

Biofuel in the sustainable development of transport-forwarding-logistics (TFL) sector enterprises in the Silesian Voivodeship

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Abstract: *The article discusses the issue of the impact of biofuel on the sustainable development of enterprises in the transport-forwarding-logistics (TFL) sector in the Silesian Voivodeship. Conventional fuel has been used for nearly 140 years. The term “biofuel” has been known to mankind since the 1890s. For many years, conventional fuel and its various variants were the only forms of fuel used for vehicles. Since 2003, there has been an obligation in Poland to add biocomponents to the composition of fuel. The study examines the importance of biofuel in the sustainable development of TFL enterprises in the Silesian Voivodeship. The research in the article has been carried out by the use of a survey and an in-depth interview. The study was intentional. The survey was conducted using the CAWI (Computer-Assisted Web Interview) method on a research group of 104 respondents representing enterprises from the TFL sector in the Silesian Voivodeship. The research was performed using a snowball method on a non-random sample. The criteria of the study were established on the basis of an in-depth interview with several transport companies from the Silesian Voivodeship. The questions contained in the survey made it possible to distinguish enterprises due to their size or time of operation. The answers also provided information on the preferences of the types of fuel used to power vehicles and the impact of biofuel on the activities of enterprises from the TFL sector in the Silesian Voivodeship. The obtained results made it possible to determine that biofuel could play a significant role in the sustainable development of various enterprises in the TFL sector in the Silesian Voivodeship.*

Key words: sustainable development, Silesia, TFL sector, biofuel

JEL codes: L21, R49, Q01, Q59

1. Introduction

Conventional fuel has been used as a vehicle power supply for nearly 140 years. In 1885 Carl Benz constructed the first car powered by gasoline (www1). Over the next several decades, both the design of the engines and the way they are powered have undergone various changes. One of the energy supplies constantly offered over the years has been biofuel, which is produced in biomass processing. The beginning of biofuel dates back to the 90s of the nineteenth century when Rudolf Diesel used peanut oil in the prototypes of his engines (Rudolf, 2001). In Poland the production of biofuel began in 1929 with the offer of a mixture consisting of 30% ethanol and 70% gasoline (Majewski, 2018). Over the next several decades, various variants of fuel were offered on sale. The additives used in fuel are metal deactivators, antioxidants, detergents, anti-knock agents or products increasing the octane number of fuel. In the past, the creation of new fuel mixtures was primarily aimed at limiting the use of crude oil in fuel production and improving engine performance by affecting the burned composition of the fuel-air mixture. Nowadays, another positive effect of the use of biofuel is noticed, and that is the reduction of harmful emissions released into the atmosphere (Hassan & Kalam, 2013). It is worth noting that high energy efficiency is a part of the assumptions of sustainable development (Wehner et al. 2021), but nevertheless it also should be considered how it is linked with companies' performance (Pazirandeh & Jafari, 2013).

The answer to reducing the emission of pollutants by the use of cars was among others the development of the European emission standard (EURO) (Tab. 1).

Tab. 1 European emission standard and its year of introduction

EURO standard	Year of introduction
EURO 1	1993
EURO 2	1997
EURO 3	2001
EURO 4	2006
EURO 5	2011
EURO 6	2014

Source: (www2)

With the introduction of each European emission standard, car manufactures, which want to sell their vehicles on the EU market, have to make sure that their products meet the requirements regarding emission standard specific for each year (Singh et al. 2023).

On the one hand, vehicle manufacturers are modernizing their engines to filter the resulting pollutants, and on the other hand, the composition of the fuel is modified itself. Due to the influence of the combustion of the fuel-air mixture on what comes out of the tailpipes of vehicles, the development of biofuel has become the natural course of things in the modern world. The Act from 2nd October 2003 requires from producers in Poland to add biocomponents to the composition of fuel (www3). Currently offered fuel includes various varieties of gasoline and diesel, gas or hydrogen.

According to the TFL sector, due to accusations that it causes environmental pollution (Karaman et al. 2020), taking steps to reduce it, is important. Analyzing the activities of the transport-forwarding-logistics (TFL) sector enterprises in the Silesian Voivodeship, several key issues should be noted. In the Silesian Voivodeship alone, there are several hundred facilities, which are open to the public or serving specific enterprises that act as logistics, distribution or warehouse centers. The largest logistics enterprises operating in the Silesian Voivodeship include Panattoni, Amazon, Jerónimo Martins and Silesian Logistic Center. Particularly noteworthy is the Silesian Logistics Center S.A. (ŚCL) located in Gliwice. In addition to standard logistics operations, ŚLC offers the storage of hazardous substances and an intermodal transshipment terminal. There is also an inland port (www4).

