The Necessity of Recycling Networks for the Sustainable Usage of Automotive Parts: Case Study Germany and PR China

Alexandra Pehlken, Wolfgang Kaerger, Ming Chen and Dieter H. Mueller

Abstract The aim of this chapter is to point out, that developed processing of end-of-Live-Vehicles has a high potential for sustainability. We present existing networks for used automotive parts with the case study of the callparts network in Germany. Callparts Recyling GmbH provides a network for the automotive industry to guarantee a high standard of end-of-life vehicle recycling. Their main interest lies on the distribution of used automotive parts. The potential for sustainable resource management will be shown accordingly to the Chinese ELV market. Used automotive parts are kept in a closed loop recycling system and are further used as automotive parts by showing a good overall lifecycle performance. This implies savings of primary resources on material and process level. Among recycling hierarchy the reuse of used parts always achieves the most favorable eco-balance and thus, gains the highest priority. The legal situation in China has to pave the way for tapping their potential for saving materials and energy in the future through car parts remanufacturing. By setting up a nationwide recycling network we might achieve the goal.

Keywords Remanufacturing · Closed loop supply chain · Recycling network · Database

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1 Introduction

The EU Disposal of end-of-life Vehicle (ELV) Act specifies quotas of material recycling (EU 2000). The ELV Directive 2000/53/EC established goals to minimize the effect of ELV's by setting recycling, reuse, and recovery targets for the materials used in all manufactured vehicles. The directive requires that 95 % of ELV waste must be reused by 2015, with only 10 % of this recovered through energy. In addition to pure recycling of materials, the reuse of components and subassemblies makes sense not only in line with the Lifecycle Management and Waste Act (KrW-/AbfG 1994) from Germany but also from the economic perspective.

The reuse of automotive parts and subassemblies necessitates not only an unambiguous identification and classification of the extracted parts, but also a comprehensible documentation and description of their present condition, as automotive parts and subassemblies have been produced by different manufacturers and have been extracted from different vehicles. Consequently a reliable classification and identification is necessary to gain the acceptance of the customers. The present VDI-guidelines VDI 4080, 4081, and 4082 "Recycling of cars" are limited to a description of the treatment process of used automotive parts [VDI 4080–4082]. However, representative quality methods to anticipate the future life-time of recycled automotive parts and guarantees are still missing. Due to the increasing market for cars and also the increasing amount of vehicle types, not only for cars but also of different components per type, it is necessary to establish an excellent data network between different recycling companies on the one hand and, on the other hand, to establish competence centres for quality analysis to improve the contingent and market for reused parts.

A system like recycling stock exchange is the basis for a well operated network and raises the chances for being successful. In Germany exists a well operated Callparts IT-network which has already shown an available option for automotive components reuse. The distribution of automotive parts is sustained by providing a website and developed software. The software provides information on the logistics as incoming vehicles, market place for residues, storage and sale of automotive parts. Through the software all partners are linked and their virtual storage is made visible on the website.

Very important and the basis for a market of reused/remanufactured components represents classification regulations to specify the quality like vehicle bodies and engines/transmissions for example. Quality methods help to raise the acceptance for used automotive parts and increase the reliability of these parts (Pehlken and Müller 2009).

2 Automotive Car Parts in Germany

In Germany § 4 of the Lifecycle Management and Waste Act (KrW-/AbfG 1994) clearly indicates that all kind of waste materials has to be avoided before it comes to recycling procedures. Remanufactured parts are reused for their original purpose and perform the best life cycle compare to most recycling processes. The "Alt-fahrzeug Verordnung" (Altfahrzeug 2002) regulates that all car manufacturer in Germany are obliged to take back their scrap cars and recycle them in dismantling facilities. 95 % of a car has to be reused AND recycled by the year 2015.

The German car market has a volume of around 45 million cars. The average life cycle of cars is around 8 years. Especially those which are older than 3 years are suitable for used spare parts demand.

