

# The Remanufacturing of the Automotive Components in Poland—Development Prospect

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## 1 Introduction

The development of the remanufacturing of the automotive components is in Poland dictated by an the introduction of the EU provisions to the national legislation, particularly regulations of Directive 2000/53/WE of the European Parliament and of the Council of 18 September 2000 on end-of-life vehicles.

Moreover, the awareness of car manufacturers and users in the field of environmental protection is growing. Many car manufacturers offers its customers the automotive components after remanufacturing. For example Toyota concern proposes: complete remanufactured clutches, alternators, steering gears, actuators, motors/heads, the air conditioning compressor.

The objective of this chapter is to present a development prospect of the remanufacturing of the automotive components in Poland considering two aspects:

- the analysis of statistical data on the resources indispensable to execute a remanufacturing process of automotive parts,
- the analysis of statistical data on the volume of the input stream—the number of end-of-life vehicles.

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## **2 The Development Prospect of the Remanufacturing of the Automotive Components in Poland in Terms of Existing Resources**

The remanufacturing of the automotive components is part of recycling and utilization of end-of-life vehicles and their components system that is directly connected with European Union provisions and legislation, especially with regulations of Directive 2000/53/WE of the European Parliament and of the Council of 18 September 2000 on end-of-life vehicles.

The most important elements of Directive with respect to the development of the remanufacturing process are as follows:

- The duty to create by manufacturers and professional car importers the network of collection, treatment and recovery of end-of-life vehicles, cost of building these networks is also borne by them.
- The obligation for producers to take into account already at the stage of design and production of the cars requirements for the dismantling and recycling of end-of-life vehicles and should also label components and materials, in order to facilitate their identification in order to reuse and recycle.
- The achievement of the following indicators of recovery vehicles: No later than 1 January 2015, for all end-of-life vehicles, the reuse and recovery shall be increased to a minimum of 95% by an average weight per vehicle and year. Within the same time limit, the re-use and recycling shall be increased to a minimum of 85% by an average weight per vehicle and year all end of life vehicles will have to be delivered to authorized collectors/dismantlers. The last car owner is responsible for such delivery and he will receive final demolition certificate necessary to de-register the vehicle (Jastrzab 2011, p. 4).

The author evaluates the prospect of the remanufacturing of the automotive components in Poland in terms of existing resources in context of the range of collection network, recycling and recovery of end of life vehicles and the number of cars deregistered in Poland in recent years.

The duty to create by manufacturers and professional car importers a network of collection, treatment and recovery of end-of-life vehicles written in Directive 2000/53/WE of the European Parliament and of the Council of 18 September 2000 on end-of-life vehicles is consistent with the Polish legislation.

In accordance with article 79.1 of the Act of 20 June 1997 the law on road traffic, the vehicle shall be subject to deregistration at the request of its owner in five cases (The Act of 20 June 1997—Law on the road traffic):

- scrapping in Vehicle Dismantling Station,
- vehicle is stolen,
- export to country, its sale and registration in another country,

- random cause when it is necessary to scrapping the car, even if as a result of an accident or fire-raising,
- justification of permanent and complete loss of the vehicle.

The main task of the manager of dismantling station is to ensure that recycling of end-of-life vehicles and arising wastes will be safe for the environment and human health (Golińska 2013, p. 82).

In 2012 in Poland 784 stations of disassembly holding the integrated permit or other decisions functioned in the required waste disposal in relation to running the station of disassembly (so-called official stations of disassembly) and 125 points of collecting vehicles having a business license in collecting waste (Merkisz-Guranowska 2013, p. 4).

