

## **DEVELOPMENT OF VEHICLES RECYCLING SYSTEM**

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**Abstract:** Fast development of automotive industry in Poland in recent years involves the need for rational waste management from the destruction and exploitation of vehicles. Rising number of new cars in Poland and existing age structure of the domestic park of vehicles will contribute to the increase number cars withdrawn from use. The way to solve the growing problem of waste recycling is the development of vehicles recycling system which contributes to the economic management of natural resources and energy. The ability to reuse parts, components and materials used in automobiles reduces the waste stream irrevocably deposited in landfills.

**Keywords:** automotive, recycling, reverse logistics

### **1. Introduction**

In 2013 the Polish automotive industry production reached 109,2 billion PLN. This is 6,3 percentage points more than in the previous year. The growth has contributed to the production of commercial vehicles, parts and automotive accessories. Improvement was also observed in the Polish market vehicles. By the 6,3 percentage points increased the number of new passenger cars registrations on an annual basis which gives 289,9 thousands. Registrations of commercial vehicles increased to an even greater extent, this was due to the implementation of Euro VI.

The first quarter of 2013 was a reflection of economical growth inhibition, but the second half was an upward trend and turned out to be much better. In the third quarter, in Poland, GDP grew by 1,9 percentage points, while the fourth is estimated to increase by 2,7 percentage points. The gradual improvement in the economic situation, which has evolved since the beginning of 2013, had a major impact on improving sentiment businesses and individual consumers. Indicators of economic fluctuations (cyclical) in both sectors of purchasers are still negative, which translates into a tendency to incur significant capital expenditure.

Second half of 2013 has brought an increase in registrations of new passenger cars with a 14,9 percentage points on an annual basis, which helped to improve the results all year round. A total of 289,9 thousands registered in 2013 new passenger cars, an increase of 6,3 percentage points more than in 2012. In 2013 were brought to Poland 712 thousand used cars, and private individuals with the inclusion of individual entrepreneurs have bought only 121 new vehicles [1]. It is worth noting that utility vehicles, parts and components are driven to the Polish automotive industry. In 2013, manufactured in Poland 590.3 thousands motor vehicles - about 8,9 percentage points less than a year earlier and more than one-third less than in 2008 (data rates do not include special vehicles). The passenger car segment corresponds to a decrease. In 2013, it was produced 475,1 thousands, which is about 12 percentage points less than the year before.

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A different situation occurs in the segment of vans and lorries, which five years marks systematic growth and had returned fully to equilibrium after the crisis. Throughout year 2013 it was produced 111,1 thousands pieces – 6,9 percentage points more than in year 2012. Production of buses also increased to 4,2 thousands pieces (which gives 4,8 percentage points). Better results than the forecasts predicted, has achieved business of automotive parts and accessories (including glass and batteries) as well as tires. During the first three quarters of 2013 their exports increased (in EUR) respectively by 6,7 percentage points and 6,4 percentage points per annum. Overall in 2013 sold production of Polish automotive industry reached 109,2 billion PLN. It is nominally by 6,3 percentage points more than in year 2012 [1].

Automotive service industry is currently one of the fastest growing industries in Poland. It is characterized by a high degree of complexity and diversity of form, organisational structures, including ways of doing business. In addition, the image of the sector affected by the changing environment - especially in terms of requirements for environmental safety posed car manufacturers. The aim of environmental regulations is a continuing concern for the environment and the use of materials and raw materials recycled, the desire to reduce pollutants emitted by the engines, reduction of volatile organic compounds in the process of car paint etc. Compliance with environmental safety standards in turn leads to the search for new design solutions and technological innovations in the operation of vehicles and their servicing.

This article shows the recycling and reuse of waste products in the sector of automotive industry.

## **2. Reverse logistics in the automotive industry**

Reverse logistics is the process of reverse flow of products from their typical final destination to destination in order to recover their value or proper disposal, with the same end use may in practice be understood and interpreted differently. Thus, reverse logistics concept involves reverse flows which are characterized by the opposite direction and a smaller value relative to the main flow of goods and services and the lower flow rate [2].

Reverse logistics processes occur both in closed cycles, and separately, to a full coordination and control of the physical collection and delivery of materials, parts and products directly to the processing and recycling or disposing another and return to the area of use [3].

Given the above, it is clear that reverse logistics plays an essential role in the activities of companies in the automotive service, as all phases of operation of a motor vehicle, as well as out of service require a substantial share of reverse logistics. Thus, in the automotive reverse logistics services applies to operating supplies, including liquids and oils, worn or damaged parts, components and assemblies, packaging, automotive vehicles withdrawn from service [4].

The economy continues to put pressure on many industries and the automotive aftermarket industry is no exception. Faced with challenges that include cost containment, anti-counterfeiting, and inventory management, the industry continues to seek ways to streamline operations, cut costs and improve profitability and at the same time apply green sustainability practices. While important opportunities to achieve these goals exist within the reverse supply chain, they are most often overlooked. "Reverse logistics is especially

critical to the aftermarket. Transporting, handling, and returning used products present significant challenges, as well as potential profitability, for distributors [12].

