

## IS SPAIN THE BEST VEHICLE RECYCLER COUNTRY IN EUROPE?

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### Abstract

The amount of waste generated at the vehicles end of life is an issue that concerns to the European Commission. According to the Directive 2000/53/EC on end-of-life vehicles, since January 2006 the 80% of the vehicle's weight has to be recyclable and reusable and the 85% has to be recoverable. By 2015, according the same directive, these targets should be 85% for recycle and reuse and 95% for recovery.

The aim of this communication is to know the status of Spain regarding the rest of European countries to achieve the targets set by the Directive 2000/53/EC. Furthermore, the best end of life strategies will be identified.

**Keywords:** *End of life (EOL), Recycling, Reuse, Recovery.*

### 1. Introduction

The amount of de-registered vehicles or reaching the end of their life increases every year and, furthermore, an increase of this number is foreseen for the coming years. One example is that all over the world 30 million of end of life vehicles (ELV) are generated, 14 million of them are generated in Europe (EC, 2007; Johnson & Wang, 2002), and for the year 2015 this number will grow up to 17 million ELV (Collins et al., 2002).

ELVs are considered by the European Community as hazardous wastes. In order to manage these wastes the Directive 2000/53/EC on end-of-life vehicles was created, which aim is to minimize the generation of wastes from vehicles at their end of life. In order to do this, it promotes the reuse of components, recycling materials and energetic recovery. Some of the main changes established by the Directive 2000/53/EC on end-of-life vehicles were:

- Mandatory decontamination of the vehicles prior to their shredding, to avoid classifying fragmented wastes as hazardous wastes.
- Creation of a web of Authorized Treatment Facilities (ATF), which will receive and decontaminate the vehicles in appropriate facilities. These are correctly certified companies.
- Implementation of a certificate of destruction that is necessary in order to de-register the vehicle, which will be given by an ATF to the owner, and will be necessary to de-register the vehicle.

- After 1<sup>st</sup> of January of 2006, 80% of the vehicle's weight must be recyclable and reusable, and 85% recoverable.
- After 2015 reuse and recycling will increase to 85% and recovery up to at least 95% of the vehicle's weight.

This Directive 2000/53/EC has strong implications for: producers, providers, authorized treatment facilities, shredding plants, car dealers and the owner of the vehicle. In the same way, the Directive 2000/53/EC wants to prevent ecological damages derived from abandoning cars and accumulation of scrap, such as pollution and the important environmental costs that derives from the loss of not recycled resources or not reused from ELVs and, therefore more raw materials will be necessary to keep on producing, leading to an exhaustion of these resources.

There are different reports and studies related to the degree of compliance with the Directive 2000/53/EC on end-of-life vehicles in different countries of the European Union:

- Fergusson & IEEP (2007) made a study of the different action lines in some of the countries of the European Union.
- The Report from the Commission of the European Parliament of 2007 made a study of transposition of the Directive 2000/53/EC on end-of-life vehicles (EC, 2007).
- In Spain, the Spanish Association for environmental treatment of end of life vehicles (SIGRAUTO), in its annual memory of 2007, collects information about the number of ELVs listed by autonomous communities (SIGRAUTO, 2008).
- Eurostat made a report in 2006 gathering data about ELVs in every country. This data has been updated in 2008 (Eurostat, 2008).

Analysis of the different studies have concluded in a disparity of their results.

## **2. Goals/ Objectives**

The aim of this study is to determine whether Spain is the best vehicle recycler country in Europe.

For that purpose firstly the materials of the vehicle are analyzed and then recognize the wastes generated in their end of life. Next, chapters 4 and 5 show the analysis of recycling and reusing rates of different countries and Spain respectively. Afterwards chapter 6 discusses the information of chapters 4 and 5 in order to know if Spain is the best recycler. To end up, main conclusions are drawn, as well as recommendations are given in order to improve the vehicles end of life.

## **3. Vehicle's materials, wastes in the EOL**

Table 1 shows the main vehicle's materials. They have been collected from different bibliographic sources (IHOBE, 2001; Kanari et ál. 2003; Staudinger & Keoleian, 2001; Medina et ál., 2007).