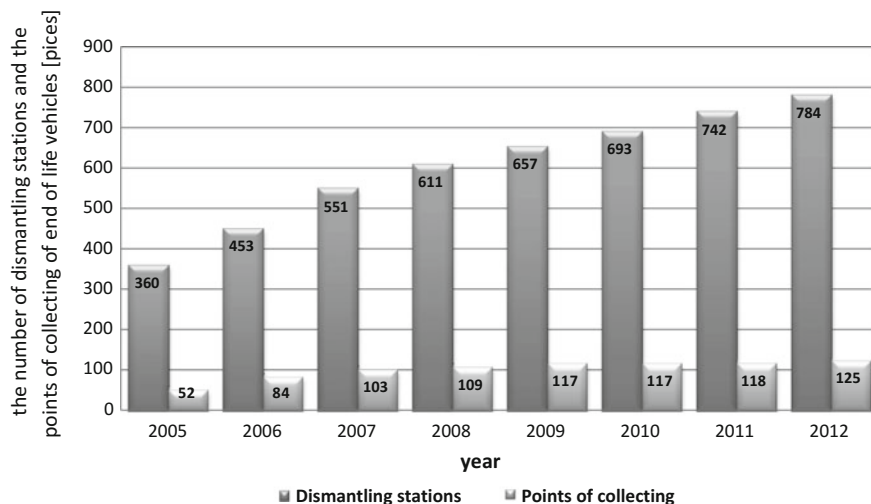
Other points of a recycling network of end-of-life vehicles are presented in Table 1.

Since the implementation of the administrative legislation concerning recycling of end-of-life vehicles in Poland, the number of the dismantling and collecting vehicles gradually increased in each subsequent year (Fig. 1), although the pace of growth in recent years has decreased.

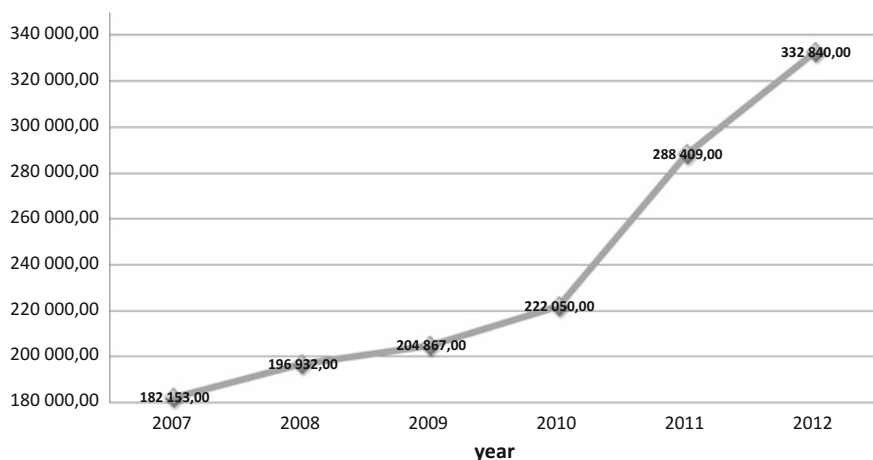
**Table 1** The size of the end-of-life vehicle recycling network in Poland in 2012

Points of recycling network of end of life vehicles	Amount (2012)
Shredder and processing scrap, equipped with industrial shear	11
Wholesale ferrous scrap collection centers cooperating directly with the ironworks and foundries	163
Collection centres of non-ferrous metals intended for direct recovery	125
Ironworks and large foundries	20
Non-ferrous metal recovery plants	27
Plants for the processing of cullet of glass and headlights	6
Recovery plants of used oils on an industrial scale	11
Recovery plants of brake fluids	3
Recovery plants of coolants	3
Recovery plants of car batteries	2
Tire recycling plants (excluding plants for the retreading of tires) and recovery organizations of waste tire centre providing the reception of tires from anywhere in the country	About 20
Plants for recovery of plastics from vehicles	17
Rubber waste recovery plants on an industrial scale	10
Cement industry leading energy recovery from waste, including waste from vehicles	3
Oil filters recovery facilities	5

Source own study on the basis (Merkisz-Guranowska 2013, p. 4)



**Fig. 1** Dismantling stations and the points of collecting of end-of-life vehicles in Poland in the years 2005–2012. *Source* Own study on the base: (Golińska 2012, pp. 46–49)



**Fig. 2** The number of deregistered vehicles in Poland in years 2007–2012. *Source* own study on the basis (<http://www.cepik.gov.pl> (12.06.2013r.))

