VALIDATION OF THE RECYCLING PERCENTAGES FOR END-OF-LIFE VEHICLES AT SHREDDER COMPANIES AND FLOTATION UNITS

OPENBARE VLAAMSE AFVALSTOFFENMAATSCHAPPIJ

Samen maken we morgen mooier.

Documentbeschrijving

OPENBARE VLAAMSE AFVALSTOFFENMAATSCHAPPIJ

1. Titel publicatie

Validation of the recycling percentages for end-of-life vehicles at shredder companies and flotation units

2. Verantwoordelijke uitgever

Henny De Baets, OVAM, Stationsstraat 110, 2800 Mechelen

3. Aantal blz.

51 p (without confidentiel annexes)

4. Wettelijk depot nummer

D/2008/5024/49

5. Aantal tabellen en figuren

7 tables et 15 figures

6. Publicatiereeks

7. Datum publicatie

2008

8. Trefwoorden

shredder, flotation, European Directive 2000/53/EU, end-of-life vehicle, report, RDC,

9. Samenvatting

The goal of this study is to calculate the recycling percentages for the end-of-life vehicles treated in 2006 for each shredder company in Belgium individually. For that purpose, 2 steps have been taken. On the one hand it has been determined what is the input of the installation and on the other hand what exactly happens inside the installation. The input is the average composition of an end-of-life vehicle. Secondly an estimation has been made for each material as for their division during separation at the shredder and flotation units. To do this all separation processes have been set out. From the collected data a model has been developed in order to calculate the recycling and recovery rates. Finally this study reports also on which data will have to be collected in order to calculate the recycling percentages for the years to come.

10. Begeleidingsgroep en/of auteur

OVAM, IBGE/BIM, OWD et RDC Environment

11. Contactperso(o)n(en)

Afvalstoffenbeheer, dienst selectief ingezamelde stromen, Anneleen De Wachter en Johan Verlinden
anneleen.de.wachter@ovam.be - 015/284 161
johan.verlinden@ovam.be - 015/284 367

12. Andere titels over dit onderwerp

Contents

Abbreviations

ABS:	Acrylonitrile Butadiene Styrene
ABSR:	Alternative Fuel from Shredder Residue
AEEA:	End-of-Life Electric and Electronic Appliances
Al:	Aluminium
Cu:	Copper
DELV:	Depolluted End-of-Life vehicle
ELV:	End-of-Life vehicle
EPP:	Expandable Polypropylene
Fe:	Iron
Ferro:	Collective term for ferrous metals like steel
Pb:	Lead
PE:	Polyethylene
PET:	Polyethylene terephthalate
PMMA:	Polymethyl methacrylate
PP:	Polypropylene
PP-EPDM:	Polypropylene-Ethylene Propylene-diene terpolymer
PST:	Post Shredder Techniques
SHF:	Shredder Heavy Fraction
SLF:	Shredder Light Fraction
Zn:	Zinc

Executive summary – Nederlands

Het doel van deze studie is om per shredder in België een recyclagepercentage te berekenen dat behaald wordt op afgedankte (gedepollueerde en gedemonteerde) wagens. De bedoeling is om percentages te geven waarvan we zeker zijn. Dit wil zeggen dat als er onzekerheid is er gekozen is voor de minst gunstige situatie. Om deze percentages te berekenen moeten er twee stappen uitgevoerd worden, namelijk vastleggen wat er in een shredder binnenkomt en bepalen wat er precies bij de shredder gebeurt.

Eerst werd nagegaan uit welke materialen een afgedankte auto in 2006 bestond. Hiervoor werden algemeen beschikbare gegevens gebruikt, alsook gegevens van autoconstructeurs. Hier werden dan de materialen die bij depollutie en demontage verwijderd worden van afgetrokken. Zo werd een gemiddelde samenstelling bekomen van wagens die in een shredder worden verwerkt. Deze gemiddelde afgedankte wagen bevat ongeveer 72% staal, 5% aluminium, 2% andere metalen en een 12% plastics. Gedurende deze stap werden de depollutie en de demontage ook in rekening genomen.

Hierna werd per materiaal een schatting gemaakt van hoe ze verdeeld worden tijdens de scheidingen die bij de shredders (en flottatie-eenheden) gebeuren. Om te weten te komen welke scheidingen door welke shredder worden uitgevoerd, werd vervolgens een (of meerdere) bezoek(en) gebracht aan elke shredder in België. Bovendien werd ook een bezoek gebracht aan alle bedrijven in België die shredderafval verwerken. Op basis van deze bezoeken werden alle processen in kaart gebracht (voor zoverre dit werd toegelaten door de shredderbedrijven).

Uit de verzamelde gegevens werd dan een model opgesteld waarmee het percentage berekend werd. Uit deze berekeningen is gebleken dat alle Belgische shredders tussen de 78.1% en 92.6% recyclage en energetische valorisatie verwezenlijken (gegevens 2006).

Om de recyclagepercentages op afgedankte wagens de komende jaren op dezelfde manier te kunnen berekenen, worden de benodigde gegevens het best in de drie Gewesten in België op een gelijkaardige manier opgevraagd. Er moeten gegevens verzameld worden over hoeveelheid en bestemming van alle uitgaande stromen, alsook moeten nieuwe installaties in de al verzamelde processen ingepast worden. Een internationaal uniform systeem zou de mogelijkheid bieden om de berekeningen gemakkelijker door te voeren voor de bedrijven die bepaalde stromen naar het buitenland sturen.

Executive Summary – Français

Le but de l’étude est de calculer un pourcentage de recyclage obtenu sur des épaves de voitures (dépolluées et démontées) par shredder en Belgique. Le but était d’obtenir des pourcentages avec un grand degré de certitude. Pour suivre ce principe en pratique nous avons travaillé avec des hypothèses conservatrices en cas d’incertitude. Afin de calculer ces pourcentages deux grandes étapes ont été effectuées. La première étape est de définir ce qui rentre chez le shredder. La deuxième étape est de bien définir ce qui se passe chez le shredder/

Dans la première partie de cette étude une analyse approfondie a été effectué afin de définir la composition d’un VHU de 2006. Pour effectuer cette analyse des données disponibles auprès de fédérations et dans des rapports scientifiques ont été utilisées. Les constructeurs automobiles ont aussi procuré des informations utiles. Sur base de ces informations la composition moyenne a été définie ; un VHU contient 72% d’acier, 5% d’aluminium, 2 d’autres métaux et 12% de plastics. Lors de cette étape de calculer le démontage et la dépollution ont aussi été prises en compte.

Durant la deuxième étape une estimation a été faite de la distribution de chaque matériau au sein de l’installation de shredder (et des flottations qui suivent). Pour définir l’efficacité de chaque shredder en Belgique nous avons visité (une ou plusieurs fois) chaque shredder. Nous avons aussi visité les installations de flottation ainsi que les installations PST. Sur base de ces différentes visites nous avons mis en carte tous les procédés présents pour chacune des installations belges (pour autant que nous en avons reçu la permission).

Sur base des informations obtenues un model a été créé pour calculer le pourcentage de recyclage que chaque shredder peut obtenir. Sur base de ces calculs nous avons obtenu des résultats qui indiquent que chaque shredder se trouve dans un intervalle de valeurs entre 78.1% et 92.6% pour le recyclage et la valorisation énergétique (chiffres 2006).

Afin de pouvoir calculer les pourcentages de recyclage obtenus sur les VHU pour les années à venir, les données a collectés devraient être collecté de la même manière dans les trois Régions en Belgique. Ceci permet d’éviter une distorsion du marché. Les données à collecter sont des données concernant la taille et la destination de tous les flux sortants, ainsi qu’une déscription des changements dans le procédé. Un système de calcul international et uniforme permettrait d’effectuer les calculs plus facilement (et plus correctement) pour les entreprises qui envoient une partie de leurs flux à l’étranger.

Executive summary – English

The goal of this study is the calculation of recycling percentages attained per shredder in Belgium on end-of-life vehicles (ELVs) after depollution and dismantling (DELV). The intention is to provide percentages that we can guarantee, which means that in case of uncertainty the least favourable situation was chosen. In order to be able to calculate these percentages two steps need to be carried out - namely the shredder input must be determined and secondly the processes that take place at the shredder site must be known and understood.

First the material composition of an average ELV in 2006 in Belgium was determined. Publicly available data were used for this, as well as data from car manufacturers. After extraction of the materials removed during depollution and dismantling an average composition of a shredded car was obtained. This average DELV contained around 72% iron, some 5% aluminium, some 2% other metals and around 12% plastics. During this calculation step dismantling and depollution have also been taken into account.

Secondly it was estimated material by material how they are distributed during the different separation steps at the shredder (and flotation units). In order to learn what separations are carried out by which shredder, at least one visit was made to all shredders in Belgium. Furthermore a visit was rendered to all companies that process shredder output. A flow chart of all processes was composed based on these visits - as far as the shredding companies allowed.

With the collected data a model was built for calculating the percentages. Results indicate that all Belgian shredders attain between 78.1% and 92.5% recycling and energetic valorisation in 2006.

In order to be able to calculate these percentages for ELV in the same way in the future, it is advisable that the necessary data be retrieved from companies in the three regions of Belgium in the same way. Information regarding quantity and destination of all outgoing streams needs to be collected. Furthermore new installations need to be taken into account in the already collected processes. An international uniform system would facilitate the calculations for the companies that export particular streams.

Executive Summary – Deutsch

Der Zweck dieser Studie ist es, um pro Shredder in Belgien der Recyclingprozentsatz zu berechnen, der bei verschrotteten (schadstofffreien und demontierten) Autos erreicht wird. Vorgegeben ist dabei, die Prozentsätze anzugeben, deren wir sicher sind, d.h. dass wir bei Unsicherheit die am wenigsten günstige Situation angenommen haben. Zum Berechnen dieser Prozentsätze mussten zwei Schritte durchlaufen werden, nämlich die Feststellung, was bei einem bestimmten Shredder eingeht und die Feststellung, was genau im Shredder geschieht.

Zunächst wurde analysiert, aus was für Materialien ein verschrottetes Auto im Jahr 2006 bestand. Zu diesem Zweck wurden allgemein verfügbare Daten benutzt, sowie auch Daten von Autoherstellern. Davon wurden dann die Materialien, die bei der Schadstoffentfernung und der Demontage entfernt wurden, abgezogen. Auf diese Weise wurde die durchschnittliche Materialzusammenstellung der Schrottwagen bestimmt, die im Shredder verarbeitet wurden. Dieser durchschnittliche Schrottwagen enthält ungefähr 72% Stahl, 5% Aluminium, 2% andere Metalle und 12% Kunststoffe. Bei dieser Berechnung wurden auch die Schadstoffentfernung und die Demontage berücksichtigt.

Danach wurde pro Materialsorte geschätzt, wie dieses Material bei den Abscheidungsvorgängen verteilt wird, die in den Shreddern (und den Flotationseinrichtungen) stattfinden. Um feststellen zu können, welche Abscheidungen von welchem Shredder ausgeführt werden, wurde danach jeder Shredder in Belgien ein oder mehrere Male besucht. Darüber hinaus wurden auch alle Betriebe besucht, die in Belgien Shredderabfall verarbeiten. Auf der Grundlage dieser Besuche wurden alle Prozesse aufgezeichnet (soweit uns dies von den Shredderbetrieben erlaubt wurde).

Aus den so erhaltenen Daten wurde sodann ein Modell erstellt, mithilfe dessen der Prozentsatz errechnet wurde. Aus diesen Berechnungen ging hervor, dass alle belgischen Shredder eine Wiederverwertungs- und energetischen Valorisierungsgrad von zwischen 78,1% und 92,6% erzielen (Daten von 2006).

Um die Recyclingprozentsätze bei Schrottautos auch in den kommenden Jahren auf dieselbe Art und Weise berechnen zu können, müssen die erforderlichen Daten vorzugsweise in allen drei Regionen Belgiens auf die gleiche Art und Weise angefordert werden. Dabei müssen Daten gesammelt werden über die Menge und die Endbestimmung aller ausgehenden Materialströme. Auch müssen neue Anlagen in die bereits gesammelten Prozesse eingeordnet werden. Ein international uniformes System würde die Möglichkeit bieten, die Berechnungen für Betriebe zu erleichtern, die bestimmte Materialströme ins Ausland exportieren.

1 Introduction

Reading guide

In chapter 1 some definitions are repeated which will later be used in the subsequent chapters. The general methodology which was used in the study is described in chapter 0. This methodology is based on the average composition of an end-of-life vehicle (chapter 3) and on the efficiency which can be obtained in the various steps at the shredder companies (chapter 4). In order to validate the techniques each shredder applies, company visits were carried out (chapter **Fout! Verwijzingsbron niet gevonden.**) In chapter **Fout! Verwijzingsbron niet gevonden.** some hypotheses regarding the calculations are explained. Chapters 7 and 0 show how the percentages could be calculated in the coming years.

