

## **ANNEX 3: POST-SHREDDER TECHNOLOGIES – REVIEW OF THE TECHNOLOGIES AND COSTS**

## CONTENTS

<b>1</b>	<b>INTRODUCTION.....</b>	<b>1</b>
1.1	Shredder Residue Composition .....	1
1.2	Future composition of ASR .....	1
1.3	Effectiveness of the Technologies .....	2
1.4	Technology Costs and Economies of Scale .....	4
<b>2</b>	<b>THE VW-SICON PROCESS .....</b>	<b>6</b>
<b>3</b>	<b>THE GALLOO PROCESS .....</b>	<b>9</b>
<b>4</b>	<b>THE SULT PROCESS .....</b>	<b>11</b>
<b>5</b>	<b>THE R-PLUS PROCESS .....</b>	<b>13</b>
<b>6</b>	<b>THE CITRON PROCESS.....</b>	<b>15</b>
<b>7</b>	<b>THE TWINREC PROCESS .....</b>	<b>19</b>
<b>8</b>	<b>THE SVZ SCHWARZE PUMPE PROCESS.....</b>	<b>21</b>
<b>9</b>	<b>THE RESHMENT PROCESS .....</b>	<b>23</b>
<b>10</b>	<b>CONSULTEES AND REFRENCES .....</b>	<b>25</b>
10.1	Consultees .....	25
10.2	References.....	25

# 1 INTRODUCTION

This Annex provides an overview of 8 post-shredder technologies (PST) used or potentially used for the treatment of auto shredder residues (ASR). A short description of the process is provided with an approximate mass-balance analysis provided for each of the technologies to indicate the conversions of a given unit of input into different end products and wastes. Indicative costs of the technologies are given, where available.

In summary there are two main categories of technology, those based on mechanical sorting of the waste into different fractions that can be recycled and sold; and those based on thermal treatment of the waste stream to generate feedstocks for energy generation. The various technologies described are summarised in Table 1. Note that with the exception of Reshment all the other PSTs are in development, with some technologies already operating at industrial scale (Galoo, Sult, R-Plus, Twin-Rec).

Some of the processes described (VW-Sicon, TwinRec, Reshment) are technologies which are licensed to operators. Other technologies (Citron, Galoo, Sult and R-Plus) are developed and operated by the company which owns it. This may have an impact on the investment requirements and opportunities for each technology.

Definitions of recycling and recovery match existing definitions

## 1.1 Shredder Residue Composition

All the technologies described below process shredder residue (SR), ie the waste left after initial processing, undertaken mainly to remove metals. Shredder residue is generated by the treatment of white goods and of ELVs. It is technically and economically more efficient for operators applying post shredder technologies to use a mix of waste materials as input to their treatment process.

Shredder residue from ELVs (ASR) comprises approximately 50% of total SR by weight. The composition of non-ASR and ASR does not differ substantially except that white goods may contain more copper than ELVs; and white goods contain PCBs which ELVs do not. SR from white goods would be unlikely to contain such fractions as shredder fibre. The analysis below has focused on the ASR fraction of SR. The reported mass balance figures indicate the approximate post-shredder products and fractions which would be obtained from ASR only.

The PSTs are not dependent on ASR to function effectively. However, thermal treatment operations such as CITRON have indicated that they would need to replace the ASR waste fraction with a waste of similar organic content.

## 1.2 Future composition of ASR

The mass-balance diagrams illustrate the different PST processes based on the current composition of ASR from ELVs. The main change in compositions for the treatment of future arisings is a greater share of plastics by weight, rising from approximately 95kg (10%) per ELV to 120kg (12%).

### 1.3 Effectiveness of the Technologies

The available information from operators and technology owners allows some appreciation of the environmental effectiveness of the PSTs. The information suggests that PSTs range in their reported effectiveness in terms of the overall rates of recycling and recovery of material treated from around 50% (Galoo and Citron – although the Citron process is intended to recover the 50% waste material when operating at industrial scale) to 100% (Sult and R-Plus).

In terms of recycling, the reported effectiveness of mechanical separation technologies ranges from 74% (Sicon) to 100% (R-Plus). The thermal treatment processes are also intended to recycle some material, principally the remaining metallic residues. These PSTs achieve recycling rates of between 8% (Schwarze-Pumpe) and 39% (Galoo). The planned Citron plant is intended to achieve a recycling rate of 50%.

The PSTs are designed to operate after commercial dismantling and shredding and after depollution. Thus the PSTs are designed to deal with the remaining 20% by weight of the average ELV. The implications for the overall rates of recycling and recovery of the PSTs are summarised in Table 2, based on the treatment of the residual 20%. This shows that all the technologies (with the exception of Galoo), based on the information provided, are able (with market and depollution practices) to achieve overall rates of recycling and recovery of 95% or more. It also indicates that all the PSTs (with the exception of Schwarze-Pumpe) are able to achieve in excess of the 85% recycling rate. In the case of thermal treatment plants this is mainly because of the separation and recycling of residual metal fractions. In the case of mechanical separation plants the overall rates are achieved through recycling of all fractions, especially plastics.

**Table 1: Overview of Post Shredder Technologies**

Name of Technology / Developer	Type of Technology	Level of Technology Development	Approximate Outputs from Process	Overall Rate of RRR (%)	Recycling Rate RR (%)	Indicative Gate Fee (euro per tonne of ASR)
VW – Sicon	Mechanical separation	1 trial plant (8,000 tonne) plus 2 under construction. Plans for a 100,000 tonne plant	Shredder granules 36%, shredder fibres 31%, metals 8%, wastes 26%	74	74	20 – 50
Galoo	Mechanical Separation	Operating plants	Recycled plastics 9%, metals 30%, refuse derived fuel 13%, wastes 48%	52	39	Not available
Sult	Mechanical separation	Operating plant in Japan	Organic (plastic) 50%, minerals 20%, metals 10%, water 20%	100	80	100
R-Plus	Mechanical separation	Operating plants	Organic fraction 60%, metals 5%, minerals 35%	100	100	90
Citron	Thermal treatment – oxyreducer	1 trial plant (130,000 tonne, 12,000 ASR). Plans for a 500,000 tonne (120,000 ASR) plant.	Current – Ca Fe concentrate 45%, zinc concentrate 4.3%, mercury 0.7%, wastes 50% Plan – Ca Fe concentrate 45%, Zinc concentrate 4.3%, mercury 0.7%, recovery 50%	50 100	50 50	100 – 200 (excluding energy sales)
TwinRec	Thermal treatment - gasifier	Operating plants in Japan	Metals 8%, glass granulate 25%, recovery 52%, wastes up to 15%	85	33	120 – 200
SVZ Schwarze Pumpe	Thermal treatment - gasifier	Industrial trial plant	Synthetic gas 75%, metals 8%, wastes 17%	87	8	Not available
Reshment	Mechanical separation & thermal treatment	No pilot or trial plants	Not available	Not available	Not available	75 – 140