MATERIALS	SOURCES				
	IHOBE, 2001	Kanari et ál., 2003	Staudinger & Keoleian, 2001	Medina et ál., 2007	Average
<b>Metals</b>	69.0%	-	-	-	<b>74.6%</b>
Ferrous metals	-	65.4%	68.0%	69.0%	-
Non-ferrous metals	-	10.0%	9.0%	7.9%	-
<b>Polymers</b>	-	-	-	-	<b>14.0%</b>
Rubber	4.0%	5.6%	4.0%	-	-
Thermoplastics and termostables	12.0%	9.3%	7.0%	14.0%	-
<b>Fluids</b>	7.0%	0.9	6.0%	2.1%	<b>4.0%</b>
<b>Glass</b>	4.0%	2.9%	30%	-	<b>2.5%</b>
<b>Others</b>	4.0%	5.9%	30%	70%	<b>4.9%</b>
<b>Total</b>	100.0%	100.0%	100.0%	100.0%	<b>100.0%</b>

Table 6 Percentage of materials of a vehicle

Each vehicle is composed by a different percentage of materials, being mainly: metallic materials, polymeric materials, fluids and glass. These materials present in the ELV are catalogued as hazardous wastes or non-hazardous wastes (Table 2).

HAZARDOUS WASTES	NON-HAZARDOUS WASTES
Oils used in the engine and gearbox	Ferrous materials
Transmission oil	Non-ferrous materials
Brake fluids	Plastics
Fuels	Glass
Liquid coolant/De-icer	Tyres
Air-conditioning filter	Textiles and foams
Oil filters	
Batteries	
Absorbent materials	

Table 7 Hazardous and non-hazardous wastes in an automobile

Hazardous wastes must be extracted before treating the vehicle in its end of life. It is estimated that 25% of vehicle’s weight is classified as hazardous waste (ANFAC et al., 2001). On the other hand, non-hazardous wastes are the ones that will be try to recycle, reuse or recover.

#### 4. Recycle and reuse rates in Europe

Table 3 shows the countries with the best recycle and reuse rates from the studies made by the European Commission (2007), Fergusson & IEEP (2007) and Eurostat (2008). As it is shown, Lithuania is the country with the best rates. Spain appears in 9th position with a 75% of recycle and reuse rate according to the European Commission report, whereas in the study made by Eurostat it appears in the 25th position and in Fergusson’s study it doesn’t appear at all.

Ranking	Fergusson & IEEP, 2007		European Comisión, 2007		Eurostat, 2008	
	Country	Recycle + Reuse	Country	Recycle + Reuse	Country	Recycle + Reuse

“Selected Proceedings from the 13th International Congress on Project Engineering”.  
(Badajoz, July 2009)

Ranking	Fergusson & IEPP, 2007		European Comisión, 2007		Eurostat, 2008	
	Country	Recycle + Reuse	Country	Recycle + Reuse	Country	Recycle + Reuse
1	Netherlands	85.3%	Sweden	84.0%	Lithuania	88.0%
2	Sweden	85.0%	Netherlands	83.0%	Belgium, <i>Flanders</i>	87.2%
3	Italy	82.0%	Norway	83.0%	Germany	86.8%
4	Belgium	80.0%	Denmark	83.0%	Latvia	86.0%
5	Germany	79.7%	Belgium	80.0%	Cyprus	85.4%
6	Austria	79.0%	United Kingdom	79.0%	Luxembourg	85.1%
7	-	-	Austria	77.5%	Poland	84.7%
8	-	-	Germany	77.0%	Sweden	83.4%
9	-	-	Spain	75.0%	-	-
11	-	-	-	-	Netherlands	82.5%
20	-	-	-	-	Austria	80.0%
25	-	-	-	-	Spain	76.0%
26	-	-	-	-	Italy	70.3%

Table 3 Percentages of recycling and reuse (%) by country

As Table 3 shows, there is a disparity in the results given by the different bibliographic sources. To get a deeper understanding of this disparity, Table 4 has been created from Table 3. Table 4 shows a comparative in order to appreciate the disparity between the studies, where same countries show different rates, as for instance Germany varies from 77,0 to 86,8% or Belgium changes from 80,0 to 87,2%.