The largest waste stream to further planning is generated by end-of-life vehicles. In accordance with article 4. 79.1 of the Act of 20 June 1997 the law on road traffic, the vehicle shall be subject to deregistration at the request of its owner, inter alia, in the case of scrapping in vehicles dismantling station.

The total number of deregistered cars in Poland in the years 2007–2012 is gradually increasing (Fig. 2).

### 3 The Development Prospect of the Remanufacturing of the Automotive Components in Poland in Terms of Volume of Input Stream

The development prospect of the remanufacturing of the automotive components in Poland in terms of the volume of the input stream has been assessed by the author in terms of age structure of passenger car park spaces in recent years.

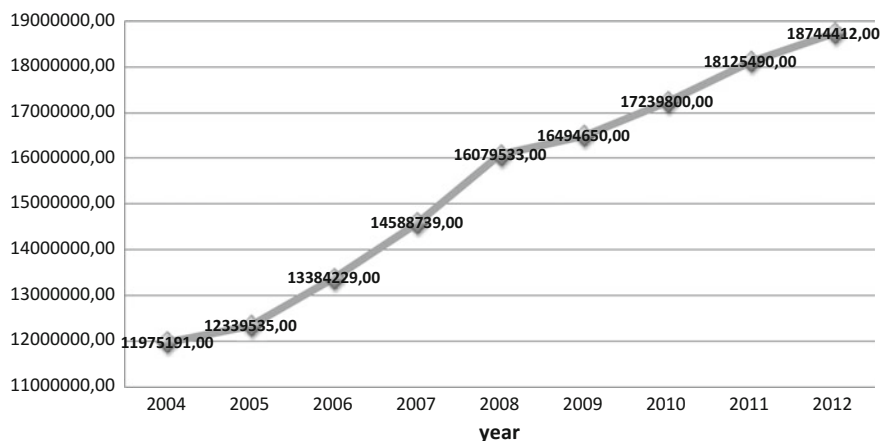
As it results from the annual reports of the Main Statistical Office (GUS) entitled “Transport in numbers” for the vehicles in Poland since 2004, maintains a growing trend with a varying growth (Fig. 3).

The Main Statistical Office data indicate that in 2012 the number of passenger cars in Poland amounted to 18,744,412 units. Approximately 30% of this amount were vehicles over the age of 20 years, only 10% of the Polish car park constituted cars below 5 years, and over 61% of cars in Poland were vehicles aged 6–20 years (Fig. 4).

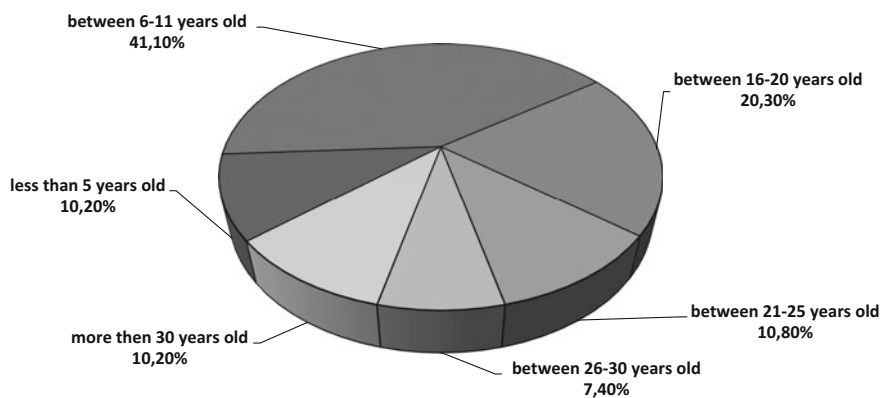
On this basis, it can be concluded that, in the age structure of passenger cars in Poland favors the development of remanufacturing in the automotive industry.

The existing theoretical and empirical research in the area of remanufacturing of automotive parts indicate that cars between 6 and 15 years old represent the input stream to the process of remanufacturing of automotive components.