Note: Gate fee is the charge to waste producers for treatment of the waste stream. The fee is determined by the treatment costs less income from sales of materials or energy. Transport costs are borne by the waste producer

**Table 2: Recycling and Recovery Rates of ELVs Using PSTs with Current Market and Depollution Practices**

Technology Developer	Type of Technology	Overall Recycling & Recovery Rate (%)	Recycling Rate (%)
VW – Sicon	Mechanical separation	95%	95%
Galloo	Mechanical separation	90%	88%
Sult	Mechanical separation	100%	96%
R-Plus	Mechanical separation	100%	100%
Citron – planned	Thermal treatment – oxyreducer	100%	90%
TwinRec	Thermal treatment - gasifier	97%	87%
SVZ Schwarze Pumpe	Thermal treatment - gasifier	97%	82%

Source: Technology Review

#### 1.4 Technology Costs and Economies of Scale

The cost information is based on interviews with the PST operators and data provided by them. The mass balance and cost information was obtained over several weeks of telephone and e-mail communication with 7 operators, with several follow-up calls to confirm and add to the information received. In addition, the internet was searched extensively for relevant information to complement the consultation.

Where information from the PST operator was unavailable, data such as market prices of waste products and energy costs were obtained from other sources (as indicated). Another useful source of data was the report by Knibb Gormezano and Partners for the ACEA, “Recycling Infrastructure & Post Shredder Technologies”. The report presents detailed costings for 4 PSTs as part of an exercise to compare the cost-effectiveness of different treatments of post-shredder waste.

The analysis of costs suggest that there are significant economies of scale associated with these technologies, with fixed costs a high share of total costs. These economies of scale are likely to result in plant with a throughput of at least 100 ktonnes of shredder wastes, and more likely a throughput, volumes of waste arisings allowing, of 200 ktonnes.

Table 3 summarises the ratio of fixed and variable costs for the four technologies for which detailed cost data is available, for plant with an approximate throughput of 200 ktonnes. Smaller plants will have a higher share of fixed costs.

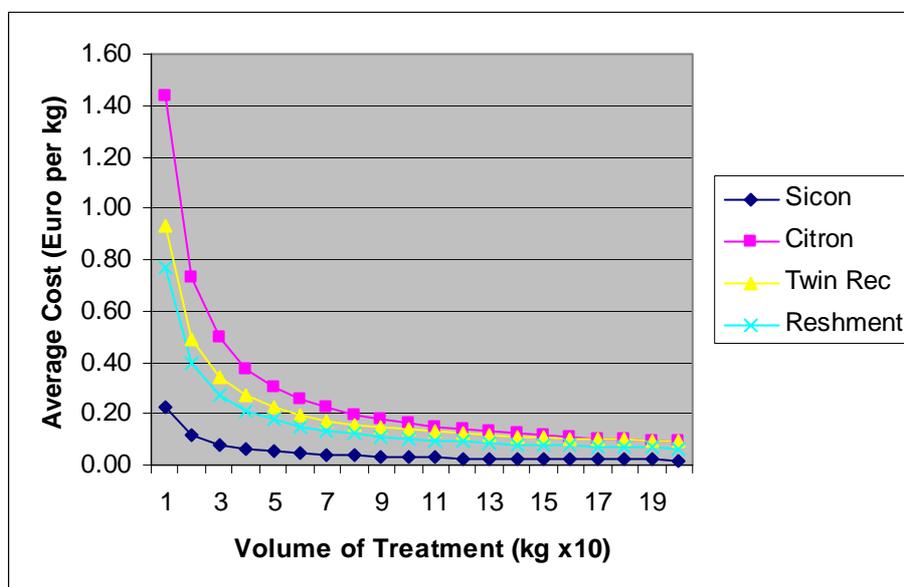
**Table 3: Summary of Available Fixed and Variable Costs for PST Plant (c200kt)**

Cost Parameter (euro per tonne)	Sicon	Citron	Twin Rec	Reshment
Fixed Cost	11	71	44	37
Gross Variable Cost (GVC)	27	97	59	48
Sales	19	77	10	20
Net Variable Cost (GVC less sales)	8	20	49	28
Total Cost	19	91	93	65
Net Variable Cost as % of Total Cost	42%	22%	53%	43%

Source: Review of Technologies, Knibb Gormezano and Partners for the ACEA, "Recycling Infrastructure & Post Shredder Technologies"

The high fixed costs mean that operators will seek to maximise throughput. There are no cost savings from a reduced level of treatment. The average costs of different volumes of treatment for the four technologies for which data is available are shown in Figure 1. This indicates costs for volumes of between 1 and 200kg (equivalent, for a 1000 kg ELV with 80% pre-shredder reuse and recycling, to a recycling or recovery rate of 81% to 95%).

**Figure 1: Average Costs (euro per kg) of Treatment Volumes, for Selected PST**



The average costs per kg of a 100% level of treatment (200kg), equivalent to a 95% rate of recycling or recovery) are between 55% (Citron) and 70% (Twin Rec) of the average costs per kg with 90% volume of treatment (approximately equivalent to a recycling or recovery rate of 85%).

## 2 THE VW-SICON PROCESS

The basic principles of the VW-Sicon process were developed on the different approaches to the separation of SR. SiCon started its activities in the field in a cooperative research programme at Witten-Herdecke University in Germany. The further development of the process was done in a joint venture with VW since 1999. Extensive trials have been undertaken at shredder sites and with users of the feedstock materials produced.

The SiCon technology is a mechanical process which deals with SR and mixed scrap waste. One small-scale plant is currently operating in Belgium, with a capacity of 6,000 to 8,000 tonnes per annum. Two more plants in Austria and France are currently under construction. There are plans for a fourth 100,000 tpa plant. The mass-balance diagram below shows the input and outputs for SR processing only. The costs (positive and negative) are shown for a plant capacity of 100,000 tpa. Investment costs are estimated to be between €6m (without separation of plastics and minimized features) and €12m (including all features and maximum security). Costs are shown in section 10.

The organic part of the ASR can be separated into plastic fractions which are sold in the recyclates market. The shredder fibres are mainly used as de-watering agent for sewage sludge which is then incinerated. The market depends on the growth of sewage sludge incineration compared to spreading on farmland. They may also be used as a substitute for coal in the production of coke.