Remark : It is important to realise that the goal of this study is the calculation of the recycling percentages which shredders in Belgium can achieve processing end-of-life vehicles (ELVs) after depollution. That is to say that the percentages which are used in this study are not to be directly compared to the objectives of the European Directive 2000/53/EG. In order to compare these figures with those of the European Directive depollution and dismantling need to be included in the calculations.

1.1 Definition

1.1.1 Shredder installation

The following definition was provided by Febelauto : *"The shredder treats - in kilograms – the biggest part of an end-of-life vehicle. In an enormous 'grinder' the end-of-life vehicle is reduced to pieces the size of a fist. A suction system separates the dust particles and the non-ferro elements which are thus ripped from the metallic fraction. The iron is separated from this heavy metal fraction by means of a magnetic drum. In most shredder-installations the non-ferro mixture is treated in a linear motor with permanent induction. This yields a non-ferro metal fraction with 95% purity. In flotation installations the different non-ferro metals are subsequently separated so that each metal qualifies for recycling. From the shredder residue the remaining materials can be separated in flotation installations for further recycling."*

1.2 European rules and regulations

The European rules and regulations are used in this study in order to calculate the recycling percentages of vehicle wrecks (at the shredder) unambiguously. The definitions of the European Directives are used to differentiate between reuse/recycling, recovery and disposal.

1.2.1 Definitions

In the European Directive 2000/53/EG the following definitions can be found; these will also be used in this report:

- reuse : any operation by which components of end-of-life vehicles are used for the same purpose for which they were originally conceived

- recycling : the reprocessing in a production process of the waste materials for the original purpose or for other purposes but excluding energy recovery. Energy recovery means the use of combustible waste as a means to generate energy through direct incineration with or without other waste but with the recovery of heat.
- recovery : means any of the applicable operations provided for in Annex II B to Directive 75/442/EEG
- disposal : means any of the applicable operations provided for in Annex II A to Directive 75/442/EEG
- In practice the use of a reducing agent in blast furnaces is currently regarded as recycling. The use of aluminium and silicon in cement ovens is also considered to be recycling. In both cases the new frame Directive about waste (under discussion[1]) might throw a different light upon this matter and might degrade these processes to "valorisation".

1.2.2 Calculation of the recycling percentages

The calculation of the recycling percentages in this report is done in accordance with the regulations of the European Directive.

1.2.2.1 Directive 2000/53/EG

Directive 2000/53/EG is the standard document with regard to the legislation on the processing of end-of-life vehicles. Percentages for the recycling of ELVs are specified. Articles 7 subsection 2 states:

"2. Member States shall take the necessary measures to ensure that the following targets are attained by economic operators:

a) no later than 1 January 2006, for all end-of-life vehicles, the reuse and recovery shall be increased to 85% by an average weight per vehicle and year. Within the same time limit the reuse and recycling shall be increased to minimum of 80% by an average weight per vehicle and year.

b) 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 reuse and recycling shall be increased to a minimum of 85% by an average weight per vehicle and year."

This Directive thus provides a basis for the calculation of recycling percentages ("average weight per vehicle and year"). A subsequent Decision (2005/293/EG) is more concrete regarding the way in which the calculation needs to be done.

---

[1] Directive of the European Parliament and the Council concerning waste (frame directive waste)
Dispatch of the proposal to the EP and the Council (document COM(2005) 667 final - 2005/281COD): 26 December 2005
Advice of the European Economic and Social Committee: 19 June 2006
Advice of the European Parliament first reading: 13 February 2007
Decision on a collective point of view of the Council: 20 December 2007

1.2.2.2 Decision C(2004) 2849 (2005/293/EG)[2]

In this document the following regarding the determination of recycling percentages for cars is stated:

"(3) The highest accuracy of the targets can only be achieved if the denominator for the calculation of the targets is based on the number of end-of-life vehicles entering a treatment system of a Member State.

(…)

(4) Balancing the risks of inaccuracies and the administrative efforts of achieving precise information, Member States are allowed **to use a metal content assumption** for the determination of **the amount of metals** from end-of-life vehicles which will be recovered.

(5) Readily available vehicle data in a standardised form should be used for the determination of the individual vehicle weight.

(6) Fuel removed during dismantling shall not be taken into account for the calculation of the targets, since reliable information about the amount of fuel in end-of-life vehicles is not available in all Member States. An EU average amount of fuel should be used for the purpose of monitoring compliance with the targets in order to harmonise as much as possible the calculation methods and ensure the comparability of the national targets achieved in the Member States.

(7) As a consequence of the internal market, Member States may export the end-of-life vehicles generated on their territory to other countries for further treatment. In order to minimise allocation problems and to avoid extensive monitoring and calculation efforts, the recycling and recovery rates from exported vehicle parts will be credited to the exporting Member State.

(8) Shredder campaigns are necessary to determine the output streams of a shredder related to end-of-life vehicles."

---

[2] Commission Decision of 1 April 2005 laying down detailed rules on the monitoring of the reuse/recovery and reuse/recycling targets set out in Directive 2000/53/EG of the European Parliament and the Council on end-of-life vehicles

2 Methodology

2.1 General principle

Shredder installations are not equipped to calculate a recycling percentage in a simple way and even less so to calculate a specific recycling percentage for end-of-life vehicles. The primary difficulties encountered for calculation are:

- Shredders work with a mixed input. They process both end-of-life vehicles as well as discarded electric and electronic devices (AEEA) and other metal appliances. The composition of the input is not known. In fact the composition of the product stream (e.g. 25 wt% ELV, 45 wt% AEE and 30% metallurgical debris) is rather well known, whereas the material stream is fairly unknown and thus difficult to monitor.
- The composition of the cars which arrive at the shredders deviates from the average composition. The cars are more or less dismantled depending on their age, make, place of origin, dismantling location (specific need for particular parts)…
- Every company in this sector is different. There are integrated and non-integrated companies. Integrated companies are companies that control all steps of the process internally (the shredding and the flotation as well as PST[3]). The non-integrated companies sell not completely sorted streams to companies that in their turn sort these streams. The exchange of sub streams makes the calculation with mass balances difficult because the composition of these sub streams is not precisely known or stable.
- Part of the streams goes to companies abroad. This can happen from the moment the end-of-life vehicle has been cut up until the moment of export of the sorted streams. The activities of these foreign companies may differ widely. Some of these companies apply the same techniques as the ones which are used in Belgium. Other, less industrialised countries might carry out the work manually. The actual recycling and its efficiency are therefore difficult to monitor.

In order to get a better view on the streams discussed in the report, Figure 1 on the following page shows a general outline of the different streams which can be found at a shredder. More detailed flow sheets can be found in the different confidential annexes.

[3] Post-Shredder Technology

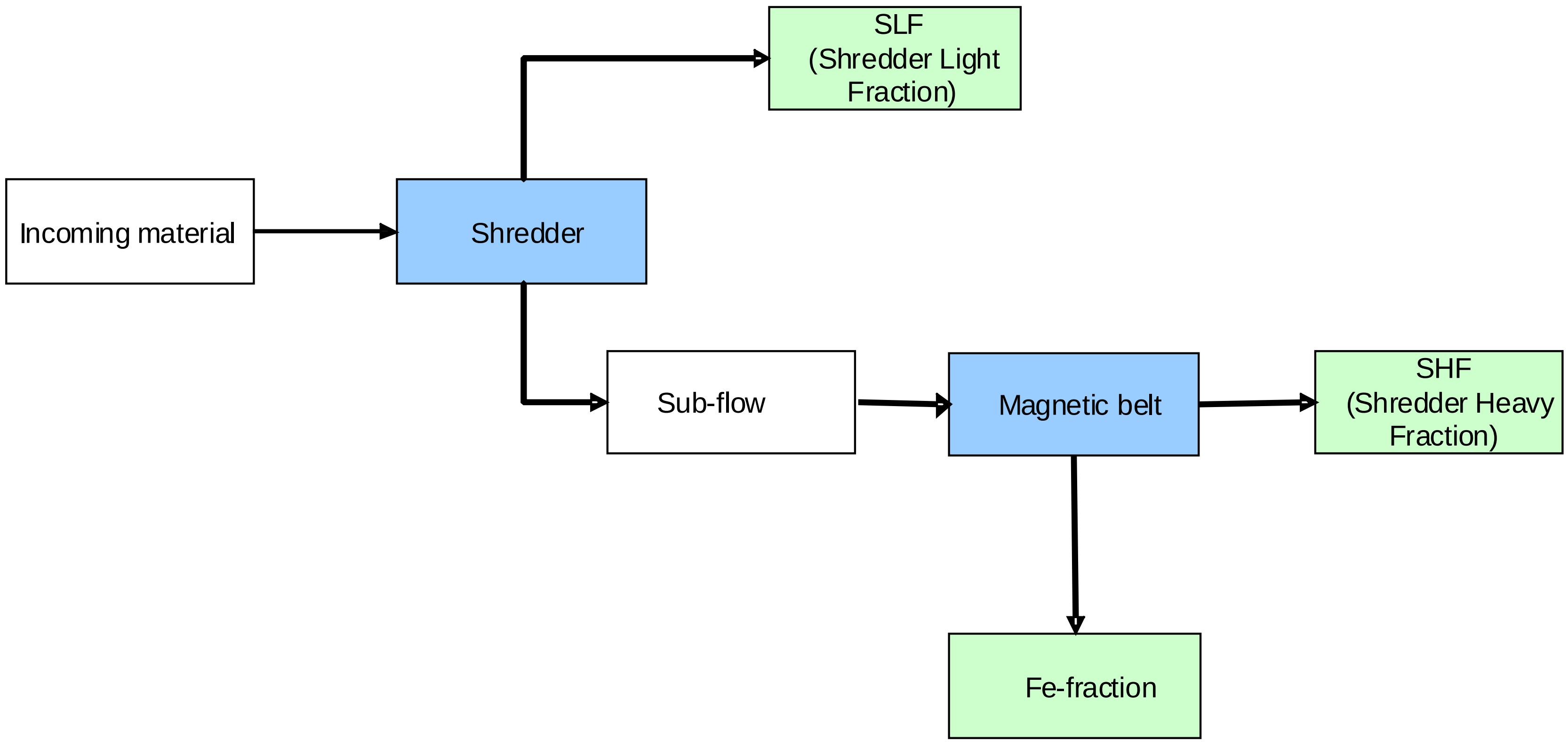

Figure 1 : General outline of a shredder

The methodology of this study is based on the following information sources:

- the outgoing streams of the shredders (amount, composition and destination)
- the technologies used and their performance
- the average composition of an ELV.

In order to calculate the recycling percentages for car wrecks in a manageable way the issue will be split up in different sub issues. These recycling percentages will be determined per material. The global recycling percentage will then be the sum, for all materials, of the recycling percentage of the specific material multiplied by the percentage in the composition of the end-of-life vehicle.

A recycling percentage needs thus to be obtained for each of the materials. Readily available data will be used for the composition of the car.

The calculation of the recycling percentages per material is based on the following:

- information regarding the different outgoing flows (amount and destination)
- a flow sheet of all the different steps in the dismantling process in the company
- the yield percentages which can be obtained per material on each of the different machines. The yields of each individual machine were measured against the default values resulting from the physical laws that support the act of separation. This will be further explained in the report.

Figure 2, Figure 3 and Figure4 on the following pages show a hypothetical example which explains how the model is built. For each process in the process tree (see Figure 2 page 17) a separation efficiency has been determined as mentioned above. In this example a shredder sends a heavy fraction (SHF) to a flotation with a density of 3 kg/l. In order to model the division of the different materials in the shredder (in a light fraction (SLF), a ferro-fraction and an SHF) and the separation of the materials in a flotation with this density (in a floating and a sinking fraction) is necessary.

The first hypothesis about the shredder itself is clarified in Table 7 on page 46. In a first step a calculation – based on this hypothesis- is made of the quantity of each of the incoming materials which end up in the different resulting streams (SLF, SHF and ferro-fraction) by multiplying the hypothesis by the amount of incoming material.

A possible hypothesis for the flotation with a density of 3 kg/l is shown in Figure 3. This hypothesis is used in the same way as the one above by multiplying the efficiency of each material by the amount of incoming material.

The model is thus conceived that the division of the different materials can be calculated step by step. Hereafter a number of hypothetical fractions are obtained which the shredder can bring to a number of different destinations.