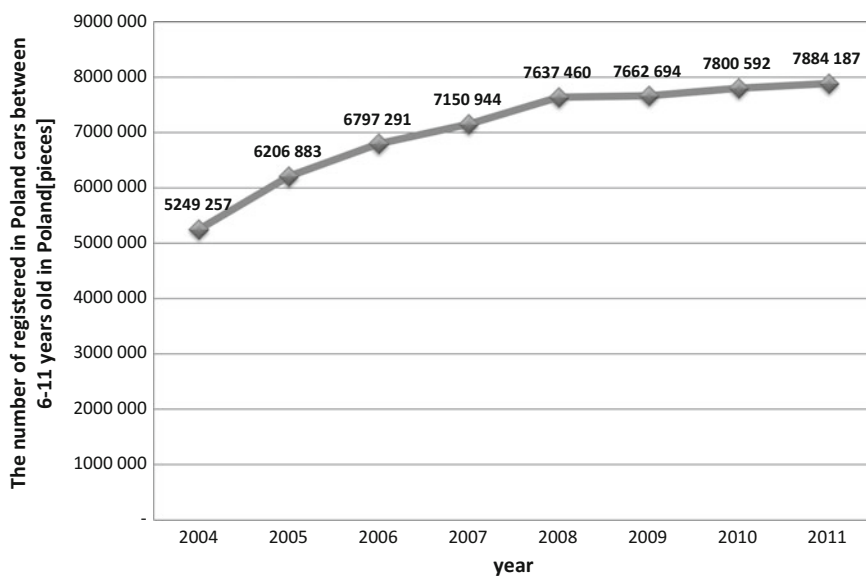
As show statistics over the years 2004–2012 share of this age group in the Polish car park has averaged 46% (Fig. 5).



**Fig. 3** The number of registered passenger cars in Poland in the years 2004–2012. *Source* own study on the basis: (GUS, “Transport—wyniki działalności”, Warszawa, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013)



**Fig. 4** Age structure of passenger cars in Poland in 2012. *Source* own study on the basis: (GUS, “Transport—wyniki działalności”, Warszawa, 2013)



**Fig. 5** The number of registered in Poland cars between 6 and 15 years old in Poland. *Source* own study on the basis: (GUS, “Transport—wyniki działalności”, Warszawa, 2004–2013)

#### 4 The Development Prospect of the Remanufacturing of the Automotive Components in Poland in Terms of Forecasts of the Volume of the Input Stream

On the basis of the data from car park in Poland in the years 2004–2012 and the number of passenger cars between 6 and 15 years old carried out econometric calculations designed to indicate the number of cars in the country, including cars more between 6 and 15 years old in 2020.

To build the prediction of the number of passenger cars in Poland by the year 2020 model used a simple linear regression (*regression methods*).

Method of simple linear regression to predict values for the data with trend characteristics.

Method uses a linear trend Eq. (1):

$$p_{t+1} = a \cdot n + b \quad (1)$$

where

- $a$ —the value of the variable over the period
- $b$ —the value of increase or decrease of dependent variable
- $n$ —the sequence number of analysed and forecast period.

In order to determine  $a$  and  $b$  parameters it is necessary to solve the two Eq. (2):

$$\begin{cases} a \sum_{i=1}^n t_i^2 + b \sum_{i=1}^n t_i = \sum_{i=1}^n t_i \cdot y_i \\ a \sum_{i=1}^n t_i + b \cdot n = \sum_{i=1}^n y_i \end{cases} \quad (2)$$

where

- $t_i$ —the period sequence number ( $t = 1, 2, 3, \dots$ ), that is a value of independent time variable
- $y_i$ —dependent variable,
- $a$ —the value of the variable over the period
- $b$ —the value of increase or decrease of dependent variable,
- $n$ —the sequence number of analysed and forecast period.

To verify the model of simple linear regression uses a coefficient of determination  $R^2$ , which determines the degree of fit of the model to the empirical data. The coefficient of determination  $R^2$  is a descriptive measure of the strength of the linear relationship between the variables, which is a measure of the fit of the regression line to data (Aczel 2000, p. 490).