Country	Fergusson & IEPP, 2007		European Comisión, 2007		Eurostat, 2008	
	Ranking	Recycle + Reuse	Ranking	Recycle + Reuse	Ranking	Recycle + Reuse
Netherlands	1	85.3%	2	83.0%	11	82.5%
Sweden	2	85.0%	1	84.0%	8	83.4%
Belgium	4	80.0%	5	80.0%	2	87.2%
Germany	5	79.7%	8	77.0%	3	86.8%
Austria	6	79.0%	7	77.5%	20	80.0%

Table 4 Comparative of recycle and reuse rates (%)

This disparity of data could be due to they are not updated or because they have been collected from different sources. In Fergusson & IEPP's report (2007) 6 of the countries' data are from 2004. The EC's report speaks about 9 European countries and the data is from 2005 and Eurostat (2008) speaks about the data of almost all the 27 countries of the EC with data from 2008.

Considering Eurostat's data the most up-to-date, from now on they will be the only data taken into account.

## 5. Recycle and reuse rates in Spain

In Spain, Directive 2000/53/EC was transposed in the Royal Decree (RD) 1383/2002 which defines the management of vehicles in their end of life. To fulfill it, the entities involved created

SIGRAUTO. These entities are: the spanish association of car scrapping and recycling (AEDRA), the spanish association of manufacturers of cars and trucks (ANFAC), the association of importers of automobiles, trucks, buses and motorcycles (ANIACAM) and the spanish federation recovery (FER).

The goal of SIGRAUTO is to reach the goals of RD 1383/2002, coordinate and manage the activities derived from the normative about ELVs, represent and defend their associates' interest towards European, central, autonomous and local Administrations as a result that an effective chain of treatment can be established.

According to SIGRAUTO (2009), Spain recovers the 86% of the vehicles at the end of their useful life, what makes Spain one of the countries with highest rate in the European market regarding recycle and reuse of ELVs. This data differs from the ones obtained by the European Commission (2007) where the data for Spain is 75% and Eurostat (2008) with 76%.

▪ **Discussion**

Each country of the European Union has transposed the Directive 2000/53/EC on end-of-life vehicles into an internal regulation to reach the specifications given by it.

To justify differences in recycle and reuse rates, the countries have defined different end of life scenarios (Table 5).

Likewise, from the composition of the vehicle (Table 1) and the end of life scenario an estimation of the recycle, reuse and recoverability rates has been made (Table 5).

Due to every country has its own regulation there are differences in the obtained rates (Table 3). According to the end of life system the recycle and reuse rates will be different. This is why these differences are in the results.

MATERIALS	EOL SCENARIOS			
	EOL-0	EOL-1	EOL-2	EOL-3
Metals	R	R	R	R
Polymers				
Rubber	L / R	L / REC / R	REC / R	REC / R / REU
Thermoplastics and thermostables	L	L / REC	L / REC / REU	REC / R / REU
Fluids	L	R	R	R
Glass	R	R	R	R
Rest of materials	L	L	REC / L	REU / REC
Estimated recycle and reuse rate	70-75%	75-86%	86-90%	90-95%
Estimated recycle, reuse and recover	75-80%	85-90%	90-95%	95-100%
Fulfilment of Directive 2000/53/EC	NO	NO-YES	YES	YES

R: Recycle; REU: Reusable; REC: Recoverable; L: Landfill

Table 5 EOL scenarios

The defined scenarios are:

- Scenario EOL-0 is the less positive, where only metals, glass and part of the rubber are recycled. The countries that don't reach the 75% of the recycle and reuse rate belong to this scenario.

- Unlike the scenario EOL-0, in scenario EOL-1 the rubber, besides being recycled and put in the dump, it starts to recover. Thermoplastics and thermo stables also start to recover and fluids are recycled completely.
- Scenario EOL-2 is an intermediate scenario. Thermoplastics and thermostables start to be reused and recovered energetically and part of the rest of materials are recovered. This scenario could be compared to the system followed by Lithuania or Belgium with a high rate of recycle and reuse, according to the report from Eurostat (2008).
- The last scenario, EOL-3, is the most futuristic comparing to the others. Polymers are recycled, reused and recovered, removing the option of the landfill, and the rest of materials are reused and recovered. Applying this scenario it would be possible to reach waste zero.