Understanding the flow of ELV (see Fig. 1), market players and competitors are examples for basics to be in favor of managing a network. The ELV-Flow under economical and legal factors affects the input of a network.

Since Germany is very ambitious on technical level and quality of cars. This also leads to a special market situation. For local use are high quality used spare parts necessary for the German market. However Germany represents for cars and also for spare parts an export market.

Germany exports high quality used spare parts to those neighbors who buy the younger used cars and the necessary spare parts from the German market. For example European neighbors, Eastern Europe and the Middle East.

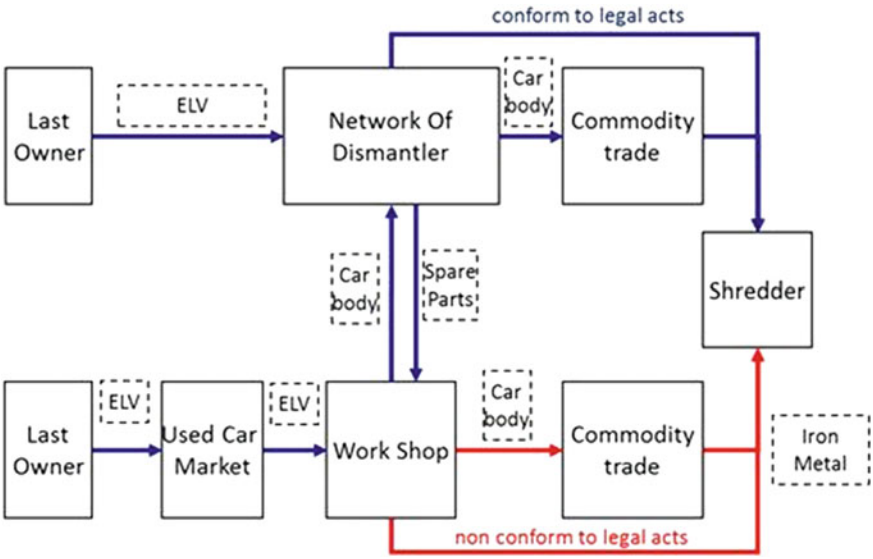

Fig. 1 Flow of ELV under controlled or less developed conditions

Low quality and lower price level is expected to those countries which import older cars and older used spare parts like African countries, Arabian countries but also Bulgaria and Romania.

The sales of used spare parts is performed by car dismantlers and used spare parts dealers who act against retail markets with commercial clients (repair shops, garages) and private clients (who buy only 1–3 times in their life).

The sales media are

- the counter of dealers and dismantlers,
- the prolonged counter of dismantler networks with virtual storage,
- and the internet platform which are maintained by car dismantlers.

To improve the used spare parts sales the policy has to

- present used spare parts in a single form (not as bulk ware),
- present spare parts on high quality level with a qualified data base and pictures, and
- use dismantler networks or virtual stocks to meet the clients demand as much as possible.

Reused parts have to follow quality guidelines as well. The VDI Guidelines "Recycling of cars" VDI 4080, 4081 and 4082 specifies minimum criteria for the qualitative description of used car parts (passenger cars, commercial vehicles and motorcycles). The highest quality level represents class A, followed by class B and C. The quality of class A is comparable to new automotive parts with nearly no minor functions, whereas class C represents the car parts with functional defects. Table 1 shows descriptions of class A and class C used engines according to the VDI guideline. Proper handling of used parts includes, moreover, clear labeling, well storage and packaging. Used car parts come from ELV without further reconditioning or remanufacturing. In accordance remanufactured parts are used parts that are remanufactured according to the state of the art. They must be comparable to the corresponding of a new part in terms of quality and function.