The coefficient of determination is in the range  $<0, 1>$ . When the value of the coefficient is closer to 1, this means that the estimated model explains in nearly 100% of the variability of the dependent variable. It proves that the model is well

fitted to empirical data. If  $R^2$  is close to 0, it means that the model is poorly matched to the empirical data.

The trend Eq. (3) for the analyzed data takes the form:

$$y = 900\,863.37x - 1\,793\,492\,353.74 \quad (3)$$

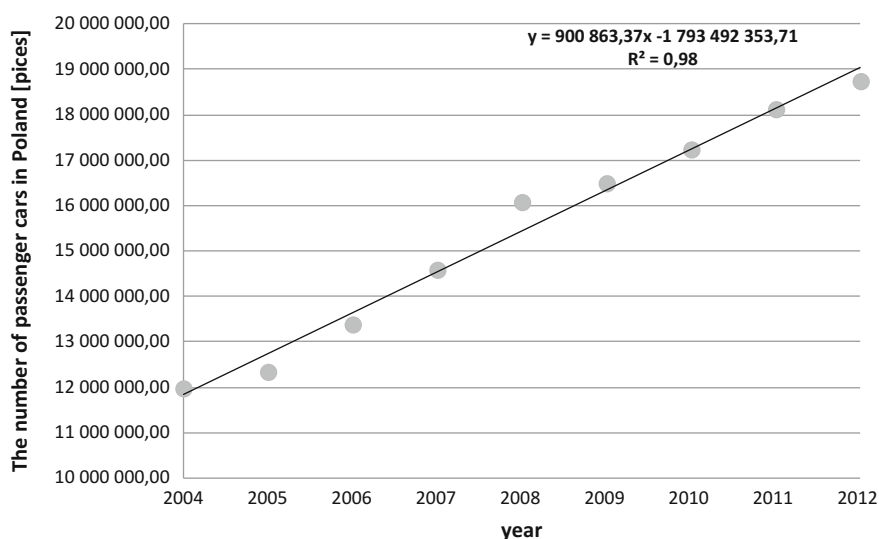
a coefficient of determination  $R^2 = 0.98$ , what indicates a good match of regression line with a primary data (Fig. 6).

On the basis of the trend equation a forecast of the number of registered passenger cars in Poland up to 2020 has been estimated as 27,028,646 pcs (Fig. 7).

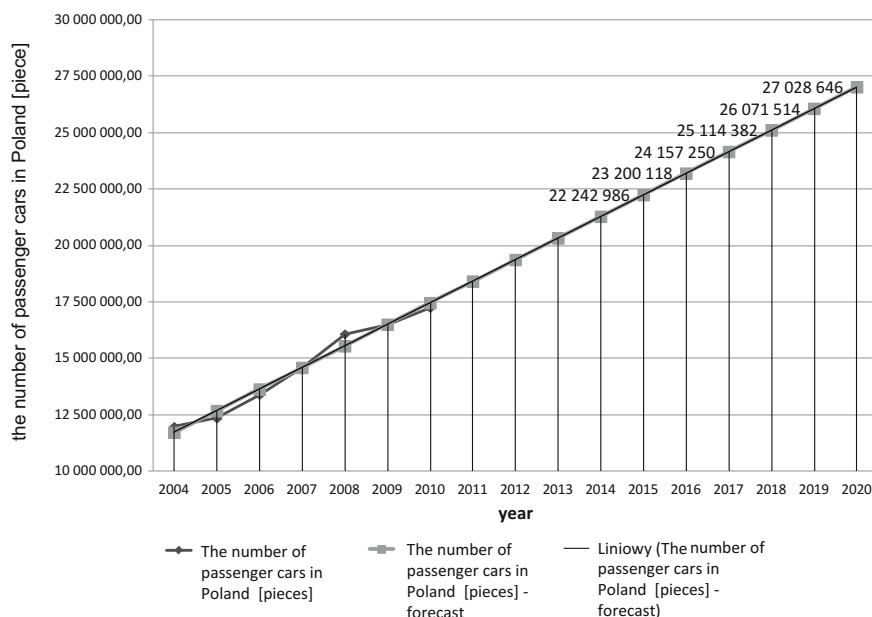
In the same way the forecast calculations has been made for the number of passenger cars between 6 and 15 years old in Poland in 2020.