Referring to the available data, it should be noted that in the Silesian Voivodeship alone there are about 345 thousand registered trucks operated by several thousand companies (www5). The number of registered trucks in the Silesian Voivodeship accounts for nearly 10% of the total number of cars registered in Poland. However, it should be borne in mind that some logistics enterprises use various forms of vehicle financing (e.g. leasing) and their cars are often registered in other voivodeships.

Rich in logistics facilities, the region attracts the attention of a large number of enterprises providing transport services. Therefore, it should be considered, what role biofuel plays in the sustainable development of the TFL sector in the Silesian Voivodeship and whether in the future they will constitute a significant share in the ways of powering vehicles.

The aim of the article is to assess the importance of biofuel in the sustainable development of TFL sector enterprises in the Silesian Voivodeship. The survey prepared for the purpose of

the article will allow to deepen the information about enterprises from the TFL sector operating in the Silesian Voivodeship.

2. Methodology and Data

In order to determine the share of biofuel in the sustainable development of TFL sector enterprises in the Silesian Voivodeship a research was conducted by the use of a survey. The form contained questions that were arranged on the basis of criteria set out through an in-depth interview carried out with several transport companies from the Silesian Voivodeship. The survey was conducted using the CAWI (Computer-Assisted Web Interview) method on a non-random sample. The form was carried out using a snowball method. At the beginning the survey was sent to few enterprises of the TFL sector in the Silesian Voivodeship, and then they sent the questionnaire to other companies providing similar services. Responses were collected from March to April 2023. The prepared author's survey form was completed by 104 respondents ($n = 104$).

The survey consisted of 10 closed questions. The first three questions concern the activity conducted by enterprises from the TFL sector. Questions 1-3 allow to outline the operability of a given company by indicating the period of activity, the number of trucks owned or the average annual number of kilometers driven by one vehicle. The next four questions deal with the subject of the power supply of trucks itself. In questions 4-7 respondents were asked, what percentage of their fleet is not diesel, to what extent they prefer the chosen ways of powering vehicles and how much biofuel affects the operation and use of the truck. The last three questions focus on the modern use of biofuel. In questions 8-10 respondents answered to what extent biofuel sets the direction of sustainable development in the TFL sector, what is the biggest competition for biofuel and what other methods of powering vehicles in addition to conventional fuel they have encountered in the case of other modes of transport.

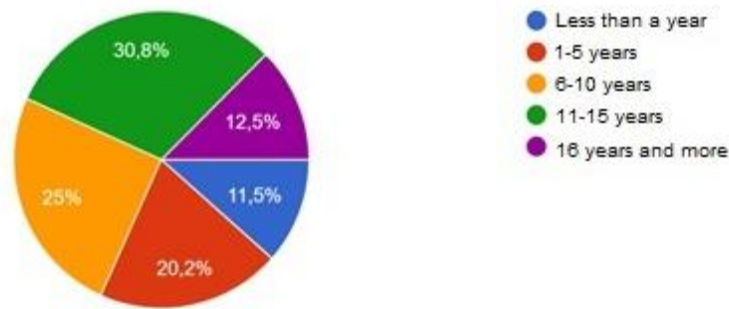
The results of the study are presented in the third chapter.

3. Results and Discussion

The first three questions in the survey included the characteristics of activities conducted by enterprises from the TFL sector in the Silesian Voivodeship.

The obtained answers concerning the period of operating a business by enterprises from the TFL sector in the Silesian Voivodship are presented in Figure 1.