These can be dumped or be processed further. If a fraction is dumped then it is seen as a total loss in the final calculation of the percentages. For the fractions which are processed externally it is determined which materials are recycled or energetically valorised and which are finally disposed of.

In Figure4 on page 19 an example is given of a fictitious calculation of the percentages for recycling and energetic valorisation. It is assumed in this example that the ferro-fraction is completely recycled, that the SLF is dumped, that the sinking fraction is sent abroad and that the floating fraction is treated further in Belgium. Treatment abroad means the recycling of some of the metals present, while for the treatment in Belgium in this example the recycling of all the metals and the glass and a valorisation of 10% of other materials is assumed. This results in a recycling percentage of 80.7% and furthermore an energetic valorisation of 0.5% (Figure4).

It has to be stressed within this framework of this calculation the calculated fractions do not correspond to the actual outgoing fractions because only the part taken from the vehicles has been taken into account. The amount of vehicles processed by Belgian shredders is rather limited which means that the outgoing flows only to a very small degree consist of material coming from end-of-life vehicles. For more information, see chapter 6.7 on page 47.

During the whole study extra attention was paid to the critical streams. These are briefly dealt with in chapter 2.2.

Shredder

Inkomend shredder	
Inkomend materiaal (kg)	
Ferro	614
Al	42
Cu	9
Zn	3
Pb	6
PP	52
PE	24
PMMA	7
ABS	5
PET	4
EPP	4
PP-EPDM	5
Polyurethaan	3
Rubber	32
Textiel	12
Glas	31
Totaal	852

Ferro 1	
kg	
Ferro	604.7
Al	0.0
Cu	0.0
Zn	0.0
Pb	0.0
PP	0.1
PE	0.0
PMMA	0.0
ABS	0.0
PET	0.0
EPP	0.0
PP-EPDM	0.0
Polyurethaan	0.0
Rubber	0.1
Textiel	0.0
Glas	0.0
Totaal	605

SLF	
kg	
Ferro	3.1
Al	2.9
Cu	0.6
Zn	0.2
Pb	0.4
PP	41.9
PE	19.4
PMMA	5.4
ABS	3.9
PET	3.1
EPP	3.1
PP-EPDM	3.9
Polyurethaan	2.9
Rubber	8.0
Textiel	11.5
Glas	6.1
Totaal	117

SHF	
kg	
Ferro	6.1
Al	38.6
Cu	8.2
Zn	2.7
Pb	5.5
PP	10.4
PE	4.8
PMMA	1.4
ABS	1.0
PET	0.8
EPP	0.8
PP-EPDM	1.0
Polyurethaan	0.0
Rubber	24.2
Textiel	0.2
Glas	24.5
Totaal	130

Flotatie 3 kg/L

Drijvende fractie	
kg	
Ferro	0.3
Al	27.1
Cu	1.6
Zn	0.1
Pb	0.1
PP	10.3
PE	4.8
PMMA	1.3
ABS	1.0
PET	0.8
EPP	0.8
PP-EPDM	1.0
Polyurethaan	0.0
Rubber	24.0
Textiel	0.2
Glas	22.0
Totaal	95

Zinkende fractie	
kg	
Ferro	5.8
Al	11.6
Cu	6.6
Zn	2.7
Pb	5.4
PP	0.1
PE	0.0
PMMA	0.0
ABS	0.0
PET	0.0
EPP	0.0
PP-EPDM	0.0
Polyurethaan	0.0
Rubber	0.2
Textiel	0.0
Glas	2.4
Totaal	35

Figure 2 : Example of a process tree of a fictitious shredder for the calculations of the recycling percentages

Shredder
Incoming shredder
Incoming material (kg)
Ferro
[…]
Polyurethane
Rubber
Textile
Glass
Total

Ferro 1
[idem]

SLF
[idem]

SHF
[idem]

Flotation 3 kg/l
Floating fraction
[idem]

Sinking fraction
[idem]

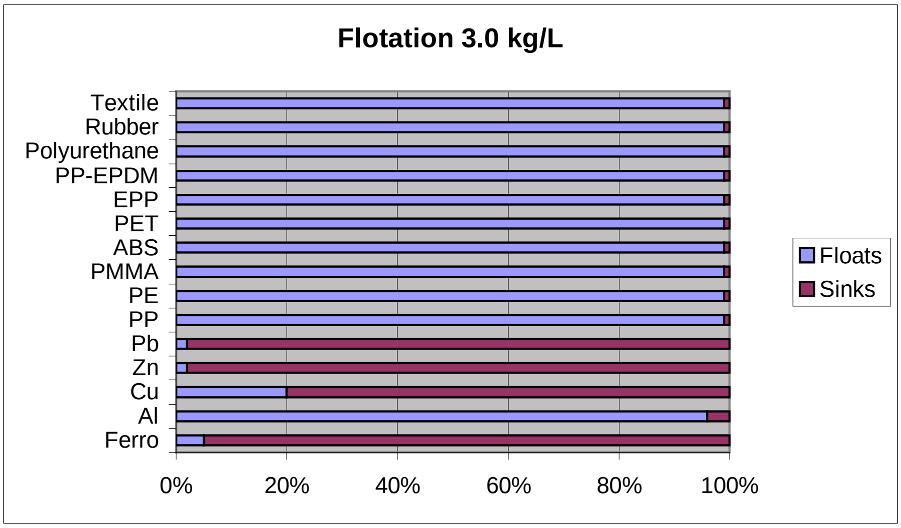

Figure 3 : Separation efficiencies for a flotation of 3.0 kg/l

Recyclage	ELV	Ferro	Zinkende fractie	Drijvende fractie	Totaal	%
Ferro	613.9	604.7	5.8	0.3	610.8	99.5%
Al	41.6	0.0	11.5	26.8	38.3	92.1%
Cu	8.9	0.0	6.5	1.6	8.1	91.1%
Zn	3.0	0.0	2.7	0.1	2.7	92.1%
Pb	5.9	0.0	5.3	0.1	5.4	92.1%
PP	52.4	0.1	0.0	0.0	0.1	0.1%
PE	24.3	0.0	0.0	0.0	0.0	0.1%
PMMA	6.8	0.0	0.0	0.0	0.0	0.1%
ABS	4.9	0.0	0.0	0.0	0.0	0.1%
PET	3.9	0.0	0.0	0.0	0.0	0.1%
EPP	3.9	0.0	0.0	0.0	0.0	0.1%
PP-EPDM	4.9	0.0	0.0	0.0	0.0	0.1%
Polyurethaan	2.9	0.0	0.0	0.0	0.0	0.1%
Rubber	32.3	0.1	0.0	0.0	0.1	0.2%
Textiel	11.8	0.0	0.0	0.0	0.0	0.2%
Glas	30.6	0.0	0.0	22.0	22.0	71.9%
Totaal	851.8	604.9	31.7	50.9	687.5	**80.7%**

Energetische valorisatie	ELV	Ferro	Zinkende fractie	Drijvende fractie	Totaal	%
Ferro	613.9	0.0	0.0	0.0	0.0	0.0%
Al	41.6	0.0	0.0	0.0	0.0	0.0%
Cu	8.9	0.0	0.0	0.0	0.0	0.0%
Zn	3.0	0.0	0.0	0.0	0.0	0.0%
Pb	5.9	0.0	0.0	0.0	0.0	0.0%
PP	52.4	0.0	0.0	1.0	1.0	2.0%
PE	24.3	0.0	0.0	0.5	0.5	2.0%
PMMA	6.8	0.0	0.0	0.1	0.1	2.0%
ABS	4.9	0.0	0.0	0.1	0.1	2.0%
PET	3.9	0.0	0.0	0.1	0.1	2.0%
EPP	3.9	0.0	0.0	0.1	0.1	2.0%
PP-EPDM	4.9	0.0	0.0	0.1	0.1	2.0%
Polyurethaan	2.9	0.0	0.0	0.0	0.0	0.0%
Rubber	32.3	0.0	0.0	2.4	2.4	7.4%
Textiel	11.8	0.0	0.0	0.0	0.0	0.2%
Glas	30.6	0.0	0.0	0.0	0.0	0.0%
Totaal	851.8	0.0	0.0	**4.4**	**4.4**	**0.5%**

Storten	ELV	Ferro	SLF	Zinkende fractie	Drijvende fractie	Totaal	%
Ferro	613.9	0.0	3.1	0.1	0.0	3.1	0.5%
Al	41.6	0.0	2.9	0.1	0.3	3.3	7.9%
Cu	8.9	0.0	0.6	0.1	0.0	0.8	8.9%
Zn	3.0	0.0	0.2	0.0	0.0	0.2	7.9%
Pb	5.9	0.0	0.4	0.1	0.0	0.5	7.9%
PP	52.4	0.0	41.9	0.1	9.3	51.3	97.9%
PE	24.3	0.0	19.4	0.0	4.3	23.8	97.9%
PMMA	6.8	0.0	5.4	0.0	1.2	6.7	97.9%
ABS	4.9	0.0	3.9	0.0	0.9	4.8	97.9%
PET	3.9	0.0	3.1	0.0	0.7	3.8	97.9%
EPP	3.9	0.0	3.1	0.0	0.7	3.8	97.9%
PP-EPDM	4.9	0.0	3.9	0.0	0.9	4.8	97.9%
Polyurethaan	2.9	0.0	2.9	0.0	0.0	2.9	99.9%
Rubber	32.3	0.0	8.0	0.2	21.6	29.8	92.4%
Textiel	11.8	0.0	11.5	0.0	0.2	11.7	99.6%
Glas	30.6	0.0	6.1	2.4	0.0	8.6	28.1%
Totaal	851.8	0.0	116.5	3.3	40.0	159.8	**18.8%**

Figure4 : Fictitious final calculation of the percentages

<u>Recycling</u> ELV Ferro Sinking fraction Floating fraction Total
Ferro
[…]
Polyurethane
Rubber
Textile
Glass
Total

<u>Energy recovery</u>
[idem]

<u>Disposal</u>
[idem]

2.2 Critical streams

The critical streams in this study are those streams that are economically less (or not) interesting to recycle. We deal with streams whose market value is too small compared to the investments needed for correct separation. In practice we have paid particular attention to the following streams:

- Plastics
- Glass
- Textiles

An extra focus point is the exemption of the disposal taxes which the shredders can take advantage of. After all it is cheaper for them to dispose waste. As long as it is cheaper to dispose of the stream than it is to recycle it, this will remain a critical stream. This then makes it easy to determine the critical streams. It is important to note that some companies are already trying to attain the European recycling percentages. This implies that they have to reduce the stream going to the tip drastically.

The light fraction (SLF) or ‘fluff’ is a stream that traditionally didn’t use to be treated further. This stream consists of everything that was extracted via suction during the shredding process – i.e. especially the lighter materials among which most plastics which are used in cars. In a lot of cases the SLF is immediately disposed of. Most of the time some minimal process is carried out in order to remove remaining metals.

There are some companies which further treat this fluff in order to reuse or to valorise part of this stream. These companies have realised that this treatment is the only way to further increase the recycling percentage.

Another fraction which will be a future focus point is the fraction in which the glass of a vehicle ends up. This is mostly a mineral fraction which can contain a myriad of other materials like certain heavy materials, dust or stones. Because of this composition this is a fraction which is very difficult to valorise.

The divisions in which one of the two outgoing streams directly goes to the rubbish tip are crucial in the calculations of the recycling percentages. After all this is an on/off situation. With divisions where both outgoing streams are processed further this separation is less crucial while there is further recovery on both streams.

3 Average composition of a vehicle

3.1 Literary data

End-of-life vehicles which are further treated at the shredder vary in composition both in type of car and in time.

In order to calculate the recycling percentages of end-of-life vehicles it is necessary to have a good idea of the average composition of a car which is introduced into the market. After all, the obtained recycling percentages vary depending on the material.

The composition of a car is a crucial factor in the calculation of the recycling percentages.

The following compositions were obtained from literary data.

3.1.1 Smidt and Leithner, 1995

In "Automobilrecycling"[4] Smidt en Leithner show the evolution of the composition of cars over a period from 1965-1995 (Table 1 and Figure 5). The average steel[5] content decreases, whereas the amounts of aluminium and polymers increase with time.

Table 1: Evolution of the composition of cars from 1965-1995 (Smidt and Leithner, 1995)

Year of production	1965	1985	1995
Component	(%)	(%)	(%)
Steel	76	68	63,5
Aluminium	2	4,5	7
Non-ferro metals	4	3	3
Polymeres	2	10	12,5
Other	16	14,5	14
Total metals	82	75,5	73,5

[4] Smidt J. en Leithner R., Automobilrecycling. Berlin : Springer-Verlag, 1995.