Table 1 Example for quality classes for used engines [VDI, 4080]

Component	Quality class A	Quality class C
Engines	Mileage passenger car <75.000 km and age to 5 years	Mileage passenger car from 150.000 km
	Commercial vehicle <200.000 km	Commercial vehicle from 700.000 km
	Motor cycle <l20.000 km	Motor cycle from 40.000 km
	Functional or performance test; no recognizable defects	Functionality
	Good compressions	
	No unusual sounds	Unusual noises
	No leaks at the gaskets	Leaks
	History known	History unknown or incomplete

Table 2 Data records for car parts as EDP interface [VDI 4081]

Meaning	Type of format	Brief description
No. of car manufacturer	Numerical	Identification of manufacturer
No. of car model	Numerical	Identification of model
No. of car types	Numerical	Identification of vehicle
VDI part No.	Numerical	Identification of part
Supplement or part No.	32 charchters	Field no currently in use; intended for supplementary identification of part
Location of installation	32 characters	Identification of location of installation by combining criteria
Quality	Numerical	Specification of quality class (see VDI 4080)
Date of first registration	7 characters	Month two digit number/Year three digit number
Motor code	32 characters	Motor code
Transmission code	32 characters	Transmission code
Quantity	Numerical	Quantity
price	Numerical	Supplier's price w/o additional charges (shipping, commission, insurance)
Shipping cost	Numerical	Shipping cost
currency	3 characters	Default setting: Euro
Type of insurance	Numerical	0 = uninsured; 1 = insured by recipient of data; 2 = insured by supplier
Comment	255 characters	Available for individual comments
Upload ID	16 characters	Unambiguous label allowing to idetify source of data and upload. This allows unambiguous allocation of later uploads

To be "comparable" a standard has to be set. The offer and supply of reused and remanufactured parts and subassemblies removed from end-of-life vehicles has to be developed with the requirements in Table 1.

The list of recycled parts compiles all parts disassembled during the recycling process. This list and the coding of the parts serve for unambiguous identification, creating the basis for data exchange using electronic data processing (EDP) interface for recycled car parts data records. The disassembling company has the responsibility to make a decision if disassembly and exploitation of these parts are reasonable. Table 2 shows data records for recycled car parts, which using several parameters by means of the EDP interfaces.

According to the available information necessary data on the components and their registration document, number of previous owners, environment of use, type of use, maintenance and repair documentation are listed. Every car part is labeled with the necessary information and provided within the network (Fig. 2).

Fig. 2 Example of component identification code

3 Network in Germany for Used Car Parts

The Callparts Systems is one of the important players in the field of used spare part marketing on high quality level in Germany.

Callparts was founded in 1993 in accordance with the European Institution and the implementation of the waste management systems in the EU and their member states. They were focused on ELV-treatment and-organization.

Callpart's idea was to implement 80 partner networks in Germany to take back and treat ELVs in an adequate manner, which is achieved in the meantime. Priority has had the reuse of spare parts out of dismantled cars. Second priority according to the waste pyramid was to reuse secondary raw materials and save resources.

Nowadays Callparts Recyling GmbH provides a network for the automotive industry to guarantee a high standard of end-of-life vehicle recycling. Their main interest lies on the distribution of used automotive parts. The CallCar network was implemented in 2004 with the participation of two automotive producers, automotive import companies and about 100 vehicle dismantling companies (see Fig. 3). Additionally, they possess a dismantling plant near Berlin with a capacity of dismantling 15.000 cars per year. Main focus lies on the extraction of high valuable materials or components from end-of-life vehicles for further use (Kaerger 2010). No other company is providing their own dismantling company and their own network within the automotive industry. The advantage is that all information about automotive parts is directly available without any filtering by other providers.

Callparts System provides a network for dismantling companies (Fig. 4). The distribution of automotive parts is sustained by providing a website and developed software. The software provides information on the logistics as incoming vehicles, market place for residues, storage and sale of automotive parts. Through the software all partners are linked and their virtual storage is made visible on the website www.callparts.de (Fig. 5).