Manufacturers can obtain tangible benefits by introducing reverse logistics to company policy.

### **3. Recycling in the automotive industry**

The issue of sustainable development is one of the most important challenges facing the modern enterprise, and among a set of basic concepts management of product recovery is significant, leading place.

The main objective of sustainable development is to protect the natural capital [5].

The main areas of sustainable development are the economic, social, ecological and spatial areas. The social area includes issues related to the functioning of society in the context of social ownership and the supply of, and access to public goods. The spatial aspect concerns the issues related to planning and territorial organization of individual regions. The economic aspect affects, in turn, the economy of business and market processes and the external and internal costs of production processes, services and consumption [6].

The definition of recovery by the Act of 27 April 2001 on waste is very extensive and includes any action on waste product that does not endanger the health and life of humans or the environment, and which rely on the use of waste in whole or in part, and tend to recovered from waste material, substance or energy. Similarly, widely defined is the concept of recycling, be understood as the use of waste products, and commonly understood to be their destruction. While recycling is defined in more detail and refers to the manufacture of new products by repeated use of waste materials in closed loop. Waste products in automotive services include all combinations of vehicles or their components, parts, consumables including oils and tyres. Recycling products is to recover and reuse components, assemblies, parts, and supplies after their cleaning and verification of the status of wear or possible regeneration and it is the most rational kind of recycling [7].

The rapid development of the automotive industry entails the need for rational management of waste from operation and vehicles disposal. The sharp increase in the number of cars and their age structure, where a significant proportion of the vehicles are old and worn-out, contribute to the steady growth of the total weight of automotive waste (Figure 1). It becomes urgent to create the conditions, both the legal, organizational and technical foundation in the country to the collection system, use and disposal of waste. The ability to reuse parts, components and materials used in cars would be of great importance from the point of view of efficient management of natural resources and energy, would be affected in a reduction in the waste stream irrevocably deposited in landfills [8].

Landfill capacity has become limited and expensive. Alternatives such as repackaging, remanufacturing and recycling have become more prevalent and viable [9].

Development of a system of collection and processing of waste gives new jobs but should first and foremost be aimed at eliminating the threats posed to the environment are automotive waste, because many of them are wastes considered dangerous [8].

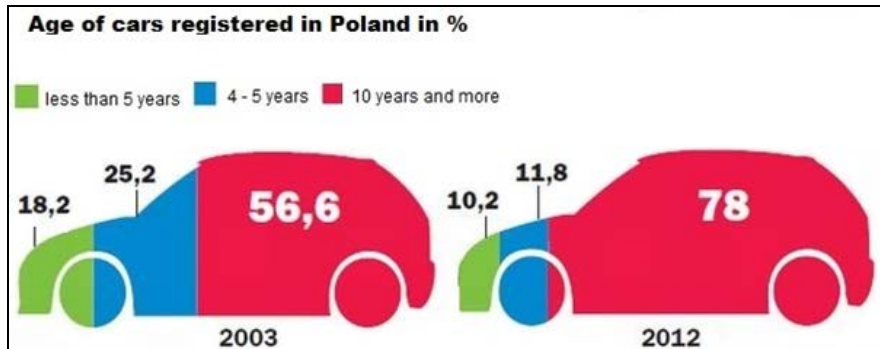


Figure 1. The percentages at the end of 2003 and 2012, according to the *Wyborcza Newspaper*

The development of the national system of recycling of vehicles seems to be the solution to the problem of waste. The term ‘recycling of vehicles’ should be understood as the actions relating to the end-of life automotive devices and the actions involving environmentally safe dismantling of such vehicles, the economic use of their parts and materials, and eliminating those components and materials which cannot be re-used, as well. The waste materials and parts from the ongoing life of vehicles are covered by recycling. To sum up, such groups of materials and parts as, scrap metal (iron, aluminium, copper), vehicle fluids (oils, coolants, brake fluids), tires and other rubber parts, accumulators, plastic parts, car windows, textile materials from vehicles and other regenerated parts and assemblies should be recycled. Aiming at the best economic use of waste, in the case of removable vehicles, can boil down to three options: re-use of parts (e.g. regeneration) which may be used in other vehicles, fulfilling the same functions (this is the most desirable method of recycling - so-called, product recycling); the use of various economically useful materials after processing them, e.g. metal parts, oils, fluids, accumulators (material recycling) [8]. It can be energy recovery by the use of car sludge, for example rubber derived from tires.

#### 4. Waste products in the processes of automotive service

Table I. demonstrates share of the different materials included in the total weight of the vehicle. Broken or old automotive products does not have to be useless. When the product life cycle has reached the end we have still the possibility of recycling it. In recent years, many entrepreneurs are aware of the existence of reverse logistics, which is an important area of logistics management in both individual enterprises, as well as supply chain, providing companies a lot of potential for additional revenues [4]. The Internet market is full of companies which buy up the whole product or only selected parts. The prevention of environment had a high impact on reverse logistics in automotive industry. However, an important reason for the development of this sector of the market is a profit, of course. It brings profit both to the company and the seller, because otherwise the products would probably find their place in the garbage.