As shown findings of econometric calculations this number will be formed at the level of 12,224,851 pcs, which will constitute 45% of all vehicles registered in Poland in 2020. Assuming that the age structure of Polish passenger car park will not significantly change until 2020, it can be assumed that almost half of cars respectable numbers in Poland will be a vehicle between 6 and 15 years old, which from the point of view of the remanufacturing is a positive.

The volume of the input streams determine the development of this process in Poland, the stream will be greater the demand for remanufacturing services will grow.



**Fig. 6** Trend line and  $R^2$  of number of passenger cars in Poland in years 2004–2012. Source own study on the basis: (GUS, “Transport—wyniki działalności”, Warszawa, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013)



**Fig. 7** The forecast of the number of passenger cars in Poland in 2020. *Source* own study on the basis: (GUS, “Transport—wyniki działalności”, Warszawa, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013)

## 5 Remuneration, as a Determinant of the Development of Automotive Components Remanufacturing in Poland

Age structure of passenger car park may be derived from the wealth of the country residents.

Therefore, in examining the prospects for the development of remanufacturing process in terms of the volume of the input stream relevant seems to explore the relationship between the level of the average monthly income per person in the household and the age structure of registered passenger cars in Poland.

For that purpose the author proposes the use of analysis of the interdependence of phenomena whose objective shall be to predict the direction and pace of development of examined variables and to define the strength and the shape of relations between the variables.

Correlation which was used in the study, is a special case of the stochastic dependency.

Set the values of one variable correspond to specific mean values of the other variable. One can determine how changes, on average, the value of the dependent variable (Y) depending on the independent variable X. Numerical confirmation of interdependence of phenomena does not always mean the existence of cause-effect

between examinees phenomena. The analysis identifies only the existence of the relationship, however, you cannot establish a causal link which is the base of these relationships.

Correlation analysis enables to detect and describe the quantified only interact with the variables. Granting these connections cause and effect character requires a deeper substantive analysis (Wyrwicka and Wener 2010, p. 218).

Pearson coefficient of the correlation is used for variables quantitative in nature. It is used to determine the direction and strength of occurring dependencies.

The value of the coefficient of correlation is calculated from the Eq. (4):

$$r_{xy} = \frac{\sum_{i=1}^n (x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum_{i=1}^n (x_i - \bar{x})^2 \sum_{i=1}^n (y_i - \bar{y})^2}} \quad (4)$$

where

- $x_i, y_i$ —values of variables appropriately X, Y for observation  $i(i = 1, 2, 3, \dots, n)$ ,
- $n$ —the number of observations,
- $\bar{x}, \bar{y}$ —values of arithmetic mean for X, Y variables.

The coefficients of correlation with values range from  $-1.00$  to  $+1.00$ . The value of  $-1.00$  represents a perfect negative correlation, and a value of  $+1.00$  perfect correlation positive. A value of  $0.00$  is the lack of correlation (Pedersen et al. 2010, p. 158).

Pearson coefficient of correlation calculated (Table 2) for the relationship between the level of the average monthly income per person in the household and the numerical structure of registered passenger cars in Poland is  $0.996043$  for the total number of registered cars in Poland,  $0.161335$  for the number of registered passenger cars newer than 5 years,  $0.875392$  for cars at the age of 6–15 years,  $0.995641$  for cars at the age of 16–20 years registered in Poland and  $0.985492$  for cars at the age of 16–20 years.