Fig. 3 Callcar recycling network

The network system in Germany can be extended with quality assets like description and function of automotive parts. The components which are good for re-use or remanufacture respectively are being identified in the country of origin. After being transferred into a database, the information is available all over the country in the world-wide-web.

Quality statements have to be developed and when possible, physical descriptions have to be identified and quantified, like (mainly based on VDI 4080) vehicle bodies, engines, other units, electric parts, interior equipment, and identification of valuable recycling components (like catalysts).

Unambiguous quality statements are necessary to improve the acceptance of remanufactured components; this involves an evaluation on the automotive parts potential for being remanufactured. The intended network will increase the recycling potential of automotive parts because automotive parts (1) will be listed (2) will be made available for an international market and (3) besides remanufacturing, also further possibilities of re-use and material recycling are considered.

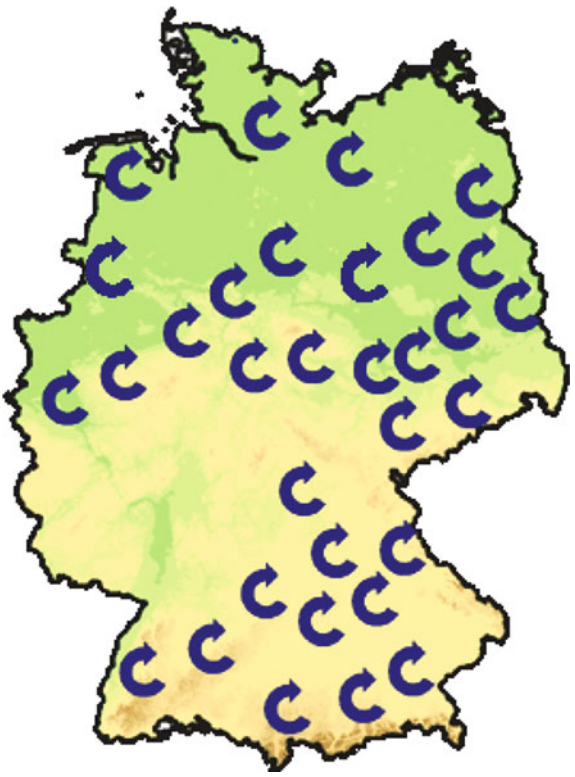

Fig. 4 Callparts network for ELV

4 Situation for Used Car Parts in PR China

4.1 History of Car Sales and the Need for Used Car Parts

In recent years, vehicle population has increased annually in China. According to statistical data from the China Association of Automobile Manufacturers, the vehicle market in China set a record with sales of approximately 13.791.000 units in 2009, bringing the total number of vehicles to 62.800.000. In 2010, China became the global leader in automotive production and consumption after surpassing the United States. The total number of automobiles reached 75 million at the end of 2010. According to conservative estimates, the total number of automobiles in China is expected to be over 490 million in the future (Wang and Ming 2011). The Table 3 shows the forecast of vehicles in China; the statistical data was provided by the China Automotive Technology and Research Center (CATARC). In general, the volume of ELV increases with the rise in vehicle sales. The rapid growth of vehicle population in China would cause subsequent environmental problems if not addressed in advance.