Fig. 1 Period of time running a company in the TFL sector

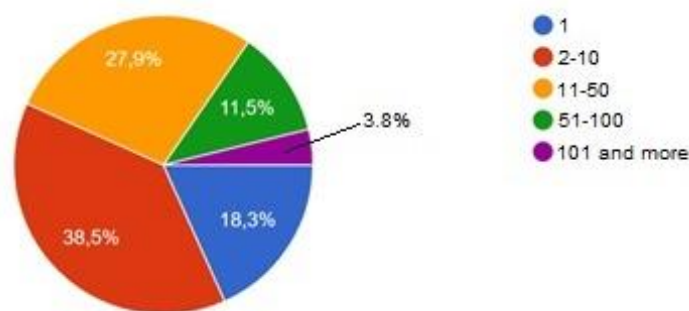


Source: own study

The results of the survey show that the largest number of respondents - 30.8% ($n = 32$) - has been in business from 11 to 15 years. The second most frequently chosen answer was the range from 6 to 10 years, which was marked by 25% ($n = 26$) of respondents. 20.2% ($n = 21$) of enterprises operate their activities from 1 year to 5 years. The answer "16 years and more" was selected by 12.5% ($n = 13$) of respondents. The least frequently chosen answer was "less than a year" which was chosen by 11.5% ($n = 12$) of respondents.

The second question in the form concerned the number of trucks owned by a TFL sector enterprise (Fig. 2).

Fig. 2 Number of trucks owned by the company



Source: own study

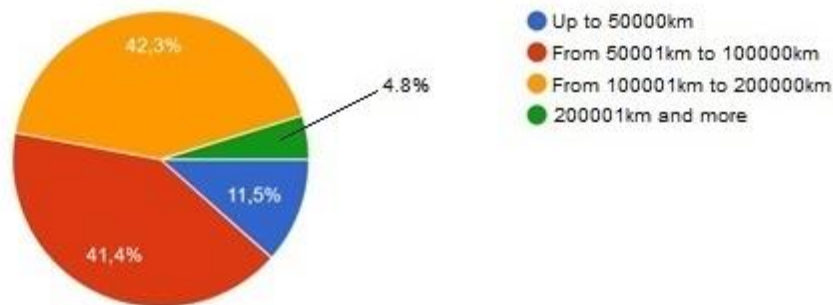
The most frequently chosen answer in the second question was "2-10", which was marked by 38.5% ($n = 40$) of respondents. In second place was the answer "11-50" chosen by 27.9% ($n = 29$) of respondents. 18.3% ($n = 19$) of respondents own just one truck. 11.5% ($n = 12$) of respondents have between 51 and 100 trucks in their fleet. Only 3.8% ($n = 4$) of respondents have a fleet of 101 or more trucks.

Comparing the data from the period of time running a business and the number of trucks owned, there can be noticed a very strong correlation at the level of the Pearson coefficient $r =$

0.81. The connection between the period of activity and amount of trucks shows that the longer the companies provide their services the more trucks they usually own.

The third question in the survey referred to the average number of kilometers driven during a year by one of the trucks of the TFL sector enterprise in the Silesian Voivodeship (Fig. 3).

Fig. 3 Average number of kilometers driven by a single truck in a year

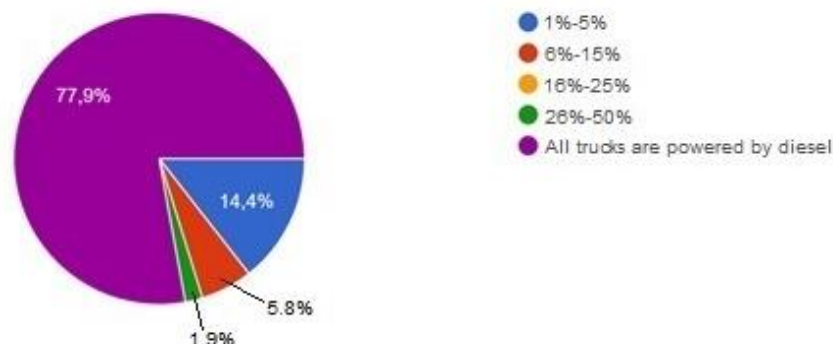


Source: own study

In this case, most respondents - 42.3% (n = 44) - indicated that one of their vehicles drives an average from 100001km to 200000km. The second most frequently chosen answer was the one with a range from 50001km to 100000km, which was marked by 41.4% (n = 43) of respondents. 11.5% of respondents (n = 12) admitted that on average their vehicle covers up to 50000km per year. Only 4.8% (n = 5) of respondents marked the answer "200001km and more".