[5] This fraction contains all magnetic metals

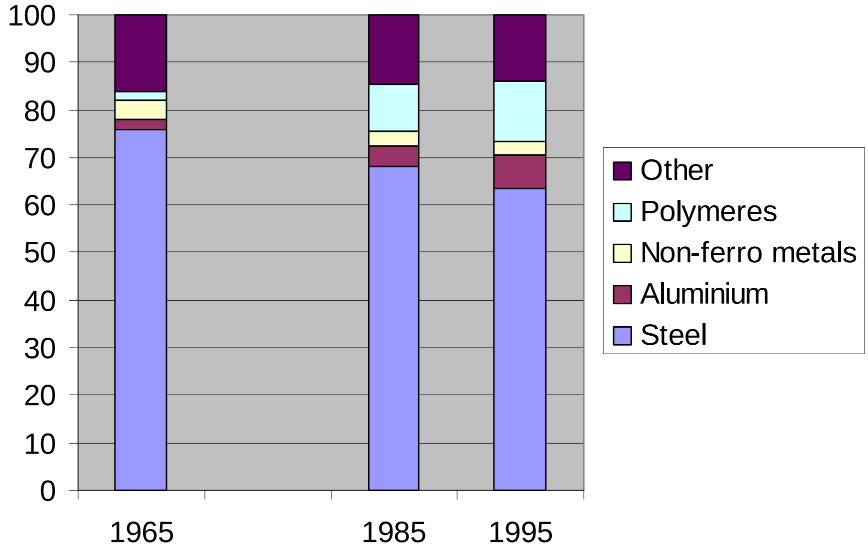

Figure 5: Evolution of the composition of cars from 1965-1995 (Smidt and Leithner, 1995)

It can be observed that the total sum of metals has decreased from 82% to 73.5% between 1965 and 1995[6]. This evolution is particularly remarkable in the first two decades (1965 – 1985), with -6.5% (and thus 3.25% per decade) and slowed down between 1985 and 1995 (a further decrease of 2%). This most recent percentage has been confirmed by car manufacturers.

3.1.2 Menges, 1988

In a study for the European Commission[7] a reference is made to Menges, 1988 for the composition of cars. The percentages are identical to the ones above (chapter 3.1.1).

3.1.3 ACORD (1999)

In 1999 the "Automotive Consortium on Recycling and Dismantling" (ACORD) published the composition of an average car in 1997 and 1998 (Table 2)[8]. Similar evolutions were observed as the ones described by Smidt and Leithner.

---

[6] Year of construction

[7] Tuddenham, M., Hempen, S. en Bongaerts, J.C (1996). End of Life Vehicles: Current basic data reflecting the overall ecological and economic context of the ELV issue. Report compiled for the Directorate General (DG XI) Environment, Nuclear Safety and Civil Protection of the Commission of the European Communities.

[8] ACORD (Automotive Consortium on Recycling and Disposal) quoted in Hooper (2001) Diversion from landfill: mechanical recycling of plastics from materials

Table 2: Average composition of an ELV in 1997 and 1998 (ACORD, 1999 in Hooper, 2001).

Scrap material	1997 (%)	1998 (%)	Difference %
Ferro	68,6	68,3	-0,3
Light non-ferro	6,1	6,3	0,2
Heavy non-ferro	1,8	1,5	-0,3
Plastics	8,5	9,1	0,6
Rubber + tyres	5,2	5,1	-0,1
Glass	2,9	2,9	0

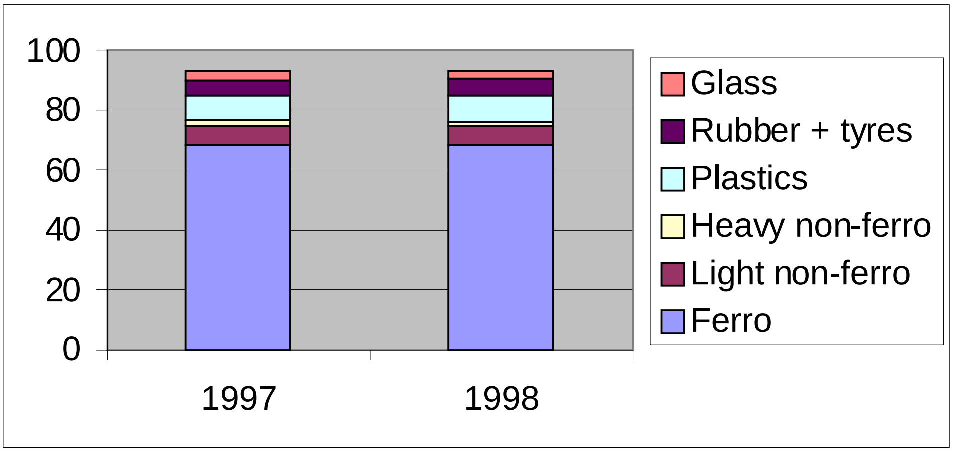

Figure 6: Average composition of an ELV in 1997 and 1998 (ACORD, 1999 in Hooper, 2001)

3.1.4 VITO (1999)

In documents of the BBT-knowledge centre of VITO the composition of an ELV from 1999 is given (Table 3). The composition of present-day ELVs will have changed slightly. A growing amount of plastics is noted.

---

recovery facilities and from shredder residue. Green Chemistry 3, 57-60. The original report was not passed on by ACORD, so no idea of the underlying data.

Table 3 : Composition of an ELV from 1999 (BBT-knowledge centre VITO)

Material	Composition (%)
Ferro	67
Non-ferro	9
Al	6
Cu	1,5
Zn	0,5
Pb	1
Glass	3
Plastics	10,4
PP	5,4
PE	2,5
PMMA	0,7
ABS	0,5
PET	0,4
EPP	0,4
PP-EPDM	0,5
Polyurethane	2
Rubber	5
Others	4

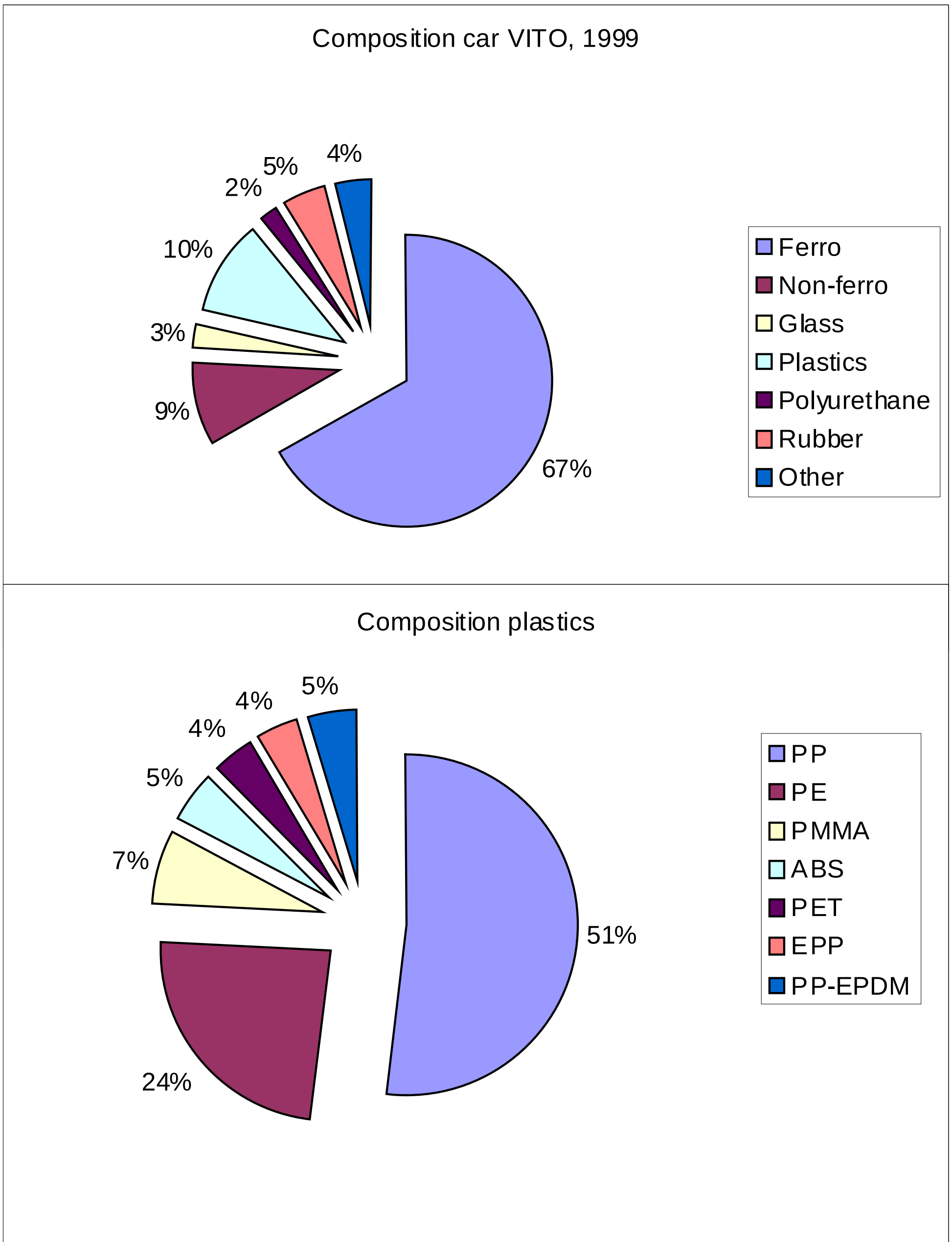

Figure 7 : Composition of an ELV from 1999 (BBT-knowledge centre VITO)

This composition corresponds quite well to the composition data we received from some car manufacturers (see chapter 3.1.6).

3.1.5 Febelauto (activities 2000)

In the document "activities 2000" Febelauto presents the composition of an ELV as shown in Figure 8.

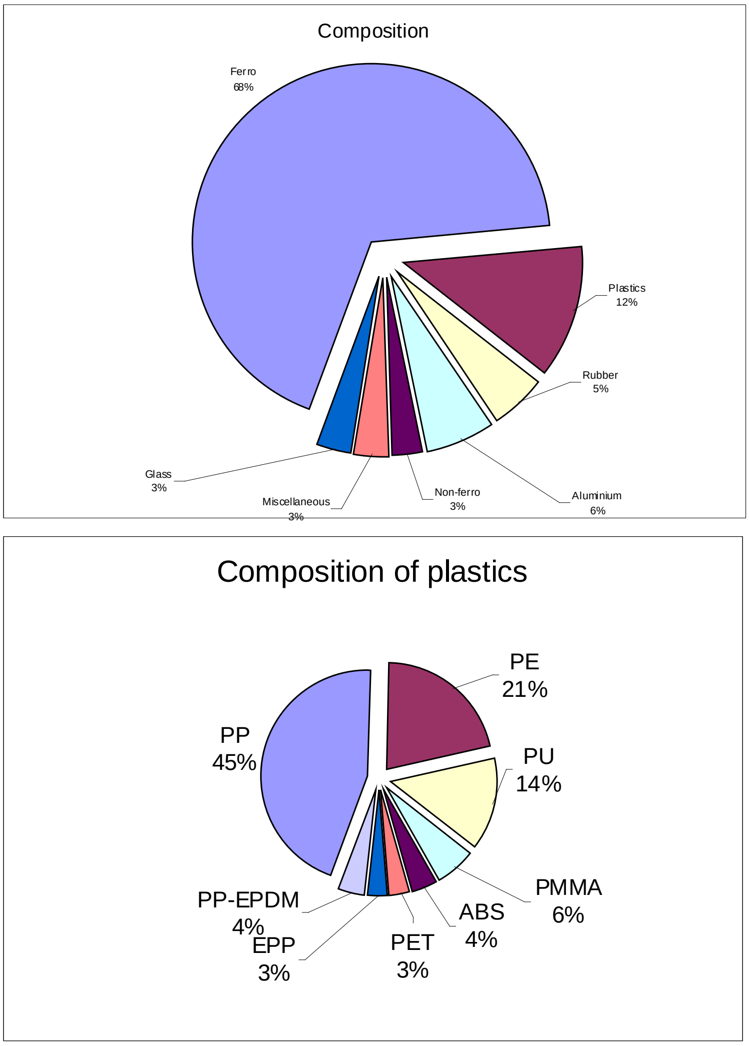

Figure 8 : Composition of an ELV (Febelauto 2000)

It is noted that the composition by Febelauto is very similar to the one drawn up by the BBT-knowledge centre of VITO. We also remark that the amount of plastics increases from 2% in 1965 (Smidt and Leichtner, 1995) to 12% in 2000 (Febelauto).

The division of the different plastics might be useful for the calculation of the recycling percentages while the recycling percentages which can be obtained from the different kinds of plastics might be very different.