The sludge, dust and shredder sand fractions produced need to be disposed of. This is done through incineration (dust), landfill (sand) or through other types of process such as Citron which deals with sludges.

Figure 2 – VW-Sicon process mass-balance flow

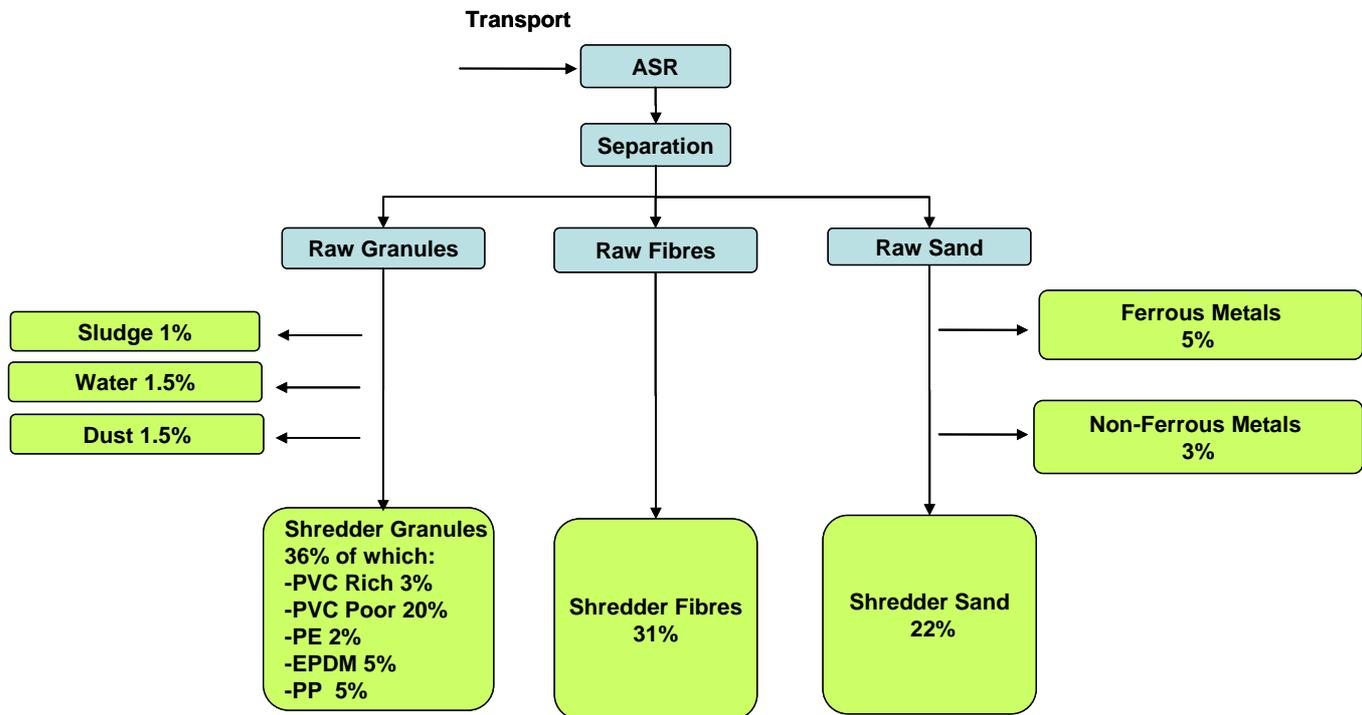
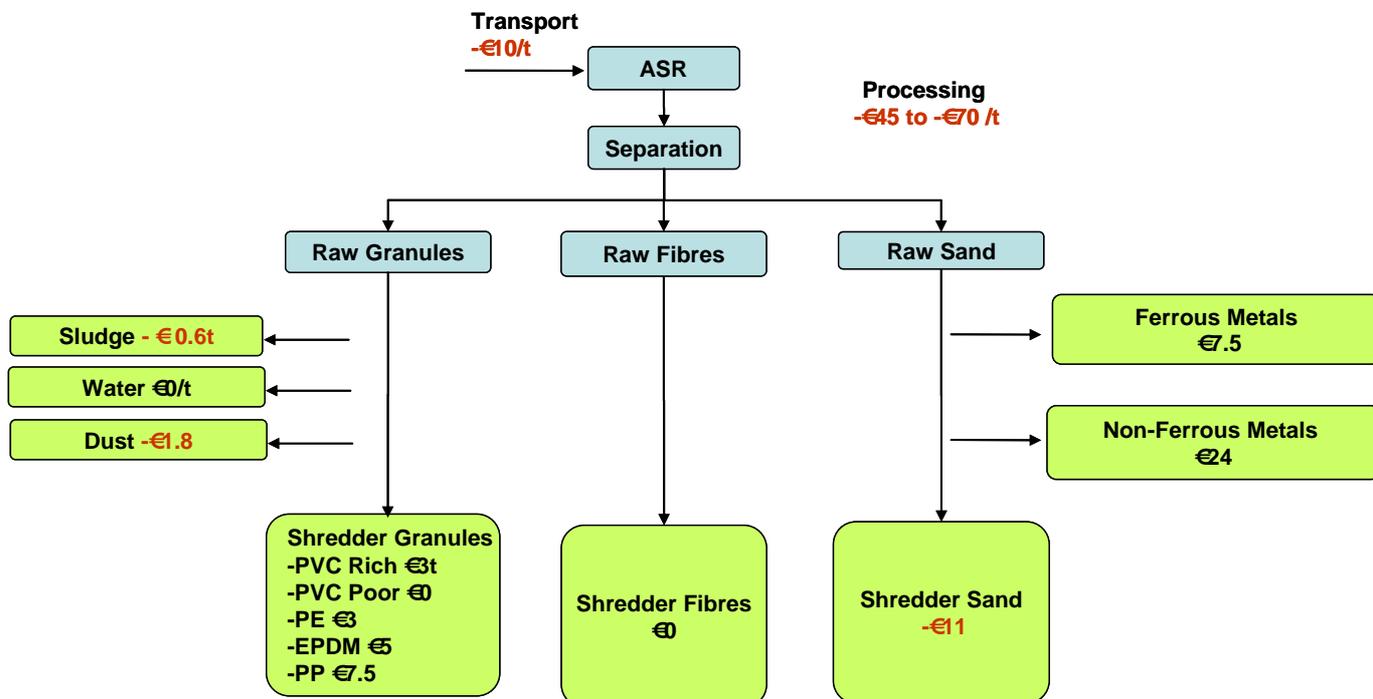


Figure 3 - VW-Sicon process costs per tonne ASR



**Table 4: VW Sicon Costs**

Indicative costs are summarised below.