In the next question respondents were asked, what percentage of trucks in their transport fleet is not powered by diesel (Fig. 4)

Fig. 4 Percentage of trucks not powered by diesel

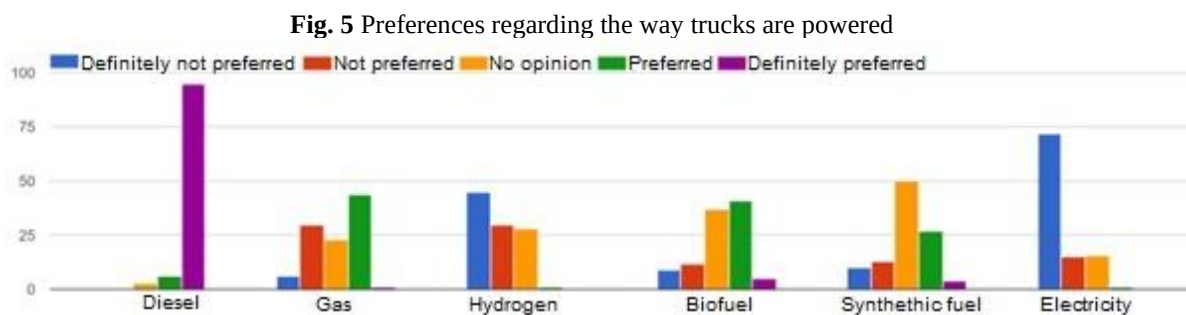


Source: own study

A significant proportion of respondents – 77.9% (n = 81) – admitted that all the trucks at the company's transport fleet are powered by diesel. 14.4% (n = 15) of respondents answered

that 1%-5% of all trucks is powered by another source. 5.8% ($n = 6$) of the surveyed enterprises from the TFL sector marked the answer "6%-15%" and only 1.9% ($n = 2$) of respondents own from 26% to 50% of trucks powered by fuel other than diesel.

In the fifth question respondents referred to their own preferences regarding the way trucks are powered (Fig. 5). Participants were asked to specify their preferences regarding the use of: diesel, gas, hydrogen, biofuel, synthetic fuel and electricity in powering trucks. Enterprises from the TFL sector in the Silesian Voivodeship were asked to rate each method of powering trucks on a scale of 1 to 5 (where: 1 – definitely not preferred, 2 – not preferred, 3 – no opinion, 4 – preferred, 5 – definitely preferred).

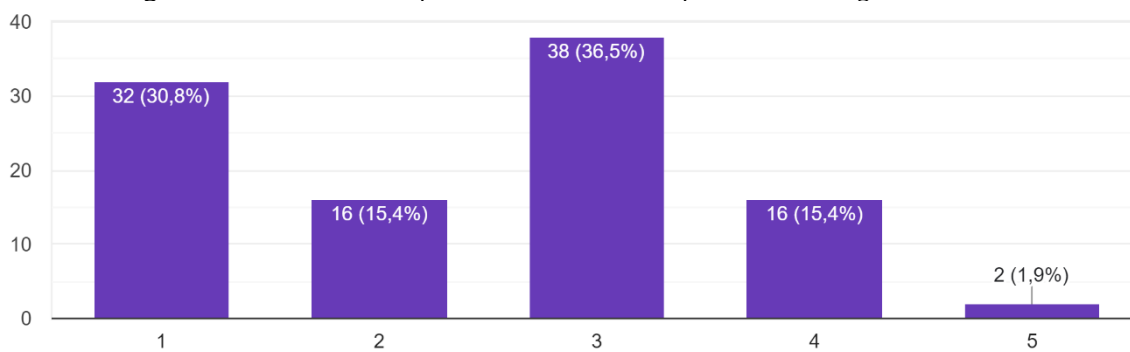


Source: own study

In the case of diesel 97% ($n = 101$) of respondents admitted that they strongly prefer – 91.3% ($n = 95$) or prefer – 5.8% ($n = 6$) the conventional way of powering trucks. For gas supply the most frequently chosen answers were "preferred" – 42.3% ($n = 44$) and "not preferred" – 28.8% ($n = 30$). 72.1% ($n = 75$) of respondents were in favour of hydrogen. "Definitely not preferred" was marked by 43.3% ($n = 45$) of respondents and "not preferred" by 28.8% ($n = 30$) of respondents. For biofuel, 39.4% ($n = 41$) of respondents chose the answer "preferred" and 35.6% ($n = 37$) of respondents admitted that they have no opinion. For synthetic fuel 48.1% ($n = 50$) of respondents reported that they have no opinion and 26% ($n = 27$) of respondents chose the answer "preferred". 69.2% ($n = 72$) of enterprises from the TFL sector answered that they definitely do not prefer electricity as a way to power trucks, 15.4% ($n = 16$) of respondents added that they have no opinion, and 14.4% ($n = 15$) of respondents do not prefer.