These scenarios have been defined starting from visits to different companies of EOL system existing in Spain, ATFs, shredding plants and dense media plants (Figure 1).

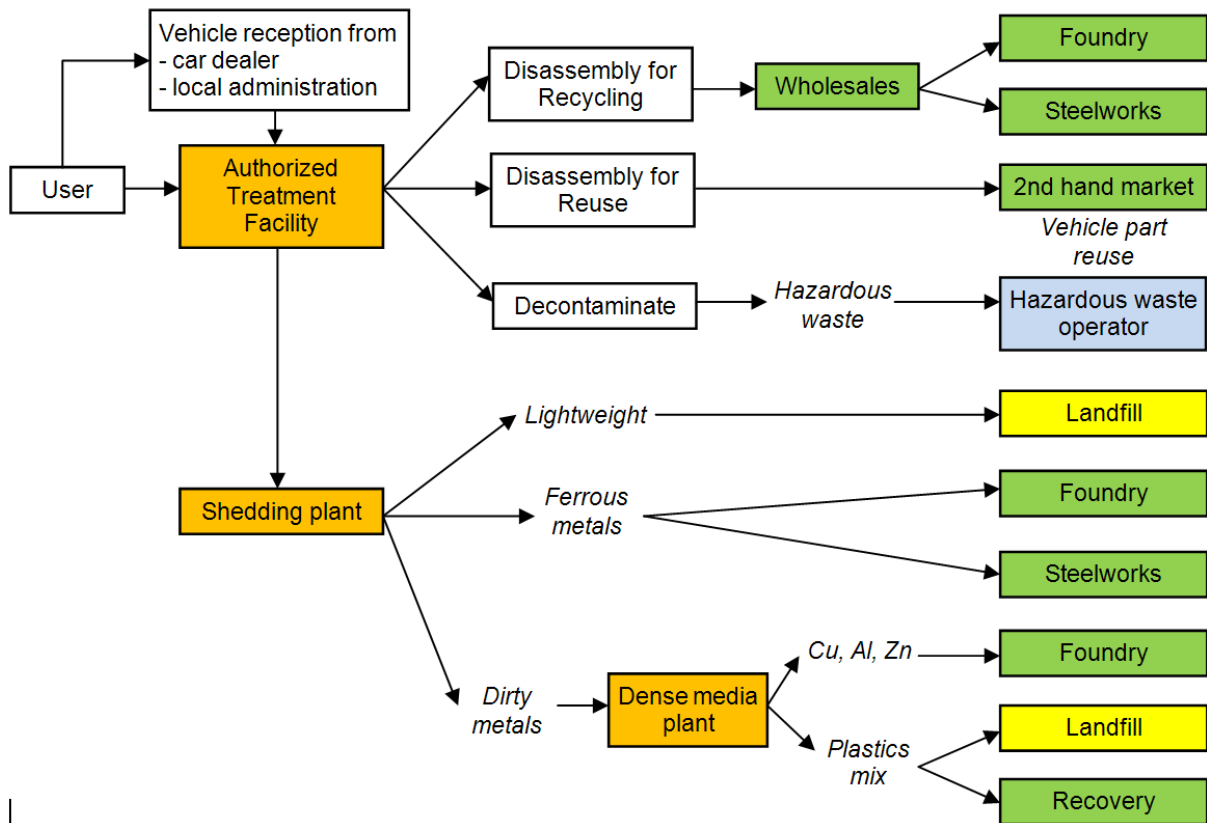


Figure 1 ELV Process

Taking the recycle and reuse rates data from the Eurostat report (2008) (Table 3), Lithuania would be the best recycling country with a rate of 88%. This high rate can be due to the fact that it is a small country where the amount of ELVs generated is not very high, and therefore its management is easier to control than in countries like Germany or Spain 5 or 7 times bigger in surface and with a volume of ELVs generated 36 and 68 times bigger respectively, as can be seen in Table 6.