<b>Costs</b>				
Processed tons per year	70,200	100,000	114,660	163,170
Total Investment (€)	10,410,000	11,540,000	10,410,000	11,540,000
Capital costs (€/y)	1,584,750	1,757,500	1,584,750	1,757,500
Capital costs (€/t)	<b>23</b>	<b>18</b>	<b>14</b>	<b>11</b>
Labour costs (€/y)	736,805	809,110	1,035,003	1,179,611
Labour costs (€/t)	<b>10</b>	<b>8</b>	<b>9</b>	<b>7</b>
Maintenance & Energy costs(€/y)	1,963,867	2,334,476	2,696,450	3,291,245
Maintenance & Energy costs(€/t)	<b>28</b>	<b>23</b>	<b>24</b>	<b>20</b>
Material sales				
<i>Metals</i>	-981,817	-1,397,201	-1,603,635	-2,282,096
<i>Shredder granules</i>	-1,298,700	-1,850,000	-2,121,210	-3,018,645
<i>Shredder Fibres</i>	0	0	0	0
<i>Shredder sand</i>	772,200	1,100,000	1,261,260	1,794,870
<i>Dust</i>	126,360	180,000	206,388	293,706
<i>Sludge</i>	42,120	60,000	68,796	97,902
Total material sales (€)	-1,339,837	-1,907,201	-2,188,401	-3,114,263
Total material sales (€/t)	<b>-19</b>	<b>-19</b>	<b>-19</b>	<b>-19</b>
<b>Total cost per ton (€/t)</b>	<b>42</b>	<b>30</b>	<b>27</b>	<b>19</b>
<b>Probable gate fee</b>	<b>47</b>	<b>34</b>	<b>31</b>	<b>21</b>

Source of data – From: *Recycling Infrastructure and Post Shredder Technologies*, Knibb, Gormezano and Partners, prepared for ACEA, June 2004.

Note on comparison with KGP report – costs updated from KGP with revised figures for material sales. This results in a positive income (19 euro per tonne) compared to a previously estimated cost of 20 euro per tonne. The gate fee of 20 to 50 euro per tonne above compares with the range estimated by KGP of 65 to 90 euro per tonne. The gate fee is based on an assumed percentage increase on the cost per tonne, as taken from the KGP report. The KGP report assumes a slightly different percentage increase for each technology type and we have used the same figures in this report (which for VW Sicon is 12%).

### 3 THE GALLOO PROCESS

The Galloo shredding company has been established since 1939 and has now diversified into metal and plastic recycling in addition to dismantling and shearing operations. The company has 24 sites in both northern France and Belgium.

GALLOO Recycling is a multi-step process for the treatment of ELV and other metallic wastes from shredding to post-shredding with sorting of heavy liquid (for metals and plastic). Currently one third of the waste processed is from ELVs. In the current process, cars are de-polluted and dismantled before being shredded. The mass-balance diagram below is based on an exercise undertaken by GALLOO whereby depolluted (but not dismantled) vehicles were shredded.

The Galloo Plastics stage produces a granulate (PP, PE or polystyrenics) which is sold to producers of plastic components. 60% of the plastics produced are sold to car manufacturers for production of new spare parts.

The data presented in Figure 5 was provided by Galloo (unless otherwise stated).