In the sixth question respondents determined on a five-point scale (where: 1 – definitely does not improve, 2 – does not improve, 3 – I have no opinion, 4 – improves, 5 – definitely improves) to what extent biofuel improves engine operating conditions (Fig. 6).

Fig. 6 Assessment of the impact of biofuel on the improvement of engine conditions

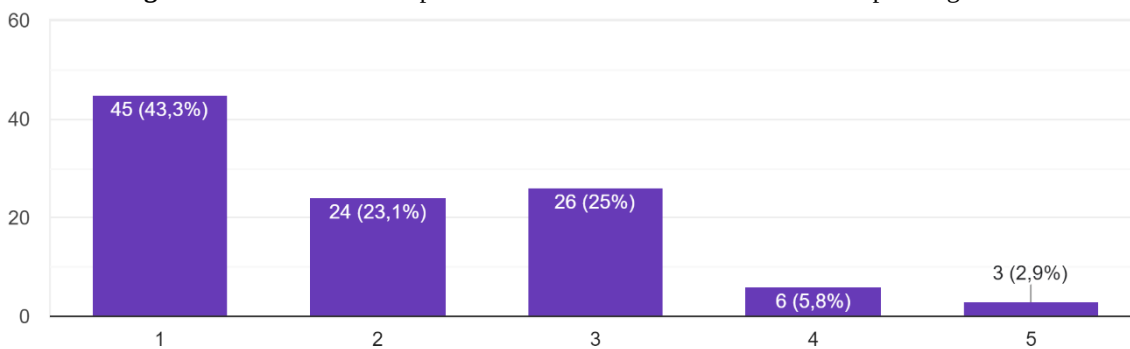


Source: own study

36.5% (n = 38) of respondents answered that they have no opinion. 30.8% (n = 32) of the surveyed enterprises stated that biofuel definitely does not improve engine operating conditions. Ex aequo 15.4% (n = 16) of respondents chose the answers “does not improve” and “improves” engine performance. Only 1.9% (n = 2) of respondents said that biofuel definitely improves the running conditions of an engine.

In the next question, respondents were asked about the extent to which biofuel increases vehicle maintenance costs (Fig. 7). The answers were made on a five-point scale (where: 1 – definitely does not increase, 2 – does not increase, 3 – I have no opinion, 4 – increases, 5 – definitely increases).

Fig. 7 Assessment of the impact of biofuel on the increase in vehicle operating costs

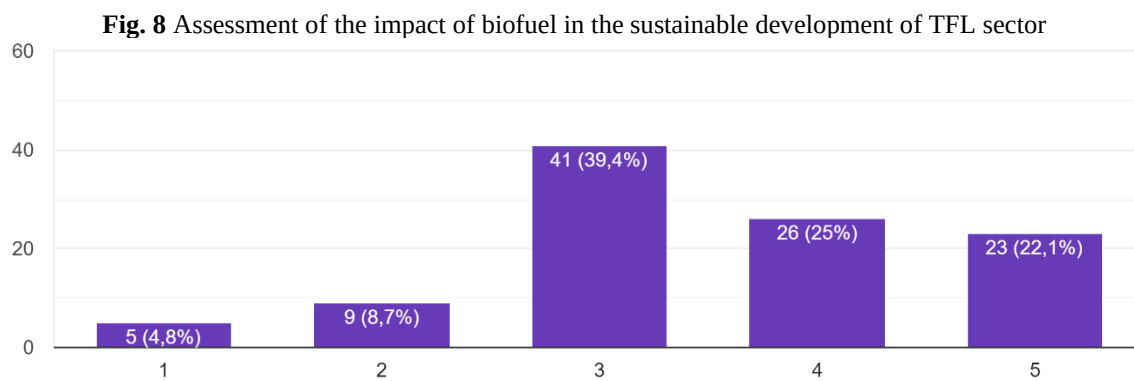


Source: own study

In the seventh question 43.3% (n = 45) of respondents admitted that biofuel definitely does not increase vehicle maintenance costs. The next most frequently chosen answer was "I have no opinion" chosen by 25% (n = 26) of respondents. 23.1% (n = 24) of the surveyed enterprises marked the answer "does not increase". The remaining 9 respondents said that biofuel has a negative impact on vehicle maintenance costs, with 5.8% (n = 6) of respondents choosing the answer "increases" and 2.9% (n = 3) of respondents "definitely increases".