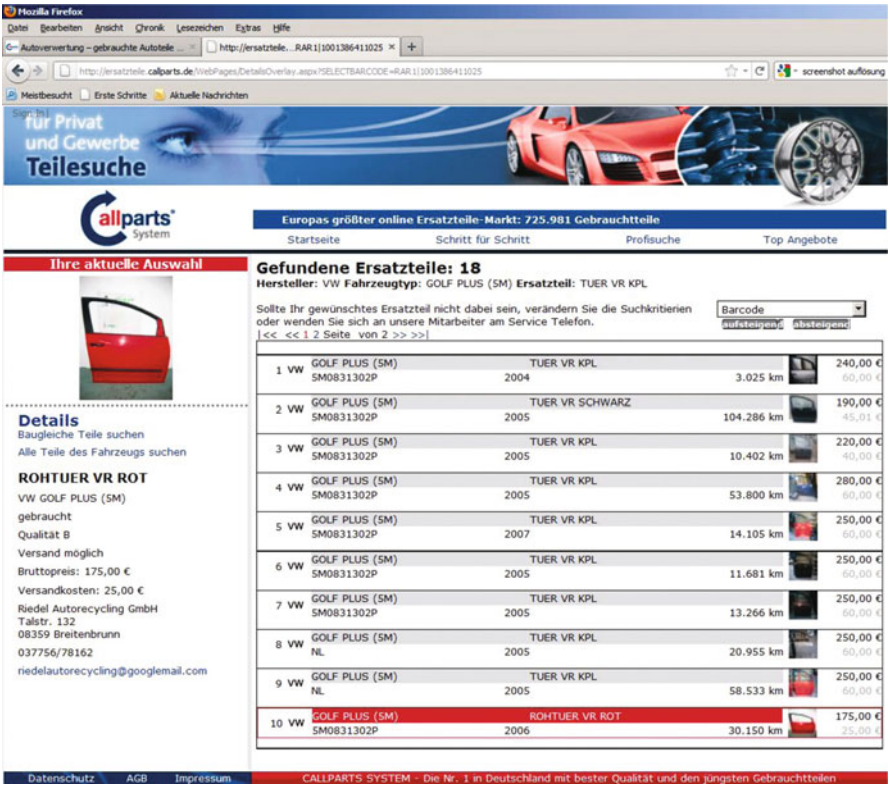

Fig. 5 Online-view into parts stock

Table 3 Forecast of vehicles in China (Wang and Ming 2011)

Years	Vehicle population (million)	Vehicle sales (million)	Total number of scrapped vehicles (million)	Ratio ELV/vehicle sales (%)
2015	95,38	14,91	6,44	6,75
2017	112,72	16,91	7,78	6,90
2020	141,03	20,05	9,95	7,06

Counting solely the amount of secondary resources that are going to be available through ELV recycling in China 10–15 % of the national scrap steel is provided each year. With the rising amount of ELV vehicles the available scrap steel is estimated for 15–22 million tons in 2020. The number for non-iron metal scrap can be predicted to 2.2 million tons in 2020 (Rueth 2011). The numbers for used car parts that are still functional and able to be reused cannot be estimated today but the value of these parts are much higher than the number for scrap metals. Additionally, the life cycle performance of these reused parts is always rated higher than common recycling processes.

4.2 Current Situation and Necessary Research

Due to the extremely increase of new car sales in China the interest in reused automotive parts is growing. As different automotive parts do not get unusable at the same time, recyclable, respective reusable, automotive parts achieve high popularity in China. Consequently there is a strong demand for automotive parts in use. Already more than 450 qualified dismantling companies have emerged their existence on this market. It is not a question whether automotive parts derive great value as resources, because they also hold residuals like catalysts, which need to be recycled mandatorily. The implementation of the EU end-of life vehicle (ELV) directive had a profound influence on China's automotive industry, leading to the consideration of concepts -such as extended producer responsibility (Zhang et al. 2011) The establishing legislation and specification system on automotive products recovery could be regarding as response of China towards EU ELV directives, from national law to detailed technical specifications, and from vehicle design to ELV recycling (Xiang and Ming 2010). The actual laws, policies and guidelines are as follows:

(1) National Law

- "Law of the People's Republic of China on Prevention of Environmental Pollution Caused by Solid Waste" The Law is enacted for the purpose of preventing and controlling environmental pollution by solid waste, safeguarding human health, safeguarding the ecological environment and promoting the sustainable development of economy and society.
- "Law of the People's Republic of China on Circular Economy Promotion" The law, designed to provide a legal framework for its national sustainable development strategy, is goal at bringing attention to a wide range of environmental considerations as China continues its high-speed economic growth. The law requires low energy consumption and high resource efficiency, low emissions of pollutants, and minimal waste discharge, using the principles of reduce, reuse and recycle. The law also requires the recycling of larger waste products such as end-of life vehicles and ships, mechanical and electrical products. Incentives and penalties are included.