3.1.6 Car manufacturers

A number of car manufacturers have provided us with the composition or the partial composition of some of their models over the years. We have been asked not to reveal these data. They have, however, been included in the calculations. The data are available in the confidential annex.

These data cover the period between 1989 and 2007. Despite differences between different makes these data are rather coherent and some evolutions are present everywhere. The general trend which can be extracted from these data is that the total percentage of metal in a vehicle has remained more or less the same (especially in the last couple of years). Ferro-metals tend to be more and more replaced by non-ferro metals (aluminium).

In terms of absolute weights the evolutions look somewhat different. The total amount of ferro-metal remains relatively constant, whereas the amounts of aluminium and plastics increase. The amounts of other non-ferro metals, rubber and glass increase slightly.

3.1.7 The evolution of the composition of vehicles

On the basis of the data mentioned above a specification of the evolution of the composition of cars between 1989 and 2005[9] can be made. In order to do this regressions have been applied in Excel® (Figure 9).

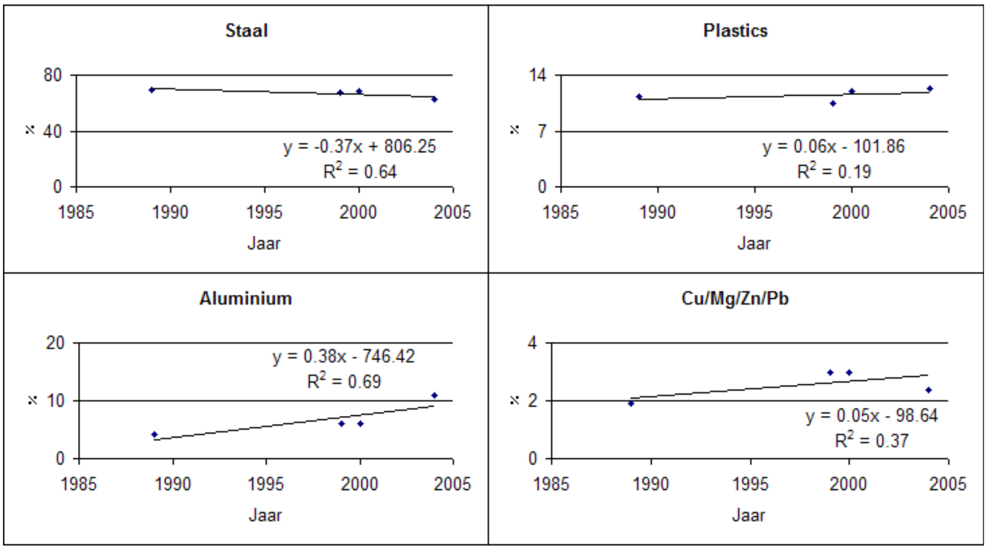

Figure 9 : Quantifying the evolutions in the composition of a vehicle

Steel	**Plastics**	**Aluminium**	**Cu/Mg/Zn/Pb**
Year	Year	Year	Year

The evolution is rather limited as far as plastics are concerned because over a period of 15 years the share of plastics has only increased by 1% (from 11% to 12%). The evolution is more significant for non-ferro metals: it has tripled for Al (from 3% to 9%) and from 2.1% to 3% for other non-ferro metals.

At Febelauto we find the division of the age of the collected end-of-life vehicles in function of the collection year (Figure 10).

[9] Of all the ELV in 2006 only a very small percentage (less than 0.1%) was of the construction year 2006 (see Figure 10).

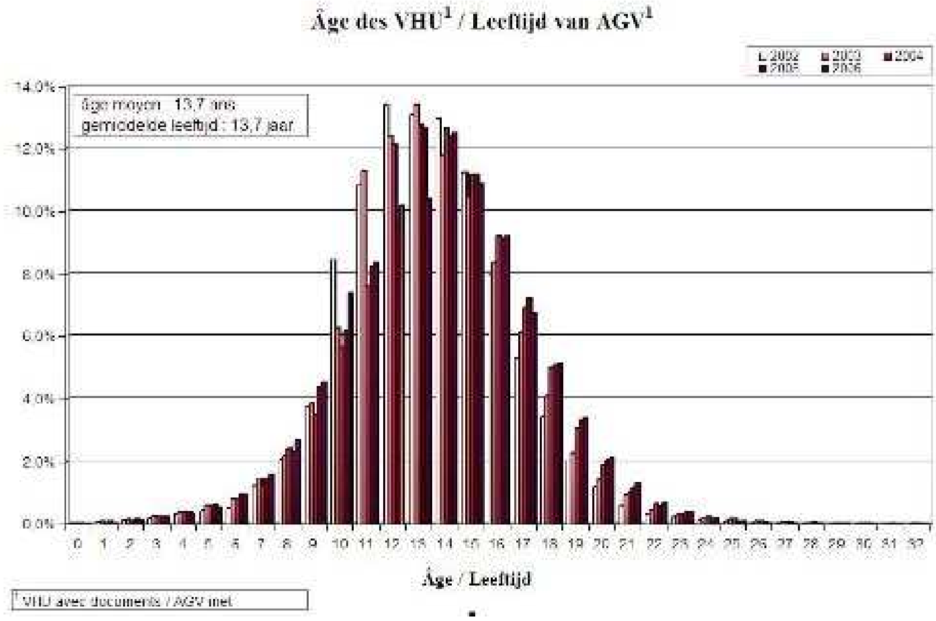

Figure 10 : Age of the ELVs collected by Febelauto

3.1.8 Mass of end-of-life vehicles

The mass of the ELVs which follow the official circuit is recorded by Febelauto (see Table 4). It can be assumed that the weight of these ELVs is representative for all ELVs which are shredded in Belgium (so also for those which are not processed in official depollution centres).

Table 4 : Number of processed ELVs in 2006 (Bron : Febelauto)

Region	Number of ELVs	Weight ELVs (kg)	Average weight ELV (kg)
Flanders	76, 827	66, 309, 704	863
Wallonia	45, 484	43, 017, 649	946
Brussels	9, 739	7.467.844	767
Total	131, 050	116, 795, 197	891

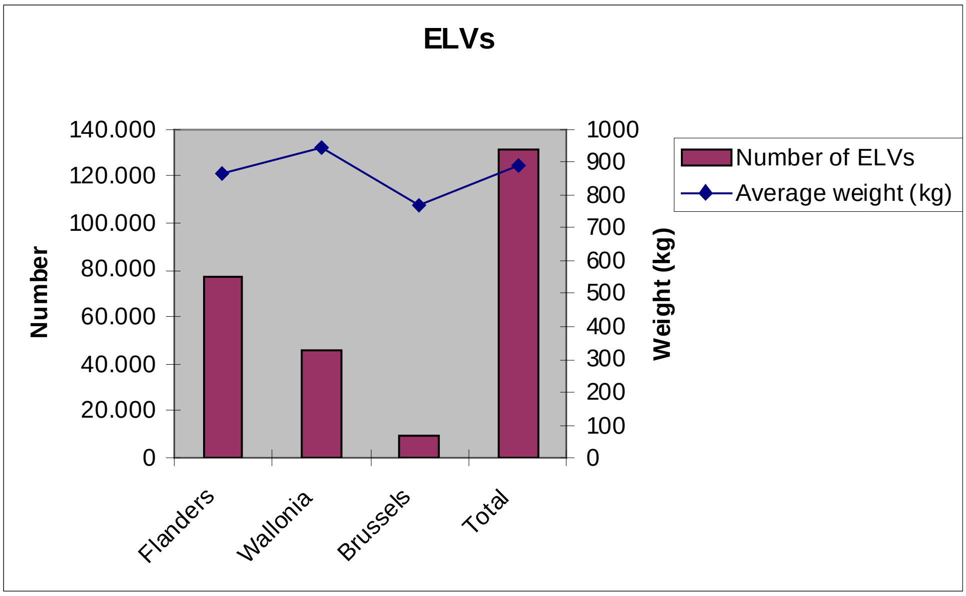

Figure 11 : Number and weight of processed ELVs in 2006 (Febelauto)

It is clear that there is a big difference between the average weights of ELVs in the three regions of Belgium. Since reports for Europe need to be about Belgium as a whole the Belgian average will be taken into account. It is also difficult to state what percentage of cars of one particular region is processed per shredder.

3.2 Removed parts at depollution centres

In order to know the weight and composition of cars which arrive at a shredder it is necessary to gain insight in the removed parts at depollution centres (see Figure 12).

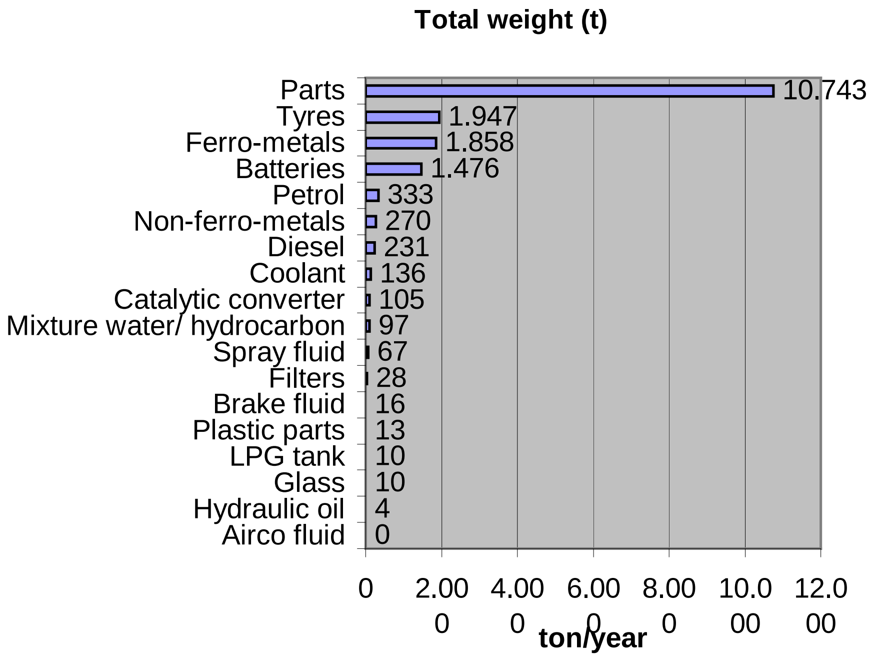

Figure 12 : Weight of the removed parts in certified depollution centres in Belgium in 2006 (SOURCE : Febelauto)

The following assumptions have been made regarding the composition of the different parts which are dismantled and depolluted (Table 5). The hypothesis for batteries is based on information from ILMC[10].

Table 5 : Hypotheses regarding the composition of depolluted or dismantled parts

Material	ferro	aluminium	rubber	plastics	Cu/Mg/Zn/Pb	other	total
Battery	0%	0%	0%	5%	17%	78%	100%
Catalytic converter	100%	0%	0%	0%	0%	0%	100%
Parts	77%	5%	2%	9%	2%	5%	100%
Filters	100%	0%	0%	0%	0%	0%	100%
Non-ferro metals	0%	0%	0%	0%	100%	0%	100%
LPG-tank	0%	0%	0%	100%	0%	0%	100%

An important assumption for the other removed parts is that their composition is the same as the vehicle without.

3.3 Average composition of an ELV

With the help of the data above the average composition of an end-of-life vehicle in 2006 can be determined (Table 6). If depollution is also taken into account the

[10] ILMC : International Lead Management Center, Inc. (www.ilmc.org), 2001, Toolbox 2.3.

average composition of a DELV in 2006 can be calculated (Table 6).