Interestingly, comparing the average annual mileage covered by one truck to the assess of the impact of biofuel on the increase in vehicle maintenance costs, there is a very low level of Pearson correlation coefficient at the level of $r = 0.08$. It shows that with more average kilometers driven by one truck, the maintenance costs of the vehicle are not increased by the use of biofuel.

In the eighth question respondents were asked to mark on a five-point scale (where: 1 – definitely does not determine, 2 – does not determine, 3 – I have no opinion, 4 – determines, 5 – definitely determines) to what extent biofuel determines the direction of sustainable development in the TFL sector (Fig. 8).



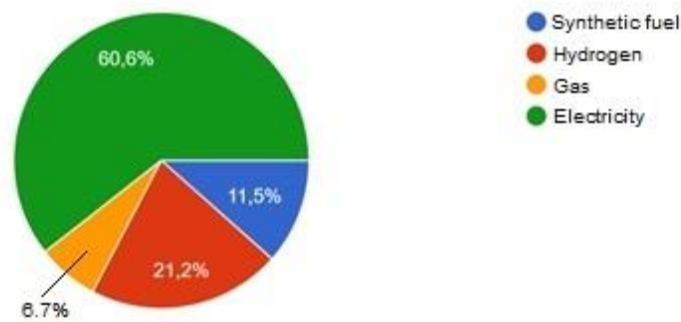
Source: own study

39.4% ($n = 41$) of respondents admitted that they have no opinion. 25% ($n = 26$) of respondents marked the answer "determines". Subsequently, 22.1% ($n = 23$) of the respondents chose "definitely determines". 8.7% ($n = 9$) of respondents said that biofuel does not set the direction for sustainable development in the TFL sector. The remaining 4.8% ($n = 5$) of respondents indicated the answer "definitely does not determine".

It is worth noting that of those who were in favour of diesel in the 5th question, 48% ($n = 48$) of respondents said that biofuel sets the direction for sustainable development in the TFL sector.

In the last before one question, respondents were asked to indicate which of the selected sources of vehicle power (synthetic fuel, hydrogen, gas or electricity) is the biggest competition for biofuel in the sustainable development of the TFL sector (Fig. 9).

Fig. 9 Competition structure for biofuel

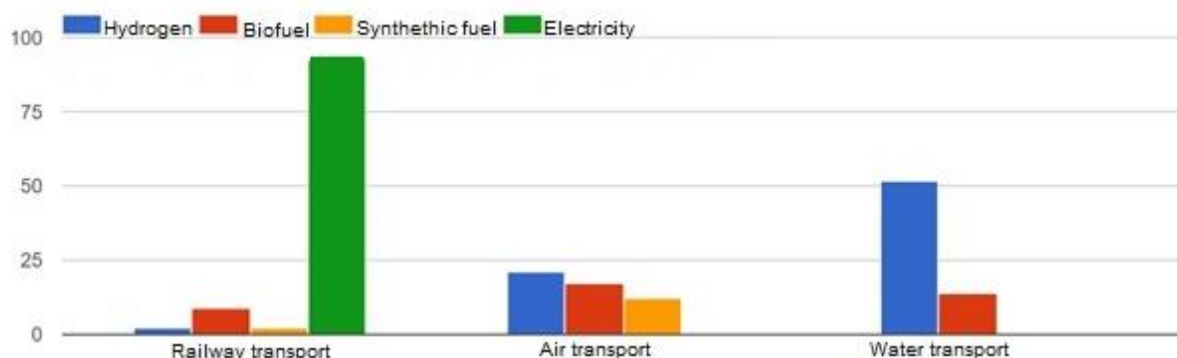


Source: own study

60.6% (n = 63) of respondents stated that electricity is the biggest competitor for biofuel in the sustainable development of the TFL sector. Interestingly, 55 respondents who admitted that electricity is the biggest competitor for biofuel in the sustainable development of the TFL sector were negative in question 5 in favour of the preference for electricity as a future way of powering their fleet. The next most frequently chosen answer in question 9 was "hydrogen", for which 21.2% (n = 22) of respondents voted. Synthetic fuel was indicated by 11.5% (n = 12) of respondents. On the other hand, gas according to only 6.7% (n = 7) of respondents, is the biggest competition for biofuel.