The analysis shows that there is positive correlation between average income of household in Poland and the number of registered cars in Poland at the age of

**Table 2** The value of correlation coefficient for examined variables

Correlations. Given coefficient of correlation are significant with $p < 0.05000$ N = 9 (the no data was being removed with cases)					
	Registered vehicles number (pcs)	The number of registered passenger cars			
		Younger than 5 years (pcs)	At the age of 6–15 years (pcs)	At the age of 16–20 years (pcs)	Of more than 20 years (pcs)
AMGR <sup>1</sup> (PLN)	0.996043	0.161335	0.875392	0.995641	0.985492

Source own elaboration (on the basis on GUS data)

<sup>1</sup>AMGR average monthly gross remuneration

6–15 years. This means that the average Pole earns more, the number of cars at the age of 6–15 years in Poland is increasing. This is quite an interesting phenomenon, because it would seem that if the average income per person in the household increases, is the standard of living raised and sold are tangible goods of higher quality.

As the results of correlation analysis, the dependence between the average level of income on people in Poland in the household and the number of registered vehicles not older than 5 years is quite poor.

It means that the number of registered passenger cars newer than 5 years, to a little extent depends on the rise in the monthly income of the average Polish man.

This may be due to factors such as rising inflation, the Poles seem to not treat a newer car, as a manifestation of the improvement of the comfort of life. For an average person, car between 6 and 15 years old, is still good enough and an increased income is not translated into purchase of a car newer than 6–15 years.

From the prospect of the development of remanufacturing of automotive components in Poland depending on the above are positive and suggest that the volume of the input stream to the factory recovery remains on the satisfactory level.

## 6 Conclusions

Provisions of the directive 2000/53/WE being in force in Poland from 18 September 2000 on end-of-life vehicles is contributing to the development remanufacturing of automotive components in the country.

Described analyses of statistical data concerning prospects of the development remanufacturing of car park in Poland, show the upturn in this respect.

The age structure of the Polish park of passenger cars is pointing, that large volume of the input stream in the prospect of 2020, will be conditioning the development of dismantle stations of end-of-life vehicles.

Both objects of described analysis—resources and the input stream are demonstrating the increasing trend. According to the author it provides the potential in Poland for the development of the remanufacturing process of the automotive components.

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## References

Aczel AD (2000) Statystyka w zarządzaniu (statistics for management science). PWN, Warszawa  
Central Statistical Office (2005) Transport—wyniki działalności. GUS, Warszawa

- Central Statistical Office (2006) Transport—wyniki działalności. GUS, Warszawa
- Central Statistical Office (2007) Transport—wyniki działalności. GUS, Warszawa
- Central Statistical Office (2008) Transport—wyniki działalności. GUS, Warszawa
- Central Statistical Office (2009) Transport—wyniki działalności. GUS, Warszawa
- Central Statistical Office (2010) Transport—wyniki działalności. GUS, Warszawa
- Central Statistical Office (2011) Transport—wyniki działalności. GUS, Warszawa
- Central Statistical Office (2012) Transport—wyniki działalności. GUS, Warszawa
- Central Statistical Office (2013), Transport—wyniki działalności. GUS, Warszawa
- Golińska P (2013) Logistyka zwrotna. Wydawnictwo Politechniki Poznańskiej, Poznań
- Jarząb M (2011) Analiza uwarunkowań prawnych w zakresie selektywnej zbiórki odpadów na terenie Polski i UE, Zgorzelec
- Merkisz-Guranowska A (2013) Ocena skutków regulacji prawnych wynikających z nowelizacji Ustawy o recyklingu pojazdów wycofanych z eksploatacji. Politechnika Poznańska, Poznań
- Pedersen TB, Mohania MK, Tjoa AM (eds) (2010) Data warehousing and knowledge discovery. In: 12th international proceedings of the conference on DaWaK 2010 Bilbao, Spain, Aug/Sep 2010. Springer, Berlin
- Wyrwicka MK, Werner K (2010) Tendencja w kształtowaniu relacji w sieciach gospodarczych. W: Wyrwicka MK (red) Tendencje rozwojowe Wielkopolski w kontekście transformacji wiedzy w sieciach gospodarczych, Wyd. Politechniki Poznańskiej, Poznań
- The Act of 20 June 1997—Law on the road traffic
- The Act of 20 January 2005—Law on the recycling End of Life Vehicles (Dz. U. z 2005 r. Nr 25, poz. 202 z późn. zm.)
- <http://www.cepik.gov.pl>. Accessed 12 July 2013

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