Table 6 : Average composition of an ELV in 2006

	Before depollution		Depollution		After depollution	
Material	Mass (kg)	%	Mass (kg)	%	Mass (kg)	%
Ferro	687,6	68,8%	89,9	60,7%	597,7	70,2%
Aluminium	46,2	4,6%	5,7	3,8%	40,5	4,8%
Rubber	50,0	5,0%	18,9	12,7%	31,1	3,7%
Plastics	111,4	11,1%	10,2	6,9%	101,2	11,9%
Cu/Zn/Pb/Mg	22,8	2,3%	5,6	3,8%	17,2	2,0%
Glass	30,0	3,0%	0,1	0,1%	29,9	3,5%
Others	51,9	5,2%	17,8	12,0%	34,1	4,0%
Total	999,9	100%	148,1	100%	851,8	100%

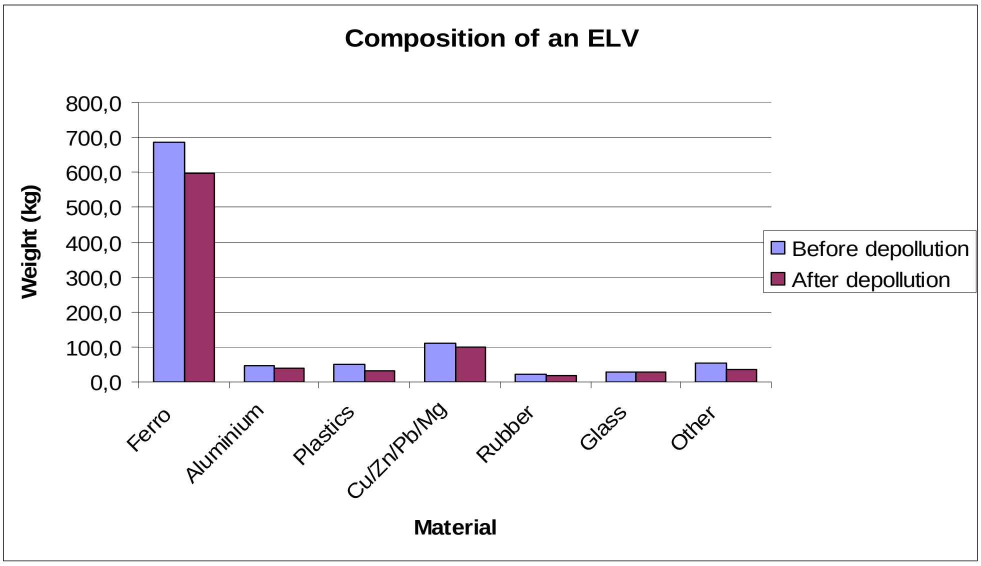

Figure 13: Average composition of an ELV in 2006

For the composition of the plastics fraction we refer to Figure 8, page 25. The fraction ‘Others' was proportionally allocated to the other fractions since it is difficult to qualify. The composition which was thus obtained is shown in Figure 14.

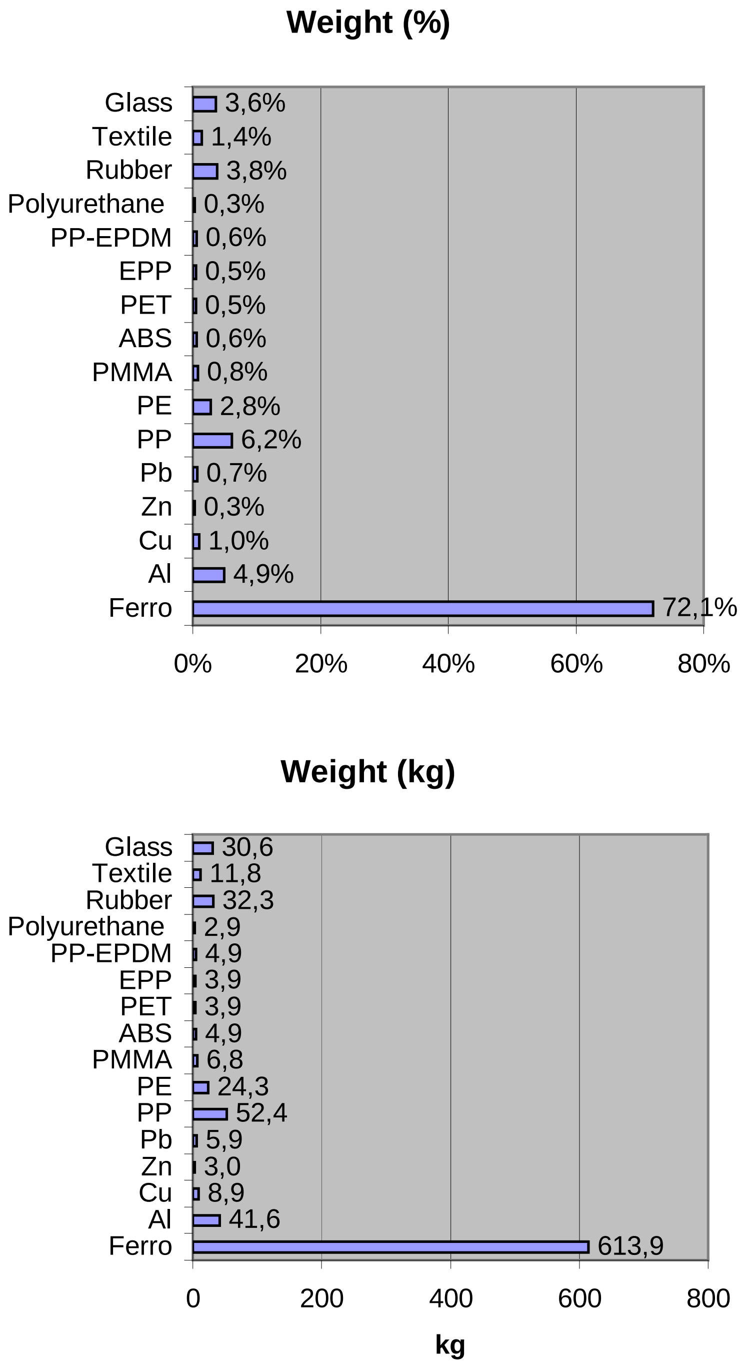

Figure 14: Average composition of a depolluted end-of-life vehicle in 2006 in Belgium

4 Yields of the different steps at shredder companies

4.1 Shredder house

This is the first step in the separation process. In this process the light, non-ferrous fraction is separated. This is done by means of a grate above or below the shredder house in which the fine material is sifted and from which the shredder dust is removed by suction. The remaining part of the product stream consists of a mixture of ferro and non-ferro metals and the heavier non-metallic fraction (rubber, stone, glass, …).

Tests carried out by Belgian and foreign shredders were used in order to determine the efficiency of this step. We have opted for conservative hypotheses (i.e. those which do not overestimate the recycling percentage) because most non-integrated shredders do not have information regarding the composition of the outgoing streams. These conservative hypotheses can be found in chapter 6.4 page 45.

These conservative hypotheses influence the result negatively, but only as far as the shredders who send their fluff to the rubbish tip (i.e. 13.7% of the car) are concerned. Thus this has only a limited influence on the global Belgian figures.

4.2 Magnetic conveyor belt

First the steel fraction[11] is separated after the initial shredding. An installation equipped with a magnet and a conveyor belt separates ferro-metals from stainless steel, non-ferro metals and non-metallic material. The magnet can be positioned above the conveyor belt or alternatively it can be integrated at the end of the conveyor belt. Thanks to the smaller distance between the parts which need to be separated this last line-up allows easy separation of weak magnetic materials.

The yield of this magnetic conveyor belt depends on the purity of the stream which needs to be processed and the distance between the conveyor belt and the magnet. In general the installations at the shredder are such that a maximum of ferro-metals can be obtained.

All shredders have one (or more) magnetic conveyor belt(s) in the sub-flow (see Figure 1 on page 14). None of the shredder companies in Belgium sell the sub-flow without first extracting the ferro-metals. Historically the shredder companies came into existence to recycle ferro-metals. Thus all shredders can attain 98.5% efficiency on the ferro-fraction. This hypothesis is not really important for the calculation of the total recycling percentages, while the ferro-part that is not separated will be separated in further steps. Only the loss of fluff (to the rubbish tip) is rather final.

[11] Light steel, heavy steel and cast iron

4.3 Eddy-Current

Non-ferro metals can be separated by means of an Eddy-Current installation. This is based on the principle that conducting materials in an alternating magnetic field themselves become oppositely magnetically charged. Eddy currents with a parallel magnetic field are formed. This causes repulsion and materials can be 'projected'. The incoming stream had better not contain any steel, as steel would stick to the magnet and would become white-hot due to the Eddy current. This would then in the end damage the conveyor belt.

This type of installation can be found both at non-integrated and integrated shredder companies. With this installation a fairly pure stream of non-ferro metals can be obtained. This appliance can be found in different places in the shredder process scheme.

4.4 Yield of the different steps in the flotation units

Flotation is a separation method which selects (mainly non-ferro) materials on the basis of their specific gravity depending on whether they float or sink. The materials which need to be separated are immersed into a fluid with a certain mass density (for example: 2 or 3 g/cm^3). The materials that float are separated and if required can be further separated either by means of an Eddy-Current installation or manually.

The following principle has been adhered to for the determination of the efficiencies which can be obtained:

- Materials with a density very different from the density used (more than more or less 20% difference): very high efficiency (> 95%)
- Materials with a density close to the density used (less than more or less 15% difference): poor to moderate efficiency (< 70%)

4.5 Yield of the different PST-techniques

Three Belgian shredders actually have a PST-technique on-site. These techniques allow for the processing of light fractions that come from the shredder house instead of sending it immediately to the rubbish tip. To date non of the shredders can recycle all materials. Each shredder still sends part of the incoming material (after processing) to the rubbish tip.

An interesting overview of the different techniques can be found in the following study: "*A study to Examine the Costs and Benefits of the ELV Directive – Final Report*" van GHK[12]. In the annex of this report a short explanation of the different PST-techniques is given. This study concludes that all shredders who dispose of a PST can easily attain the 85% recycling quota imposed by the European Directive.

---

[12] GHK : Gilmore Hankey Kirke Limited

For the description of the PST-techniques used in Belgium we refer to the confidential annexes of this report. The know-how which has been applied to these installations is so big that it is regarded as strictly confidential.

4.6 Other methods for recycling percentages

Recycling percentages also need to be calculated for AEEA (End-of-Life Electric and Electronic Appliances). The obtained recycling percentage of the shredder is also important for this calculation. The same philosophy which was used for this study is applied for the determination of the recycling percentage. Each step in the chain is carefully studied in order to see which recycling percentage can be obtained.

The practical realisation of these calculations might become a means to calculate the recycling percentages of end-of-life vehicles in the future (see chapters 7 and 0).

5 Company visits

All Belgian shredders have been visited in the framework of this study. All shredders have asked us not to disclose confidential information. Thus the information in this chapter is rather limited. For more exhaustive information we refer to the confidential annexes. These annexes can only be read by people who have signed a confidentiality agreement with the shredder in question.

The visits were carried out at shredders' who helped us with:

- The correct modelling of the functioning of individual shredders
- Monitoring the correct functioning of the machines.

We have not demanded proof. Some values were not audited. This means we have both:

- Probable results
- Proven results

5.1 General development of a company visit

The company visits served to get a good understanding of the company's installation and to collect the necessary information.

The first step in the company visit is a guided tour with an explanation of the installation. A general outline of each installation can be found in the chapters below. More specific information which was received has been used for the validation of the recycling percentages, but has not been included in this report for the sake of confidentiality.

After the guided tour of the installation more information regarding the outgoing streams was asked. Extra attention was given to the critical streams which have already been mentioned above.

During these visits on the different sites we have run our hypotheses by the experts from the sector.

It is important to note that the percentages below are only theoretical results and are thus not representative of what a shredder obtains on the total incoming stream. The percentages are only valid for that part which comes from the stream derived from end-of-life vehicles (see chapter 6.6 for more information).

5.2 Flanders

5.2.1 Belgian Scrap Terminal (BST), Kallo

BST is an integrated shredder company and consists of several shredders, from CMT and a VW-SiCon. CMT is the flotation for the processing of non-ferro metals (see chapter 5.2.3) and the VW-SiCon is a PST-technique. For more information regarding this technology we refer to the confidential annex.

For BST Kallo the recycling percentage which can be obtained is calculated on the basis of the on-site shredder.

The VW-SiCon unit only processes own material.

BST attains 84.4% recycling and 0.0% energetic valorisation on a DELV. This percentage takes into account the part of the fluff which is processed by the Sicon-installation.

For further information and precise figures we refer to the confidential annex of this report.

5.2.2 Belgian Scrap Terminal (BST), Willebroek

BST also has a shredder in Willebroek which processes cars. As this shredder is identical to the shredder in Kallo the same recycling percentage was adopted which is identical to the shredder in Kallo. If in the future the installations are no longer identical then the recycling percentages will have to be calculated for each installation separately.

See also chapter 5.2.1.

5.2.3 Craenhals Metal Terminal, Willebroek

CMT is the flotation installation of the BST group. This installation is further discussed in the confidential annex on BST.

See chapter 5.2.1.

5.2.4 Galloo, Menen

Galloo is an integrated shredder and consists further of GallooMetal and GallooPlastics. GallooMetal is the flotation for the processing of the non-ferro metals and GallooPlastics is the part of the PST responsible for the processing of the plastics.

Both GallooMetal and GallooPlastics also process the streams which come from the shredders.

Galloo attains 88.1% recycling and 2.8% energetic valorisation on a DELV.

For further information and precise figures we refer to the confidential annex of this report.