Country	Km <sup>2</sup>	ELV (units)	ELV (ton)
Lithuania	65 300	13 877	14 057
Belgium	30 510	131 043	131 030
Germany	357 050	499 756	449 280
Spain	505 000	954 715	885 689

Table 6 Data about generated ELVs

Spain is ranked the 25th among the 27 of the ranking (Table 3). However, if data from SIGRAUTO is considered, it would be the 5th of the ranking with 86%.

According to the recycle and reuse rate given by Eurostat (2008), Spain is located in the scenario EOL-0 (Table 5), while considering SIGRAUTO's data it would be EOL-1.

Currently Spain has 955 ATFs, from which 444 belong to the net of SIGRAUTO, apart from 26 shredding plants of FER (SIGRAUTO, 2009). Despite that the net of ATFs listed by SIGRAUTO is slightly higher than 50% regarding the total amount of authorized treatment facility centers in Spain, in 2007 they treated 717.668 ELVs of the 927.960 total of de-registered vehicles affected by RD 1383/2002, which means 77.33% of the total amount (SIGRAUTO, 2008). The percentage not treated by SIGRAUTO is also treated by the 26 shredding plants of FER.

A reason explaining the difference between data published about Spain from different sources can be due to considering the 100% of the ELVs managed and not only the ones treated by SIGRAUTO. For this reason, in general terms it is possible that the total rate can be lower than the 86% estimated by SIGRAUTO.

Therefore, in order to make Eurostat data consistent with SIGRAUTO data, all the ELVs should be managed by that entity.

## 7. Conclusions

Every year, between 8 and 9 million vehicles are scrapped in Europe, obtaining around 9 million tons of materials (SIGRAUTO, 2009; EC, 2007). This amount will increase once the economical crisis will be overcome.

Currently Spain recycles and reuses the 86% of the weight of an ELV (SIGRAUTO, 2009), being over the 85% of the rate established by the Directive 2000/53/EC for 2006. However, Lithuania, Belgium or Germany are above the Spanish rate. Therefore, replying to the title of the communication "Is Spain the best European country recycling vehicles? The answer would be not. If currently the rate is not higher is because it is not economically profitable for the different agents of the Spanish end of life scenario (Justel et al., 2007).

Regarding to the quality of the data analyzed it can be stated that working with sources from different countries has made impossible to contrast the information. Every source manages different rates. To avoid this, the percentages of materials that every ATF must disassembly should be defined in order to accomplish the directive. This would help governmental control and reliability of the data.

Regarding future and according to the Directive 2000/53/EC on end-of-life vehicles, from January 1st of 2015 85% of the vehicle's weight has to be recyclable and reusable, raising up to 95% with the energy recoverability. To make Spain reach this rate is necessary to improve the current scenario EOL-1 and evolve towards an EOL-2 scenario (Table 5). For which, new



ways of recovery must be developed for the rest of materials that are not possible to recycle, reuse and recover nowadays in a profitable way. Some of them could be:

- Promote recycled material markets and minimize wastes (Dallmeier, 2003; Viñoles et ál., 2004).
- Management of the vehicle after the End of Life, empowering reuse and recoverability (SEAT, 2009). For example, in Europe the use of end-of-life tires is higher than the Spanish one (II PNFU 2008-1015).
- Use of the energetic recoverability instead of landfill for light shredded waste (Rodríguez, 2006). This fraction is divided in light shredded waste composed by foams, textiles, small size plastics and a small amount of metals and heavy waste without metals forming rubbers, plastics and other materials. A solution for these wastes can be to use them as alternative energy sources in concrete production plants, enabling recoverability of 100% of the ELVs, reaching waste zero (SIGRAUTO, 2009).
- Recycle or recover energetically the mix of plastics from the dense media plant.
- Manuals given to the ATFs by the producers to make the disassembly and identification of materials easier.
- Reward producers that design their vehicles in a way that in the EOL they generate fewer wastes (Justel et ál, 2007; Zuidwijk & Krikke, 2008).

To end up, if the aim is to reach a fully sustainable development, it should evolve toward an EOL-3 scenario so that biocompatible systems can be reached, resembling nature.