*Table I.*  
*The share of the different materials included in the total weight of the vehicle*

Materials	Participation in the total mass [%]	The recovery factor of the material
Steels, cast irons	55-85	70-100
Aluminum	1,5-14	70-90
Plastics	10-16	0-30
Tyres and elastomers	2-8,5	30-50
Consumables	2,5-5	5-85

It is worth thinking about the fact which products of our own vehicles we may sell and what their impact on the environment may be. The accumulator is one of the waste components.

Not only lead and its compounds, but also corrosive sulfuric acid, sealants containing compounds of heavy metals and plastics (mainly polypropylene and ebonite) are harmful substances in the waste accumulators. Gaping ejected accumulator will cause a very serious threat to the environment. You can also sell waste engine oil. In this case the risk to human health and the environment is caused by the chemical composition of the waste oil, which contains highly carcinogenic hydrocarbons. Harmful compounds are also included in the performance chemicals.

The outpouring of even a small amount of oil contaminates soil and water on a large surface. The law requires to give waste oil to the company that guarantees its management lawfully. The brake fluid is another component qualified to the recycling process. It consists of substances chemically aggressive in contact with skin and varnished surfaces. Disposing of brake fluid is regulated by so-called 'Waste Act'. Coolant is classified as automotive waste. It consists mainly of the glycol. It prevents freezing, but it has also strong corrosive properties, thus it may cause skin irritation. Therefore it is necessary to prevent waste liquid from getting into drains or groundwater.

The Internet is full of advertisements of companies that offer to buy up waste tires. Waste tires, indeed, does not pollute the environment, but they can certainly litter it. The period of biodegradation of tires is even more than 100 years, throwing of waste tires in accidental places leaves a trail for a very long time. Every year a number of tires that need to be exploited increases. However, waste tires can be valuable raw materials used e.g. as a fuel in cement furnaces or as an additive to asphalt. They can be given for free to companies specializing in their recycling [10].

It is required from tire manufactures to achieve a particular level of recovery of waste tires; and the collection system is very well developed. The vehicle's catalytic converter is a valuable component.

The need for replacement of the catalytic converter may occur after mechanical damages or wear out, and its ejection is considered a misallocation due to the fact that in its construction there are used rare and expensive materials. Catalytic converter can be classified as one of the most valuable components of automotive vehicles, which can be recycled. Bodywork spray paints are also included in waste. They have toxic composition; it is not allowed to spill them accidentally. Similar waste is treated as dangerous. According to the rules it should be given to companies with necessary authorization. The exhaust is another component. It is entirely made of metal, thus its scrapping can be profitable.

*Table II.*

*The types and quantities of recyclables and waste arising from the dismantling the wreckage of the car*

Materials	Weight in [kg]	Material recycling	Energy recycling	Storage
Scrap	710	x		
Battery	13,6	x		
Tires	27,3	x	x	
Oils	3,6	x		
Coolant and washer fluid	3,2	x	x	
Brake fluids	2,6	x	x	
Glass	25,4	x		
Plastics	7,6	x	x	
Polyurethane foam	6,3	x		
Rubber is not contaminated	3,3	x		
Rubber contaminated	4,7	x	x	
The remaining fraction	138,7			x
All	946,3			

The data presented in Table II. shows that 85,3 percentage points of the wreckage of the car consists of the materials that may be recycled. Components from the dismantling are used as spare parts or they are directed to the recovery of useful components. Raw materials are obtained for production of new products. Some components of dismantling are substitutes for conventional fuel. The amount of useless waste which is put to landfill equals 14,7 percentage points of the total weight [11]. In Poland, there are opportunities for technological processing of most elements from car dismantling. The management of polyurethane foam is the only problem.

#### 4. Summary

The automotive market is changing rapidly, which is conditioned by the macro-economic situation, not only in Europe but also worldwide. According to forecasts, the near future is going to force companies involved in recycling and companies which regenerate parts and accessories, to more modern and comprehensive approach. One of the most important requirements for recycling is the ability to achieve efficient acquisition and processing of the removed parts in order to secure the recovery of used materials and disposal of waste which can't be re-use in the economically viable process in accordance with the principles of environmental protection. Waste products in automotive services are inter alia all combinations of vehicles or their components, parts, consumables including oils and tires. The functioning of the companies involved in the dismantling of end-of life vehicles is reverse logistics. The European Directive EU2000/53/EC, says that at the moment 85 percentage points of the average mass-produced vehicles should be able to recycling, but soon this figure should reach 100 percentage points. In conclusion the prospects of development of the system of recycling of vehicles and thereby reverse logistics in automotive services are reflected in the future.

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