5.2.5 GallooMetal, Menen

GallooMetal is the flotation for the processing of the SHF of the Galloo group.

For more information see chapter 5.2.4 and the confidential annex.

5.2.6 RETRA (Recuperatie en Transport Maatschappij), Gent

Retra is a non-integrated shredder and consists of two different shredders. Only one of these two shredders was included in this study, as the other one does not process cars.

RETRA attains 82.0% recycling and 1.5% energetic valorisation on a DELV.

For further information and precise figures we refer to the confidential annex of this report.

5.2.7 Stassen Recycling, Genk

Stassen Recycling is a non-integrated shredder.

Stassen Recycling attains 81,8% recyclage and 1,4% energetic valorisation on a DELV.

For further information and precise figures we refer to the confidential annex of this report.

5.2.8 Stelimet, Genk

Stelimet in Genk is a non-integrated shredder.

Stelimet attains 82.6% recycling and 1.4% energetic valorisation on a DELV.

For further information and precise figures we refer to the confidential annex of this report.

5.2.9 Van Dalen Belgium, Geel

Van Dalen Belgium is part of the international Van Dalen group and is an integrated shredder. This company has both a shredder and a flotation unit.

Van Dalen attains 83.1% recycling and 1.6% energetic valorisation on a DELV.

For further information and precise figures we refer to the confidential annex of this report.

5.2.10 Vanhees Metalen, Lommel

Van Hees Metalen is a non-integrated shredder.

Vanhees Metalen attains 81.8% recycling and 1.4% energetic valorisation on a DELV.

For further information and precise figures we refer to the confidential annex of this report.

5.3 Brussels Gewest

5.3.1 Groupe Derichebourg

Groupe Derichebourg in Brussels is a non-integrated shredder and is part of the “Derichebourg Environnement" group.

Groupe Derichebourg attains 82.1% recycling and 1.4% energetic valorisation on a DELV.

For further information and precise figures we refer to the confidential annex of this report.

5.3.2 A. Stevens & C°S.A.

The company Stevens was not visited in the framework of this study. The company informed us that all cars which are cut up by Stevens are then sent to Stelimet in Flanders. This has not been checked by us. Stelimet, however, was visited in the framework of this study. The company is described in chapter 5.2.8

5.4 Wallonia

5.4.1 Cometsambre S.A.

CometSambre is an integrated shredder company and apart from the shredder itself it also consists of CometTraitement, the PST unit.

CometTraitement also processes streams which come from other shredders.

CometSambre attains 89.8% recycling and 2.7% energetic valorisation on a DELV.

For further information and precise figures we refer to the confidential annex of this report.

5.4.2 Recyval S.A.

Recyval was founded 1997 by Galloo and CometSambre as a first step to maximize the valorisation of the outputs of a shredder by processing the SHF from a shredder.

Recyval has not got a shredder, but processes the streams from other shredders. Data regarding the results of the processing by Recyval are needed for the calculation of the recycling percentages of the shredders who send their outgoing streams to Recyval for processing.

The attained recycling percentage depends largely on the streams the company receives. After all efficiencies vary for the different materials.

For further information and precise figures we refer to the confidential annex of this report.

5.4.3 George & Cie. S.A.

George & Cie in Charleroi is a non-integrated shredder and is part of the "Derichebourg Environnement" group.

George & Cie attains 82.1% recycling and 1.4% energetic valorisation on a DELV.

For further information and precise figures we refer to the confidential annex of this report.

5.4.4 Keyser S.A.

Keyser is a non-integrated shredder.

Keyser attains 81.7% recycling and 1.4% energetic valorisation on a DELV.

For further information and precise figures we refer to the confidential annex of this report.

5.4.5 Recylux Belgique S.A.

Recylux is a non-integrated shredder.

Recylux attains 78.1% recycling and 0.0% energetic valorisation on a DELV.

For further information and precise figures we refer to the confidential annex of this report.

6 Calculation recycling percentages

6.1 Methodology

As mentioned above the starting point for the calculation of the recycling percentages shredders can obtain on end-of-life vehicles is the material approximation. The recycling percentage of an end-of-life vehicle is calculated as the weighted average of the recycling percentages on each of the individual materials.

The recycling percentages on the individual materials is calculated by taking into account:

- The techniques used[13]
- The outgoing streams[14]

On the basis of the techniques used it was taken into consideration how the material got divided over the various outgoing streams. This division, which is based on the (theoretical) efficiencies of the different steps, is checked on the basis of the data (composition) which we have received regarding the outgoing streams. Sensitivity analyses have shown that the uncertainty regarding the theoretical efficiencies has virtually no effect on the accuracy and reliability of the global result – especially because of the long succession of different steps. **The uncertainty** which has the biggest influence on the final results is the **composition** of the incoming cars. This, however, is the same for all shredders. The efficiency obtained by the suction installation on the shredder is quite important. We worked with conservative hypotheses for this. It was presumed that a high percentage of the plastics ends up in the fluff. This hypothesis has a negative impact only on the results of companies which send their fluff-fraction (or part of it) to the rubbish tip.

6.2 Hypotheses

It is essential to propose a few hypotheses in order to calculate the recycling percentages for end-of-life vehicles. These hypotheses are explained and documented below.

6.2.1 Depollution centres

When calculating the recycling percentages on end-of-life vehicles at the shredder it is assumed that all cars end up at the shredder via certified (also integrated) depollution centres[15]. The weight of the parts which had to be depolluted did thus not have to be taken into account (see chapter 3.2 page 3).

---

[13] This information is only available in the confidential annex on the shredders.

[14] This information is only available in the confidential annex on the shredders.

[15] During this study we learned, however, that a part of the vehicles is processed by uncertified depollution centres.

6.2.2 Non-ferro in electric ovens

It is supposed that all non-ferro, which goes to the electric ovens together with the ferro, is recycled. The economic value of the non-ferro metals has become so high for the moment that it has become interesting to remove it selectively and to recycle it.

6.2.3 Non-ferro metals

The non-ferro metals are separated in virtually all streams in order to be recycled. After all, the economic value of these non-ferro metals is so high that separation for recycling purposes is economically very interesting. So also for the installations from which we had less information we have taken a relatively high recycling percentage for non-ferro metals into account. We have made sure that the companies which sent on less information (and evidence) have not been favoured because of this.

6.2.4 Exported streams

The European Directive states: "In the case of exports to third countries the Member States shall determine whether additional documentation is necessary to provide evidence that the exported materials are actually recycled or recovered." For our calculation we have assumed that evidence is needed. The evidence that the exported streams have actually been recycled is:

- Either a certificate,
- Or a selling price which is too high to make a fuel out of it.

If no evidence is provided we have followed the hypothesis that only the most valuable materials have been recycled, namely the metals. For the other materials from the end-of-life vehicle we have then worked from the conservative hypotheses. This means that it was supposed for these materials that they are not recycled. This method might have as a result that the obtained percentage is underestimated in the results obtained. Since the companies which process external streams in Belgium were part of this study, it is possible to perform correct calculations for the shredders which send streams to these companies. These shredders do not have to provide evidence of what happens at the shredder. Shredders which do send streams to processors abroad would have to provide this kind of evidence, which in practice seems to be quite difficult. Some foreign processors probably perform just as well as Belgian processors, but if evidence of this cannot be provided this cannot be taken into account. This means that companies abroad are put at a disadvantage. This problem might be solved if the ELV Monitoring System of the regulator were applied on a European level, because then all installations abroad would be able to present a verified recycling percentage.

If the company in question does provide evidence, then again conservative hypotheses are drawn up on the basis of this received information.

6.3 Exhaustiveness of data

We started from the point of view that companies which provided less information should not be favoured. If a company cannot or will not provide data we have filled in the missing data with the aid of conservative hypotheses.

Some companies refused to show us part of their process, as it is too confidential. This is clearly explained in the confidential annex on these companies. For these steps we have built in extra certainty by using efficiencies which were rather low. This offers the certainty that no overestimations were made. We have asked for evidence for the streams about which we had doubts regarding the recycling feasibility. This applies especially to installations we did not actually see in operation.

6.4 Investments

It was decided to make the calculations in such a way that any extra investment in recycling techniques by the shredder is also clearly visible in the calculated recycling percentage. For every additional technique new hypotheses are made and applied to the company in question.

An important application of this hypothesis implies that companies which send only a part of their fluff to a PST, only get recycling percentages for that particular part. One of the reasons for this is that a shredder does not work in batches and that vehicles only form a relatively small percentage[16] of the total input. That is why it is not possible to process the part of the output which comes from processed vehicles separately.

Another reason is that it would otherwise be possible for the shredder to apply the PST only on materials which are easy to separate. This in turn might then mean that fluff which comes from end-of-life vehicles would not be processed all together.

This hypothesis implies that a bigger capacity is needed in order to process fluff.

6.5 Shredder output

The procedure of the shredder is to a large extent similar in all companies. The shredder has been designed to extract steel from the incoming stream. In this process two by-products are produced:

- the light fraction
- the heavy fraction

On the basis of various tests (both in Belgium and abroad) we can conclude that the different incoming materials behave uniformly in most shredders. Only shredders which work with a light suction system might deviate slightly. However, most of the time a strong suction system is a priority in order to obtain a pure ferro-

[16] The percentage of ELVs in the input of a shredder ranges between 0% and 20%.

fraction. The materials are divided over the different outgoing streams as shown below.

Table 7 : Division of car materials over the different fractions

		SLF	SHF	Ferro	
Ferrous	Ferro	0,5%	1,0%	98,5%	100,0%
Non-ferrous	Al	7,0%	92,9%	0,1%	100,0%
	Cu	7,0%	92,9%	0,1%	100,0%
	Zn	7,0%	92,9%	0,1%	100,0%
	Pb	7,0%	92,9%	0,1%	100,0%
Plastics	PP	80,0%	19,9%	0,1%	100,0%
	PE	80,0%	19,9%	0,1%	100,0%
	PMMA	80,0%	19,9%	0,1%	100,0%
	ABS	80,0%	19,9%	0,1%	100,0%
	PET	80,0%	19,9%	0,1%	100,0%
	EPP	80,0%	19,9%	0,1%	100,0%
	PP-EPDM	80,0%	19,9%	0,1%	100,0%
Foam	Polyurethane	99,8%	0,1%	0,1%	100,0%
Rubber	Rubber	24,8%	75,0%	0,2%	100,0%
Textiles	Textiles	97,8%	2,0%	0,2%	100,0%
Glass	Glass	20,0%	80,0%	0,0%	100,0%

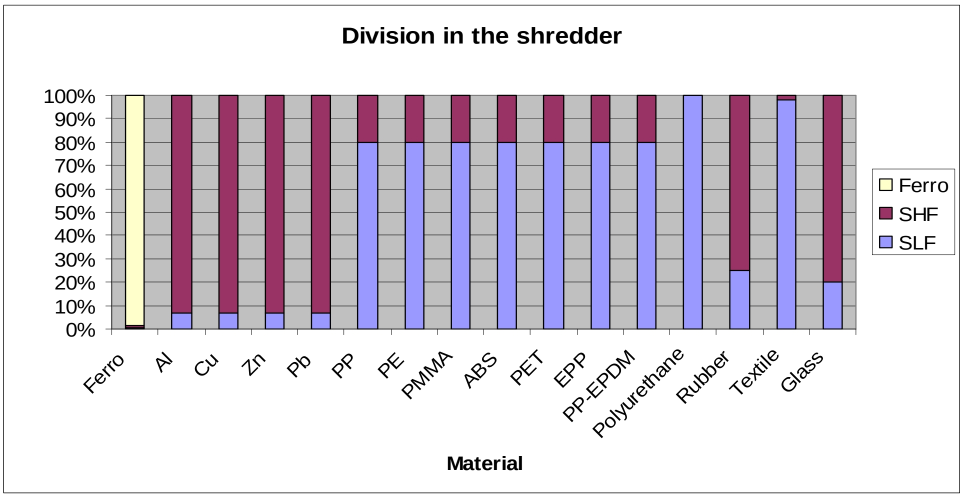

Figure 15 : Division of car materials over the different fractions

All shredders send the ferro to an EAF (Electric Arc Furnace). So this stream is recycled completely. Even if the ferro-fraction is exported (which is the case for a number of shredders), these fractions are considered as recycled. It is clear for all that the sorted ferro is recycled as this is economically interesting.

The SLF fraction can have various destinations:

- Processing within the company
- Processing at another company
- Waste disposal

The SHF-fraction is further processed by all shredders. The non-ferro fraction is separated on-site or this is done at another installation. The remaining fraction is mostly further processed for energetic valorisation or recycling.

