and has largely concentrated on the changes that have occurred over the last two decades. Owing to the fact that energy consumption and CO_2 emissions of the Polish road, air and railway transport sector have increased and continue to grow, certain actions need to be taken in order to reduce the impact of the transport sector on the economy. Furthermore, appropriate tools that would enable to assess their potential impact need to be developed.

This paper was partially performed within the statutory research program of the Mineral and Energy Economy Research Institute, PAS.

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Analiza zużycia energii oraz emisji CO_2 w polskim sektorze transportowym

Streszczenie

Transport w dużej mierze przyczynia się do rozwoju gospodarki światowej. Jest jednym z kluczowych czynników warunkujących rozwój miast, handlu oraz wzrost mobilności ludności. Obecnie transport jest również drugim najbardziej energochłonnym sektorem gospodarki w ujęciu ogólnoświatowym oraz jednym z głównych źródeł emisji gazów cieplarnianych. Po wstąpieniu Polski do Unii Europejskiej to sektor transportu znalazł się pośród tych gałęzi gospodarki, które były główną determinantą krajowego wzrostu ekonomicznego. Nastąpiła modernizacja linii kolejowych oraz infrastruktury drogowej, a całkowita liczba samochodów osobowych zarejestrowanych w Polsce niemal się podwoiła. Ponadto, rozwój sektora usług logistycznych oraz transportu drogowego towarów uczynił z Polski największego dostawcę tych usług na rynku europejskim. Wspomniany rozwój sektora przyczynił się do wzrostu zużycia energii finalnej oraz wolumenu emisji CO_2 pochodzących z transportu. Gwałtownie w ostatnim czasie zwiększyło się zużycie paliw – benzyn silnikowych, olejów napędowych, LPG oraz paliwa typu jet, co pociągnęło za sobą wzrost emitowanego do atmosfery przez sektor transportowy dwutlenku węgla z około 20 milionów ton CO_2 w 1990 roku do 46 milionów w 2013. Celem poniższej publikacji jest przedstawienie analizy zużycia energii oraz emisji dwutlenku węgla z polskiego sektora transportowego oraz dokonanie przeglądu jego rozwoju w przeciągu ostatnich dwóch dekad.

SŁOWA KLUCZOWE: transport, emisje, zużycie paliw, Polska, zużycie energii