(2) National Technical Policies

- "Automobile Industry Development Policy" released in May 2004
- "Automobile Trade Policy" released in August 2005
- "Technical Policy of Automotive Products Recovery" released in Feb. 2006
- Administrative Measures for Pilot Remanufacturing of Automobile Parts and Assemblies" released in March 2008
- "Management Regulation of ELV Take-back", a revised Decree 307, draft for review
- "Administrative Rules of Recoverability Rate and Forbidden Substances for Motor Vehicles", draft for review

(3) Technical Specifications

- GB/T 19515-2004 "Road vehicles-Recyclability and recoverability-Calculation method"

- HJ 348-2007 "Environmental Protection Technical Specifications for Disassembly of End-of-Life Vehicles"
- QC/T 797-2008 "Material Identification and Marking of Automotive Plastic, Rubber and Thermoplastic Elastomer Parts"
- GB 22128-2008 "Technical specifications for End-of-Life Vehicles recycling and dismantling enterprise"
- Twelve specifications for automotive parts and assemblies remanufacturing

The legal system of ELV recycling in China comprises three levels: national laws, national technology policies and technical specifications. At the year of 2001, Decree #307 "Management Measures on Take-Back of Scrapped Automobiles" about ELV disposal was issued by State Department of P. R. China. This is the highest law concerning about the disposal of ELV in China today. In 2006 the "The Motor Vehicle Product Recovery Technology Policy" was issued by the National Development and the Reform Commission (NDRC), the Ministry of Science and Technology and the State Environmental Protection Administration (SEPA). According to the regulation, Chinese automobile manufacturers and importers will be responsible for collecting and recycling vehicles from 2010 or designating other authorized end-of life vehicle dismantlers to handle the business. The Chinese policy requires that vehicle manufacturers recycle at every phase of the products life cycle (e.g. manufacture, sales, repair, maintenance, dismantling, etc.) to help attain a recoverability rate of 95 % on automotive products which will be manufactured and sold in China by 2017 (Ming 2009). The new regulation was designed to encourage domestic automobile producers to use more environmental benign materials. The new policy will surely raise the costs to automobile manufacturers and importers and poses a higher demand on technology innovation. But over the long term, it will help to increase the sustainability of the Chinese automobile industry.

According to Chen Ming there are about 492 qualified ELV dismantlers approved by the state administrative department, and more than 1772 take–back stations in Chinese cities. This results in a capacity of 1.2 million vehicles per year. Dismantling in China must be consistent with China's national conditions since China has abundant labour resources. Therefore, the dismantling operation mode in China is a combination of mechanization tools and manual dismantling.

A convenient infrastructure is requested, because in every province in China workshops have to deliver both: absorbing all re-usable cars and providing the automotive parts for the market. Those parts can be served on demand by the convenient delivery-services. Until now China has only few dismantling companies. However, they act decentralized. At this time, the increasing number of car sales show a lack in the support of re-usable automotive parts, as demand is even higher. Figure 6 shows the concept of a pilot recycling system for used car parts in Shanghai to cope with the rising demand for uses car parts.