6.6 Recycling companies

For the streams which are recycled by other companies we have contacted a number of companies which accept these streams. In particular we have been in touch with companies for:

- The recycling of plastics
- The recycling of steel
- The recycling of non-ferro

For the recycling of plastics we have firstly visited Galloo Plastics as described above. We have been able to check the quality of the incoming and outgoing materials. This has greatly helped us with the calculation of the percentages which can be attained by the different shredders.

Contacts were made with Umicore in order to get more information regarding the recycling of non-ferro streams. Umicore has provided information regarding the quality which is required of non-ferro streams in order to be processed further.

In order to check the processing of steel a visit was rendered to Carsid. This revealed that the further processing of ferro scrap is no problem in Belgium. Normally the ferro scrap originating from shredders needs to comply with the European E-40 standard. According to this standard 95% of scrap should be smaller than 200 mm and the maximum allowed impurity is 0.4%, of which less than 0.25% copper and less than 0.02% tin. As long as steel is used which is conform to the E-40 standard, there is no problem whatsoever to work properly. We were also informed that certain foreign companies accept steel that is not conform to the standard. There might be somewhat more problems with impurities in this steel. In practice the Belgian electric arc furnaces get the purer streams whereas the streams which have been separated a bit less purely are exported. The response of steel (and especially of the impurities) to the metallurgical processes was also discussed.

6.7 Theoretical streams

No tests were carried out for this study in order to determine the composition of the streams at the shredder. Therefore the composition of all streams at the shredder has been modelled. Firstly the composition of an average end-of-life vehicle which is processed at a shredder was determined (see chapter 3 on page 21). This composition was identical for all shredders.

Secondly for all shredders identical hypotheses were applied for the separation efficiencies of similar processes. The hypothesis for the separation of the materials is shown in Table 7.

The composition of the different streams has thus been calculated. This does not mean that the calculated composition is valid for the corresponding stream of the shredder. The calculated compositions in this study represent namely only that part in the different streams that originates from the processed end-of-life vehicles. Since shredders also process a rather big share of other materials, which do not originate from end-of- life vehicles together with the end-of-life vehicles, it is possible that the composition of the streams are in reality quite different from what our calculations show. This is why the theoretical streams are discussed in the confidential annexes.

It is important to emphasize in this context that the percentages for recycling and energetic valorisation, which are obtained by external companies on the theoretical streams, really do not reveal much about what is obtained in reality on an externally processed stream. These percentages are only valid for the theoretical streams which appear in the model used.

7 Follow-up in the coming years

In the future it will be necessary to communicate the recycling percentages attained on end-of-life vehicles to Europe on a yearly basis. It will therefore be necessary to collect a number of data in the future on a yearly basis in order to be able to calculate them. In this chapter it is shown which data should be collected and how this should be done. In a subsequent chapter more information will be given regarding the dynamic systems for the calculation of the recycling percentages. After all the question will arise from the shredders and the flotation companies to be allowed to update their percentages in the short time, which will probably become a commercial argument.

7.1 Data which need to be collected

Data which will need to be collected in order to be able to calculate the new recycling and energetic valorisation percentages on a yearly basis are:

For all outgoing streams:

- Quantity (yearly)
- Destination (with the sent quantity)

For the techniques:

- New installations need to be specified

The model is based on these data. Thus no other extra information is needed in order to calculate the percentages.

7.1.1 Information regarding the outgoing streams

Yearly reporting under aggregate form suffices for the data regarding the outgoing streams. This means that the data per stream and per destination can be passed on in tons/year. It is not necessary to specify the destination for the ferro stream since this will always be recycled. The shredders have this information regarding the outgoing streams. This information can be passed on relatively quickly. While collecting the data it is very important that the shredders only pass on information regarding materials that have effectively been processed by the shredder. – since a number of shredders also actively buy and sell metals without processing them.

7.1.2 Information regarding new techniques

If new techniques are applied for which no efficiencies are available in the model, the shredders will have to supply information on this. The information that will need to be collected at that point in time will be specific to that particular type of installation. As a general rule the shredder will have to demonstrate which separation takes places for each of the materials in the appliance.

7.1.3 Shredding per batch

If in the future some shredders decide to shred end-of-life vehicles in batch, it will be necessary to establish optimal tractability. After all a direct link needs to be apparent between the incoming stream (depolluted end-of-life vehicles) and the different outgoing streams. A special reporting system will be devised for this purpose. This separate shredding of end-of-life vehicles did not exist yet in 2006. Almost all shredders do not regard separate shredding as a possible option.

7.2 Ways of collecting data

In the first part of this chapter the preconditions regarding the way in which data might be collected are dealt with. In the second part the focus will be on IMJV, which might be a possible tool for collecting data in Flanders.

7.2.1 General context

A number of things need to be taken into account in the way in which data need to be collected:

- It will be necessary to collect the data uniformly for the three Regions. If this is not the case the risk is real that this might lead to market distortion. In addition it is particularly important that the same information be passed on by the same players . A similar document which the shredders have to submit to their respective regional authorities might be advisable.
- The information needs to be passed on in a uniform way. In the annexes a unique name or number is mentioned on each flow sheet for each outgoing stream. The information which needs to passed on has to refer to this flow sheet. This will avoid flaws in the communication when the information is passed on.
- The information needs to be passed on on a yearly basis in order to be able to comply with the European reporting requirements. The yearly reporting makes it possible for Flanders to collect information via the IMJV[17].

7.2.2 IMJV

The use of the IMJV would definitively be a good choice if one only needed to collect data for Flanders. While the IMJV needs to be filled out on a yearly basis by the companies in question, it would hardly mean extra work for the companies and for OVAM to add an extra category in which the information on the streams might be included. This has the added advantage that the data are passed on in a format the companies are already used to and thus master well.

Nevertheless the IMJV will not fulfil the condition that the data need to be collected in the same way in all three regions. The other two regions do not have a similar kind of document at their disposal. During our contacts with the shredders the need for a uniform system in Belgium was voiced. It would, however, be possible to ask the other regions to produce a similar document (only for shredders and only for the information mentioned above) that will have to be filled out by the shredders.

---

[17] Integraal Milieu JaarVerslag – Integral Environmental Annual Report

The passing on of the data via the IMJV does not offer the possibility to update the data during the year. This is, however, only necessary to make the system more dynamic and not required for the reporting to OVAM. Making the system more dynamic will be the topic of the following chapter[18].

As conclusion it might be said that extending the IMJV with the data described in chapter 7.1 might be interesting for OVAM so that they gain insight in what happens and changes on a yearly basis. However, a different system will be needed in order to allow more dynamic monitoring of the vehicle processing by shredders.

7.3 Calculations in the coming years

The different Member States will also have to report the attained results to Europe in the coming years. This methodology might also be adopted by the other Member States. The more countries would get information regarding the yields of the installations, the more precise the data will become.

It is possible to make new calculations on a yearly basis for this reporting to Europe on the basis of the confidential information in the annexes and on the basis of the Excel-sheet which was passed on by the three Regions.

[18] Making the system more dynamic means that data are not only used for reporting purposes once the year is over, but that shredders can have their percentage adapted as they have invested in new techniques without having to wait for the end of the year before they can reap the yields.

8 Dynamic systems

This chapter briefly deals with making the calculation system more dynamic.

8.1 Motivation

It will be important for certified centres to know which recycling and energetic valorisation percentage can be obtained on an end-of-life vehicle by each shredder. It will be equally important for certified centres that this is integrated into a dynamic system because then they can know beforehand which percentage can be attained. This gives the certified centres the possibility to make choices proactively regarding the division of the end-of-life vehicles over the different processing centres. If shredders only get an update of their recycling percentage at the end of the year it is quite difficult for the certified centres to make an estimate during the year. Another motivating factor for a more dynamic monitoring system is that investments will result more quickly in a higher recycling or energetic valorisation percentage. This might result in commercial advantages which would make investments in further recycling more attractive. So a system that is frequently adapted to reality can on the one hand lead to better management by the certified centres towards the percentages which need to be attained. On the other hand it might contribute to a more favourable investment climate for post-shredder technologies.

8.2 Practical realisation

The most obvious choice would be to build on the system that Febelauto already uses now for the certified centres. The tool would have to be managed by someone. It would be important in this framework that:

- The tool is dynamic,
- The manager respects confidentiality,
- The manager is a neutral party;

The daily management of such a system might be carried out by a regulator, as all parties concerned would be represented in this organisation. Constructing such a system is outside the scope of this study. Since the system would have to be dynamic it would be interesting to design a system like the WF_RepTool (WEEE Forum Reporting Tool, for more information: see www.weee-forum.org). This is a software tool that is used to determine the results of the processing of AEEA and the way in which recycling percentages are calculated for AEEA. The tool is used by 42 AEEA- return systems in Europe. It is a transparent and traceable way of collecting and processing data. This WF Reporting Tool does, however, allow relative freedom to the people filling in the data. That is why it seems advisable to impose a certain level of control regarding the correctness of the entered data.

9 Conclusions

9.1 Conclusions

The percentages mentioned are only valid for the shredder part of the processing of end-of-life vehicles. The global percentage for the complete stream processed by the shredders is as yet unknown and cannot be derived from the figures published in this report. Depollution and dismantling also need to be taken into account for the total percentages. We can draw the following conclusions on the basis of the experience we have got and on the basis of the calculations made.

The percentages that are shown below are only valid for the shredding of end-of-life vehicles. This does not apply to the shredding of other streams (with a different composition).

Conclusion 1: Between 78% and 93% recycling and valorisation at the shredders

Belgian shredders attain a recycling and valorisation degree between 78.1% and 92.6% on a DELV. Shredders who do not send their fluff to a PST attain between 78.1% and 84.7% and shredders who have their fluff processed completely or partially by a PST between 84.0% and 92.6%. There is a transition zone in which the difference between using a PST or not becomes very slim, but apart from that it is very clear that a PST provides significantly higher recycling percentages. It will be necessary for most processors to have at least part of their fluff processed in a PST.

From an environmental point of view complete processing is preferable, but from an economic and legal point of view partial processing by a PST is probably sufficient and more acceptable. Furthermore it seems that the market is already partially evolving in that direction.

Conclusion 2: Uniformity of the attained percentages

Shredders who send their fluff to the rubbish tip attain quite similar percentages (83.1%-83.5%, the peak of 78.1% is due to processing abroad and limited data provided by the shredder). This is logical while all these shredders send their SHF to a flotation unit. The yields of these flotation units are situated within the same range. Separation yields for metals are also comparable, which is why shredders who do not send their fluff to a PST attain comparable results.

Conclusion 3: The calculation method for companies that send part of their streams abroad is thus designed that their recycling percentage is definitely not overestimated

Due to the fact that conservative hypotheses have been used in cases when no data were available and that no visits were rendered to the companies abroad, the companies who send their streams abroad are potentially at a disadvantage. In practice it is quite difficult for them to proof the further processing what they send on. Only the sending on of pure streams involved no problems.

Conclusion 4 : A European calculation system would be advisable

Because the percentages that need to be attained for the recycling and energetic valorisation of end-of-life vehicles were imposed by Europe, the need for a standard European calculation system is apparent. If this is not in use in the medium long term, this might lead to a risk of market distortion between the different countries.

9.2 Recommendations

Recommendation 1: PST-techniques are necessary for vehicles that are not dismantled

Only a part of the vehicles in Belgium are drastically dismantled. Only few dismantled vehicles need to be sent to a shredder with a PST-technique in order to comply with the European Directives regarding recycling percentages. For cars which are almost completely dismantled it is less important that the fluff of the shredder is processed. For these vehicles only the steel carcass is sent to the shredder. Only very little is produced by this. This recommendation works from the hypothesis that all dismantled parts are either recycled or sold.

Recommendation 2: The use of PST-techniques for the processing of light fluff needs to be encouraged

For the moment Belgium has a number of PST-techniques which function quite well. These installations offer the possibility to keep valuable materials off the rubbish tip. Since recycling is very high above disposal on the “Ladder van Lansink” the use of these techniques should be encouraged.

The European goals for recycling percentages of end-of-life vehicles will become stricter in 2015. By then 95% will have to be recycled or valorised. In order to attain this it will be necessary to work with PST-techniques.

Annex: List of contacts at the shredders

Company	Contact
BST	Katleen Verbeeck
CometSambre	Frédéricq Peigneux
Derichebourg Brussel	Bernard Goffinet
Derichebourg Charleroi	Bernard Goffinet
Galloo	Rik Debaere
Keyser	M. Keyser
Recylux	Corrine Buffoni
Recyval	Benny Allaerts
Retra	Steven Millecamp
Stassen Recycling	Vincent en Alexander Stassen
Stelimet	Alphonse Stevens
Van Dalen Recycling	Ben Vervoorn
Van Hees Metalen	Lou Van Hees