**Figure 4 – GALLOO process mass-balance flow**

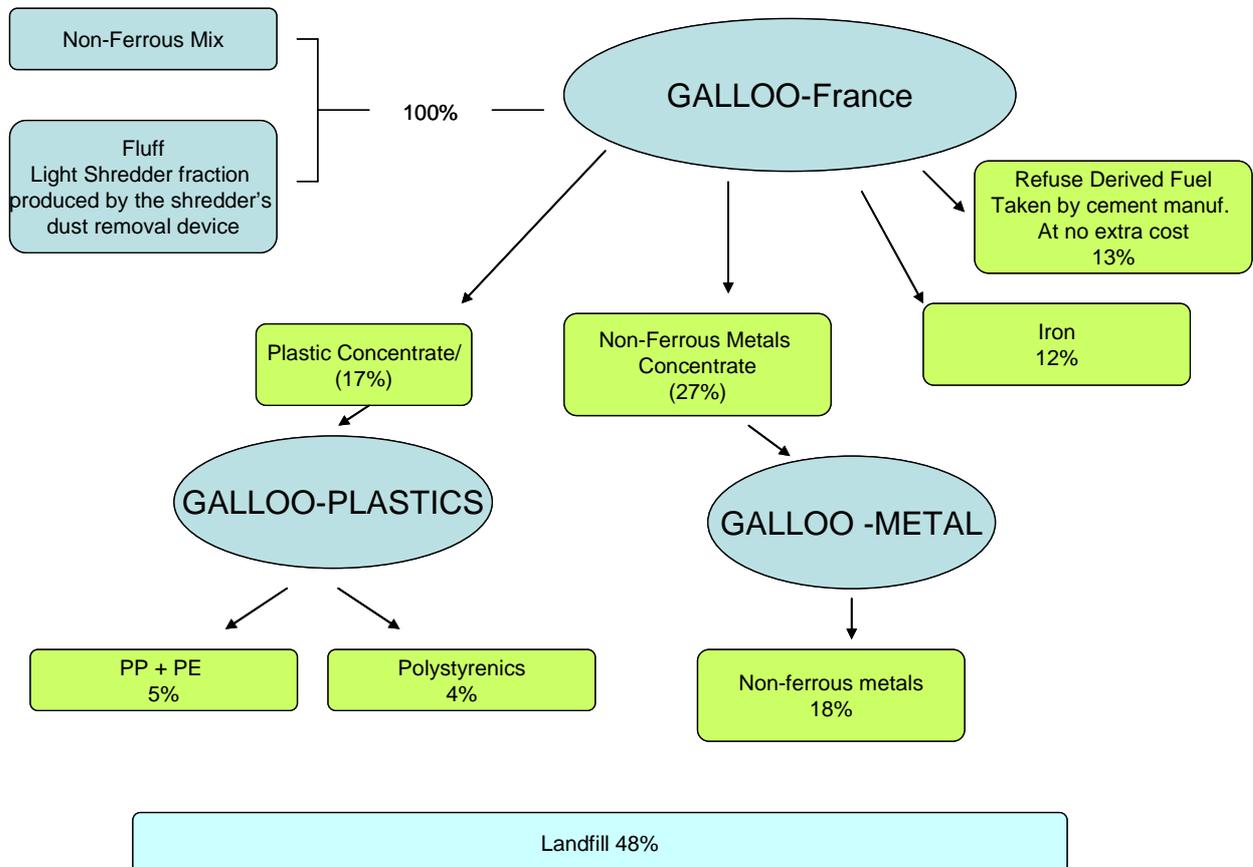
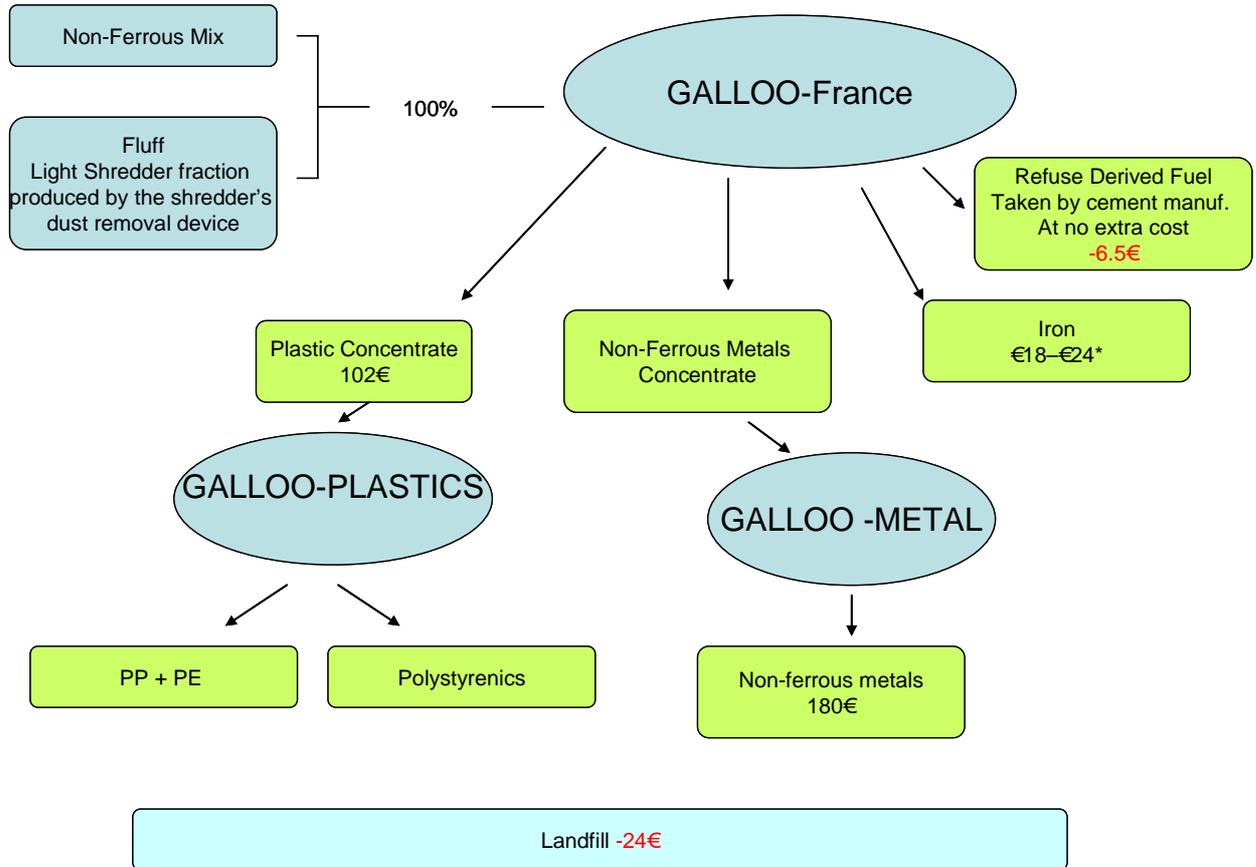


Figure 5 – Galloo process costs per tonne ASR



\*Source: [www.steelbb.com](http://www.steelbb.com)

### Costs

Full costs for the Galloo process have not been given. However the investment costs for the Galloo France and Galloo Plastics stages of the process, as provided by Galloo, are stated below.

#### Galloo France

Capacity (3 lines): 300,000t/y

Investment cost: €12million

#### Galloo Plastics

Capacity (3 lines): 20,000t/y

Investment cost: €12million

## 4 THE SULT PROCESS

The Sult process treats SR and other wastes mechanically. The waste is mechanically separated by sifting and density separation. For a typical 8tonne/hour plant, only two staff are needed. Investment costs are estimated to be €4.5 million, and operating costs around €70/tonne, including labour. There are no current Sult plants in the EU. However the shredder company R-Plus uses the technology in its post-shredder operations (see below).

The organic fraction may be separated into plastics such as polyurethane and polypropylene and recycled. The remainder of the organic fraction is used as feedstock in an electric furnace. If no plastics separation takes place, the organic fraction may be used as an alternative fuel in an electric power plant - in a fluid bed boiler unit.

The sand fraction is used as sanitary landfill cover, slope filling or in road construction. The metal fraction can be sold.

The cost data provided in Figure 7 was provided by Sult unless otherwise stated.