## 8. References

ANFAC, Arthurandersen, F.E.R, Officemen, UPM-IOL, AEDRA, Ciemat, Grupo CAT, Novafilm y CETRAA. "Informe de resultados del proyecto Profit: Valorización energética de residuos generados durante y al final de la vida de los vehículos". 2001.

Collins, C., Fanning A., Crowe M. and Meaney B. "End of life vehicles in Ireland. A sectorial report", Ireland: EPA, 2002.

European Community. "Informe de la Comisión, al Parlamento Europeo, al Comité Económico y Social Europeo y al Comité de Regiones sobre la aplicación de la Directiva 2000/53/CE relativa a los vehículos al final de su vida útil durante el periodo 2002-2005". Comisión de las Comunidades Europea. 2007.

Dallmeier, L. "Sustainable Waste Management of End of Life Vehicles", 2003. [http://www.green.net.au/hope/library\\_resources/Dallmeier\\_ENV-M402%20Essay.doc](http://www.green.net.au/hope/library_resources/Dallmeier_ENV-M402%20Essay.doc), date accessed 20-02-2009

Eurostat. "End of life vehicles". European Commision. 2008. Data 2006 (updated 2 Nov. 2008).

Fergusson, M. and IEEP. "End of Life Vehicles (ELV) Directive. An assessment of the current state of implementation by Member States", European Parliament IP/A/ENV/IFWC/2006-172/LOT 1/ C1I SC2. 2007. March.

IHOBE." Resúmenes de Legislación Ambiental". IHOBE, Sociedad Pública de Gestión Ambiental. 2001.

II PNFU 2008-1015. "II Plan Nacional de Neumáticos Fuera de Uso 2008-2015 (II PNFU)". Plan Nacional Integrado de Residuos (PNIR) 2008-2015 versión preliminar, Anexo 3.

Johnson M.R. and Wang M.H. "Evaluation policies and automotive recovery options according to the European Union Directive on end-of-life vehicles (ELV)", Automot Eng. 2002; N°9, pp.723-739.



Justel, D., Agirrezabal, L., Valor, A., Galdos, A. Sarrionandia M.A. y Lauroba, N. "Análisis del grado de reciclabilidad real de los materiales empleados en el sector electrodomésticos". Actas del XI Congreso Internacional de Ingeniería de Proyectos, AEIPRO. 2007. Lugo, España, 13-15 Septiembre.

Kanari N., Pineau J.L. and Shallari S. "End-of-Life Vehicles Recycling in the European Union". Journal of the Minerals Metals and Materials Society, JOM, 2003. Volume 55, N° 8, August.

Medina, H., Naviero, R., Malafaia, A.J. "Design for recycling improving environmental performance of automotive industry in Brazil". Proceedings of the International Conference on Engineering Design, ICED'07, 2007. Paris, France.

Rodriguez, A. "RAEEs Vs VFUs Vs Envases: Tres modelos un mismo objetivo", 2006. [http://www.mma.es/secciones/agenda/pdf/rodriguez\\_martinez.pdf](http://www.mma.es/secciones/agenda/pdf/rodriguez_martinez.pdf), date accessed 21-04-2009.

SEAT. <http://www.seat.es/es/generator/su/es/SEATServices/site/EOLVehicles/main.html>. SEAT Service, date accessed 21-01-2008.

SIGRAUTO, "Memoria Anual 2007". 2008. Disponible en <http://www.sigrauto.es>, date accessed 24-04-2009.

SIGRAUTO. 2009. <http://www.sigrauto.es>, date accessed 19-03-2009.

Staudinger, J. and Keoleian, G. "Management of End-of-Life Vehicles (ELVs) in the US". Centre for Sustainable Systems, University of Michigan, 2001.

Viñoles, R., Bastante, M.J., López, R., Vivancos, J.L. y Capuz, S. "Análisis del impacto medioambiental de un automóvil, a lo largo de su ciclo de vida", DYNA. 2004. Enero-febrero.

Zuidwijk, R. and Krikke, H. "Strategic response to EEE returns: Product eco-design or new recovery processes?". European Journal of Operational Research. 2008. Vol. 191, pp. 1206-1222.

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