We observe different economic development of eastern, central and western regions of China. Prospective it will be the characteristic Chinese economic development. The regional difference in economic requirements and consumptions leads to the obvious difference in vehicle consumptions. The new vehicles begin

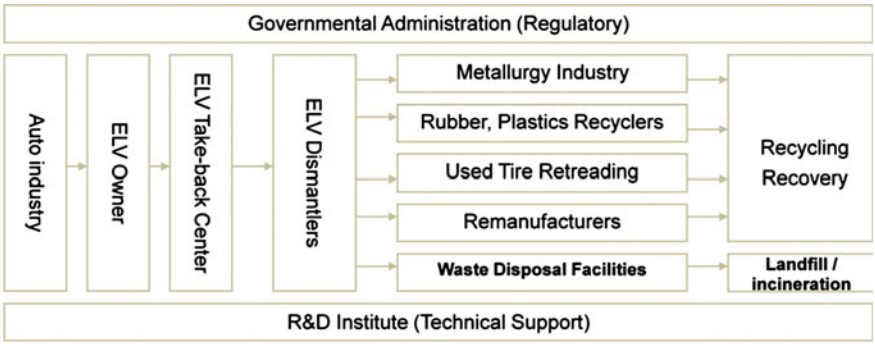

Fig. 6 A pilot recycling system for used auto parts in Shanghai, China

their life cycle in eastern and their end of life in western. The development and layout of Chinese vehicle recycling industry should consider this social fact. A model of vehicles recycling and reverse logistic infrastructure in China will consider this fact:

(1) In central and western regions of China, a lot of ELV dismantlers should be established and accept obsolete vehicles. After being dismantled, the auto bodies, tires, plastics and used oils should be treated locally. For instance, bodies are recycled as scrap steel; tires and plastics are recycled as crushed crumb. The effective and low-cost process and equipment should be developed and applied in dismantlers of these regions.
(2) The repairable parts and assemblies which are collected in dismantlers or service stations should be sent to remanufacture industry after gathering of a certain amount. The remanufacturing enterprises could be specialized or comprehensive, and could be independent or belonged to vehicle manufacturers. The remanufacturing parts came into spare parts market. The failure parts in service stations are replaced and treated as the same as those in dismantlers.
(3) Dismantlers collect reusable parts directly and send them to original equipment manufacturers (OEM) or vehicle manufacturers respectively via logistics between service stations and vehicle manufacturers. The automotive suppliers should establish their specialized workshops or departments for dealing with those parts which could be reassembled after strictly quality checking and testing (Ming 2005).

5 Conclusions and Further Research

Our aim is to receive valuable resources from End-of-Life vehicles (ELV). After their dismantling, the automotive parts get classified and catalogued. Among recycling hierarchy the reuse of used parts always achieves the most favourable

eco-balance and thus, gains the highest priority. On the same level we identify the remanufacturing of automotive parts. In order to give rise to a structured recycling process, it is intended to further develop the network based upon information on dismantled automotive parts. For this purpose, it has to be distinguished between the input (complete cars) and the output (single automotive parts) as a basis for the network.

Main objectives can be identified as:

1. Set standards and procedures for improving quality measurements like vehicle bodies, engines, transmissions, steering gear, electrical parts and others
2. Raise the market acceptance for remanufactured or reused car parts through networking in redemption and marketing communication (take-back network is highly developed in order to get as much end-of-life vehicles as possible)
3. Increase efficiency of logistics, transport and marketing (network).

The basis for a market of reused/remanufactured components can be represented by classification regulations to specify the quality like vehicle bodies and engines/transmissions for example.

The potential for sustainable resource management is very high. Manufactured products are kept in a closed-loop recycling process. Therefore, a car part is used as the same car part. Remanufactured products have a good life cycle performance as well because they are able to reach the quality standards of new manufactured products. This implies that resources (on material and process level) are kept to a minimum (Pehlken et al. 2010). The implemented network on car parts distribution guarantees an ideal communication platform between customer and product. Therefore, the access to all available parts is easier and makes the further reuse possible. The development of a new quality method for used combustion engines implies a reliable automotive parts reuse.

The network is already running successful for many years in Germany and has been implemented in the Czech Republic in 2005. China' vehicle remanufacturing industry is still in its early stage. In terms of policy China must strengthen further its implementing rules, regulation, and standards related to vehicle recycling and remanufacturing.

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