**Figure 6 – Sult process mass-balance flow**

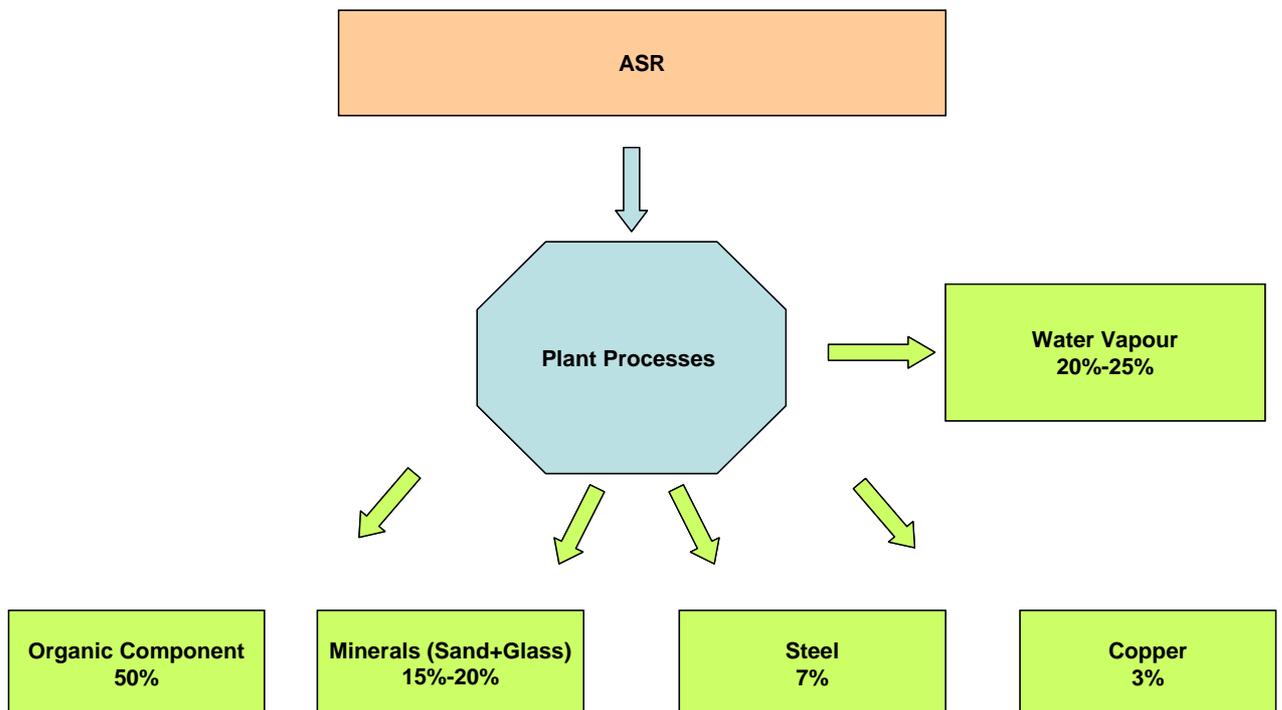
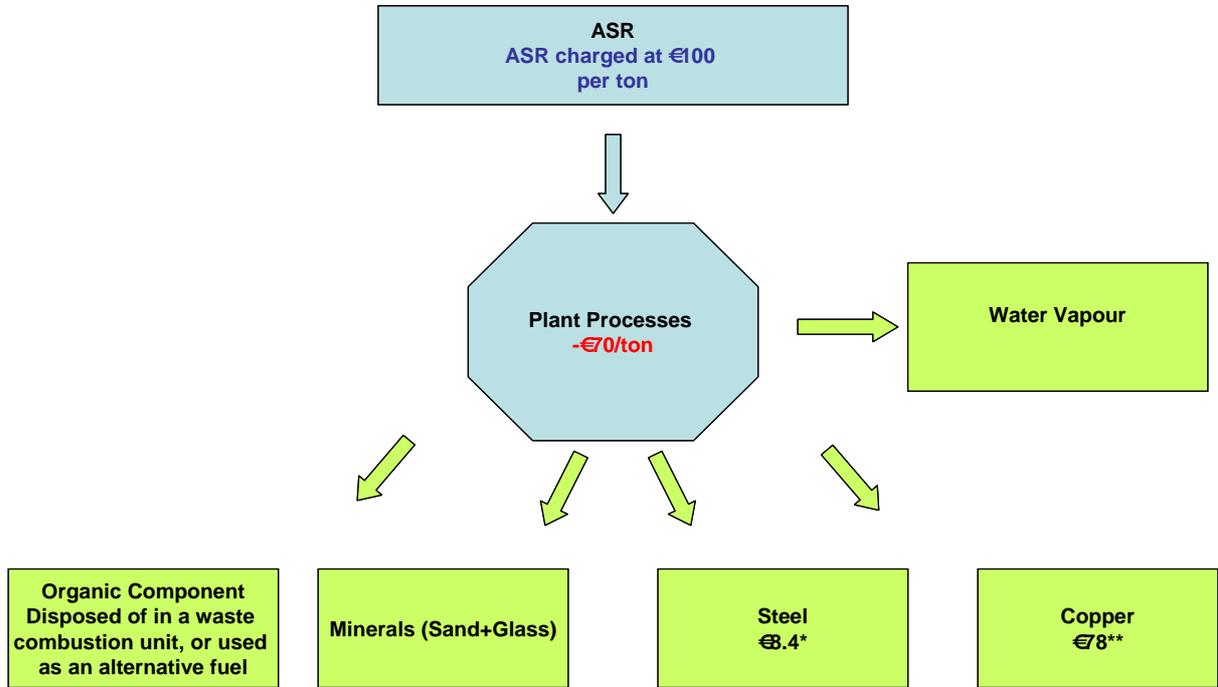


Figure 7 – Sult process costs per tonne ASR



\*Source: [www.steelbb.com](http://www.steelbb.com)

\*\*Source: [www.lme.co.uk](http://www.lme.co.uk)

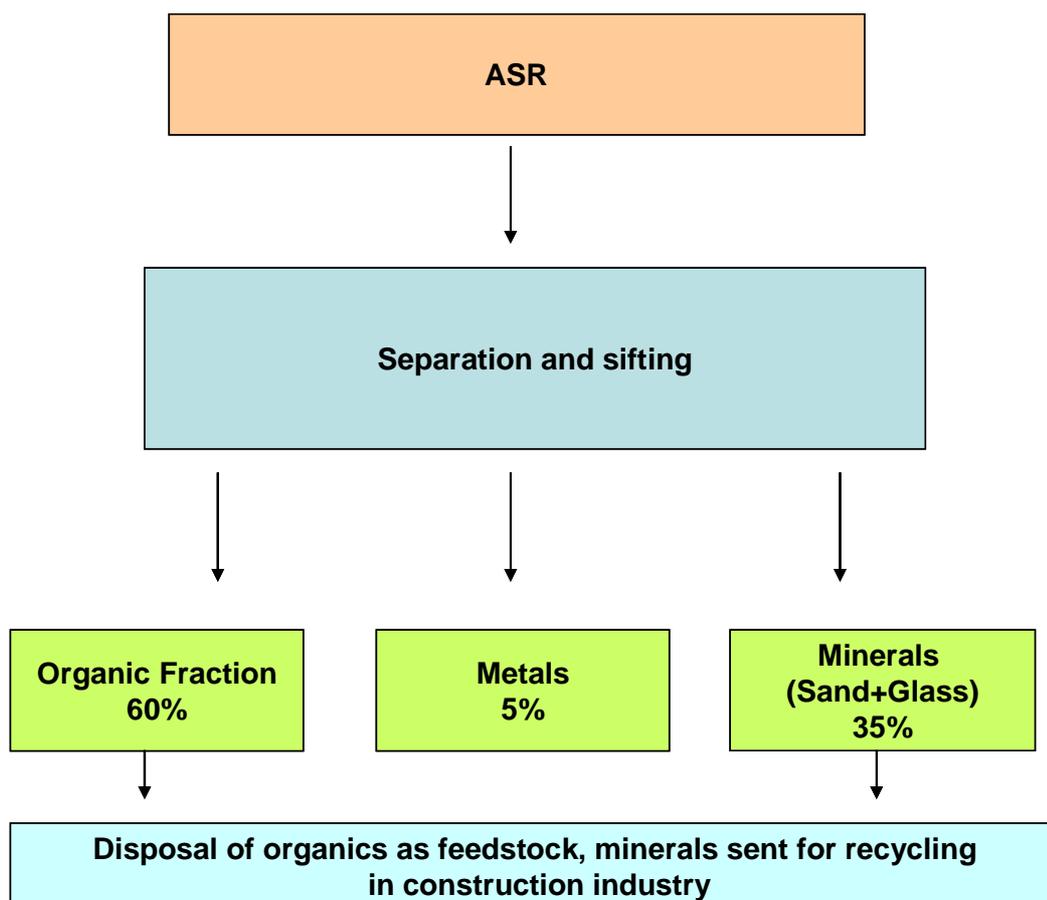
## 5 THE R-PLUS PROCESS

R-Plus recycling GmbH is a shredder/post shredder operator based in Eppingen, Germany. The company has one shredder and post-shredder plant and there are currently no plans for expansion.