In the last question (Fig. 10) respondents were asked to indicate other sources of vehicle power, in addition to conventional fuel, which they had heard about in other modes of transport (railway transport, air transport and water transport).

Fig. 10 The use of various power sources in other branches of transport



Source: own study

In the case of railway transport 90.4% (n = 94) of respondents chose the answer "electricity". 8.7% (n = 9) of respondents selected "biofuel" and ex aequo 1.9% (n = 2) of respondents indicated "hydrogen" and "electricity".

For air transport 20.2% ($n = 21$) of respondents chose the answer "hydrogen". Subsequently, 16.3% ($n = 17$) of respondents marked "biofuel". 11.5% ($n = 12$) of the surveyed enterprises indicated "synthetic fuel".

According to water transport, 50% ($n = 52$) of respondents marked the answer "hydrogen". 13.5% ($n = 14$) of respondents chose "biofuel".

4. Conclusions

Biofuel has been used as a direct power source for engines or as an additive to conventional fuel for more than 100 years. The use of biofuel in powering trucks is in line with the assumptions of sustainable development of the TFL sector. Biofuel reduces the release of harmful substances into the atmosphere.

The obtained results of the study on the impact of biofuel on the sustainable development of TFL sector enterprises in the Silesian Voivodeship allow to draw several conclusions.

First of all, it should be noted that the vast majority of respondents have between 1 and 50 trucks in their transport fleet and the average number of kilometers covered per year by one truck ranges from 50001km to 200000km. There is also a high link, at the level of the Pearson correlation index of $r = 0.81$, between the period of running a business and the amount of trucks owned, which means that usually the longer the business runs the higher the number of trucks owned gets.

Nearly 80% of respondents admitted that all trucks in their fleet are exclusively powered by diesel. In the case of changing the transport fleet, 97% of respondents admitted that they definitely prefer or prefer diesel fuel. Among those who opted for diesel, 48% of respondents believed that biofuel sets the direction for the sustainable development of the TFL sector. Biofuel as a future way of powering vehicles was supported by 44.2% of the surveyed enterprises and 35.6% of companies said that they have no opinion.

Examining the impact of biofuel on the activity of TFL sector enterprises in the Silesian Voivodeship, the majority of respondents admitted that they have no opinion on the impact of biofuel on engine operating conditions or that biofuel does not improve the operating conditions. It is worth noting that 66.3% of respondents admitted at the same time that biofuel definitely does not increase or increases vehicle maintenance costs. There is also a very low correlation between the increase in the average number of kilometers driven by one truck and the increase in the cost of using trucks by refueling them with biofuel. It is therefore concluded that biofuel does not generate additional positive effects on the operation of a truck engine, but

at the same time it maintains adequate parameters to standard maintenance operations and the associated costs.

When the enterprises were asked about the extent, to which biofuel sets the direction of sustainable development in the TFL sector, respondents most often admitted that they do not have an opinion or that it sets and definitely sets. The surveyed enterprises stated that the biggest competitor for biofuel in the sustainable development of the TFL sector in the Silesian Voivodeship is electricity, for which 60.6% of respondents voted. Interestingly, 87% of the surveyed enterprises that voted for electricity as the largest competitor of biofuel admitted also that they definitely do not prefer or do not prefer the choice of electricity as the future way of powering their trucks.

To sum up, biofuel as a direct way of powering vehicles or an additive to conventional fuel can create a significant impact on the sustainable development of TFL sector enterprises in the Silesian Voivodeship. Despite the growing popularity of powering vehicles with electricity, it is noted that the majority of surveyed respondents are still in favour of conventional fuel.

A properly conducted policy of promotion and development of biofuel can provide enterprises from the TFL sector with the same conditions as those they know today, while reducing the emissions of harmful pollutants.

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