As in the Sult process described above, the R-Plus process treats SR mechanically by sifting and density separation. ELVs make up 60% of the shredder residue. Three fractions are produced: Metals (ferrous, non-ferrous, copper) which are sold, a mineral (sand, glass etc) fraction which is used in the construction industry and an organic fraction which is used as feedstock for energy recovery or chemical processes.

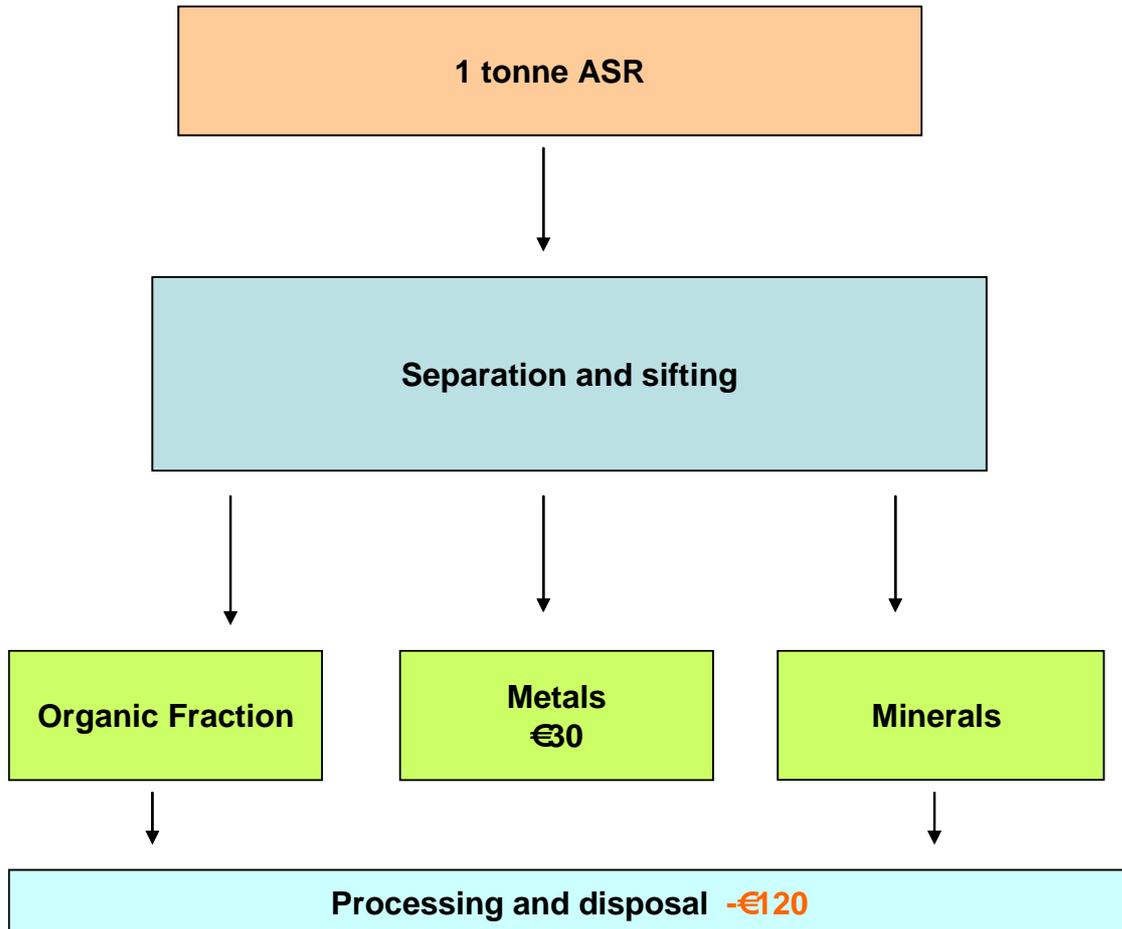
R-plus incurs costs for processing the ASR and disposal of the mineral (transport costs only) and organic fractions. Total costs are €120 per tonne of ASR. R-plus receives €30 per tonne of ASR for sale of metals. Net costs are therefore €90 per tonne of ASR<sup>1</sup>.

**Figure 8 - R-Plus process mass-balance flow**



<sup>1</sup> Mr Fahrner, R-Plus, personal communication

Figure 9 - R-Plus process costs per tonne ASR



## 6 THE CITRON PROCESS

The Citron process was developed by Citron AG of Switzerland and an operation facility exists at Le Havre in France. One of the reasons for choosing Le Havre is that it is well located for low cost transport by water.

Oxyreducer technology is used to process 17 different types of waste, including ASR. The plant processes 130,000tpa of waste, including 20,000t of SR, of which around 12,000t is ASR. Future plans include doubling the plant capacity and building a larger plant in Germany which would use the gas produced during the process in electricity production (planned power plant capacity 200MW). The latter plant would have a capacity of around 500,000tpa with 200,000 tonnes of SR (120,000t ASR) processed annually. The diagrams below show the current and future process input and outputs, and the costs of the process.

**Figure 10 - Current Citron process mass-balance flow**

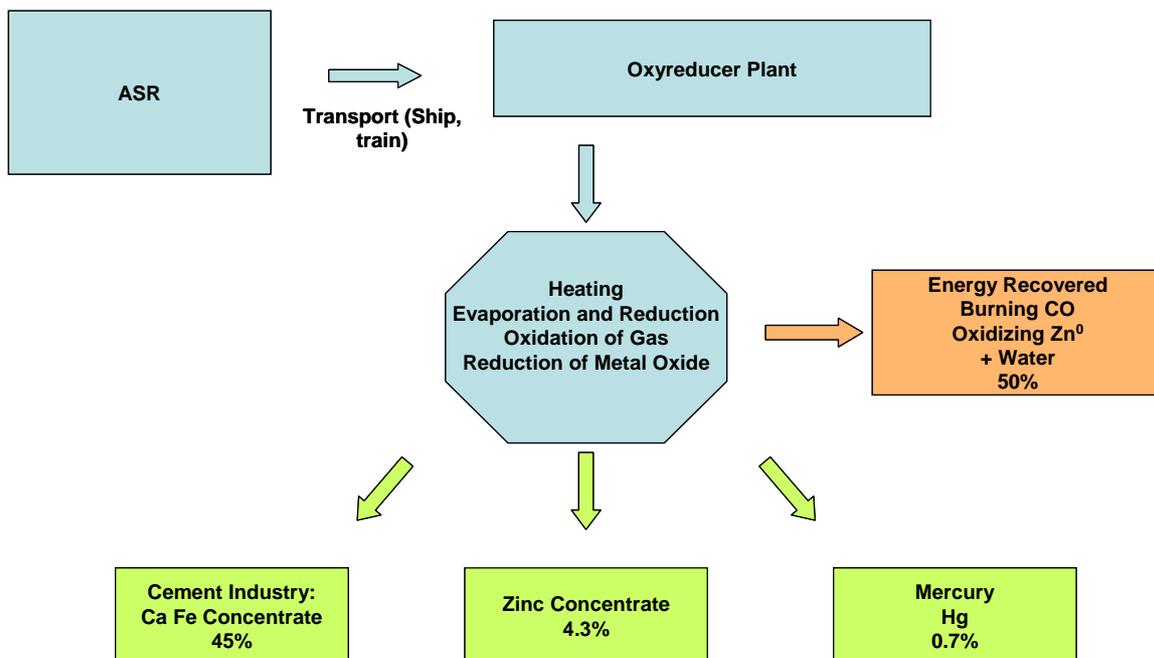
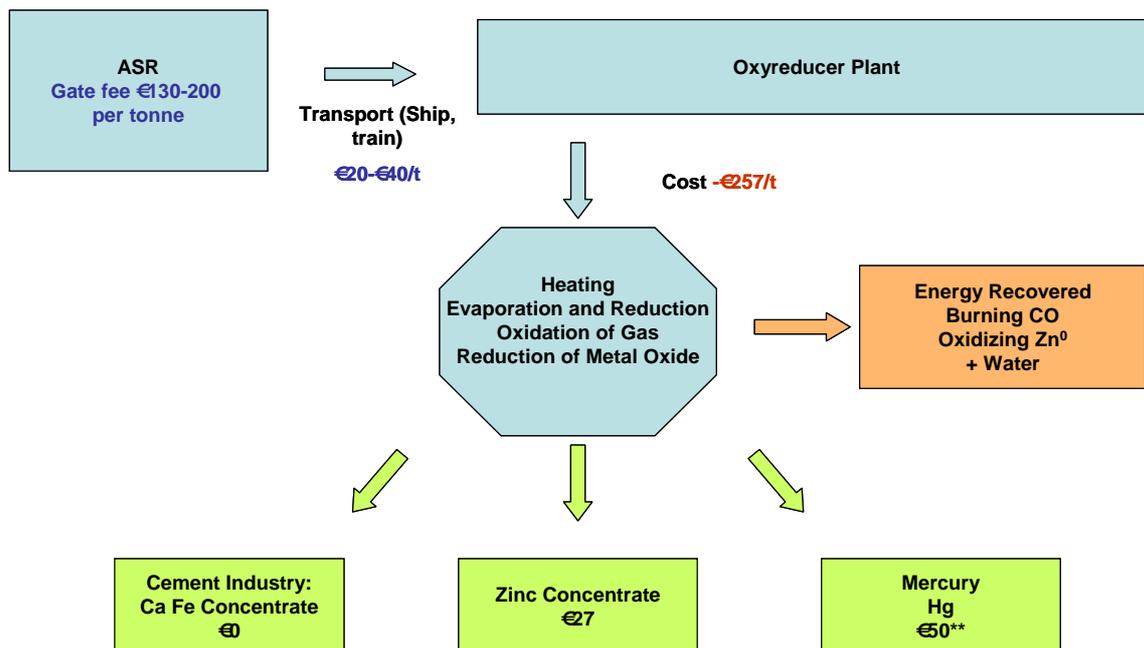


Figure 11 - Citron process costs per tonne ASR



\*Source: [www.lme.co.uk](http://www.lme.co.uk),

\*\*Source: [www.thisismoney.co.uk](http://www.thisismoney.co.uk)

## Costs

### Thermal Treatment of ASR – without electricity generation

Table 5: Citron Costs

Indicative costs are summarised below, based on the Citron process, and the reported costs by Citron.

Costs	80,000	200,000
Processed tons per year	80,000	200,000
Total investment costs (€)	58,320,000	90,720,000
Capital costs (€)	9,007,200	14,126,400
Capital costs (€/t)	<b>113</b>	<b>71</b>
Labour costs (€)	5,443,200	7,905,600
Labour costs (€/t)	<b>68</b>	<b>40</b>
Energy Costs (€)	1,270,080	2,540,160
Energy Costs (€/t)	16	13
Total Production costs (incl. energy costs) (€)	3,175,200	6,350,400
Total Production costs (including energy costs) (€/t)	<b>40</b>	<b>32</b>
Other (€)	2,980,800	4,924,800
Other (€/t)	<b>37</b>	<b>25</b>

Material sales		
<i>Zinc concentrate</i>	-2,160,000	-5,400,000
		-
<i>Mercury</i>	-4,000,000	10,000,000
		-
Total material sales (€)	-6,160,000	15,400,000
Total material sales (€/t)	<b>-77</b>	<b>-77</b>
<b>Total cost per ton (€/t)</b>	<b>181</b>	<b>90</b>
<b>Probable gate fee</b>	<b>208</b>	<b>103</b>

Source of data: *Economic Aspects of Automobile Recycling - Citron's solution for ASR*

Note: The revenue from sale of zinc and mercury is based on 50% of the market rate for these metals e.g. €600/t and €7000/t respectively. As cited by Citron in their paper on the economics of automobile recycling<sup>2</sup>, the mercury produced is directly sold to end-users<sup>3</sup>.

Note: The Plant is intended to generate electricity. As a 200 MW plant, assuming a 45% load, the plant generates 783m kWh per annum. Price per kWh €0.075. Total revenue: €58,725,000. Two/fifths of electricity generation contributed by ASR: €23,490,000. The effect is to reduce the required gate fee to -31 euro per tonne.

In other words if the plant were to operate as planned the technology would provide an incentive to waste producers; and result in economic benefits to them equal to the difference between current disposal costs and any gate fees applied by the Plant.

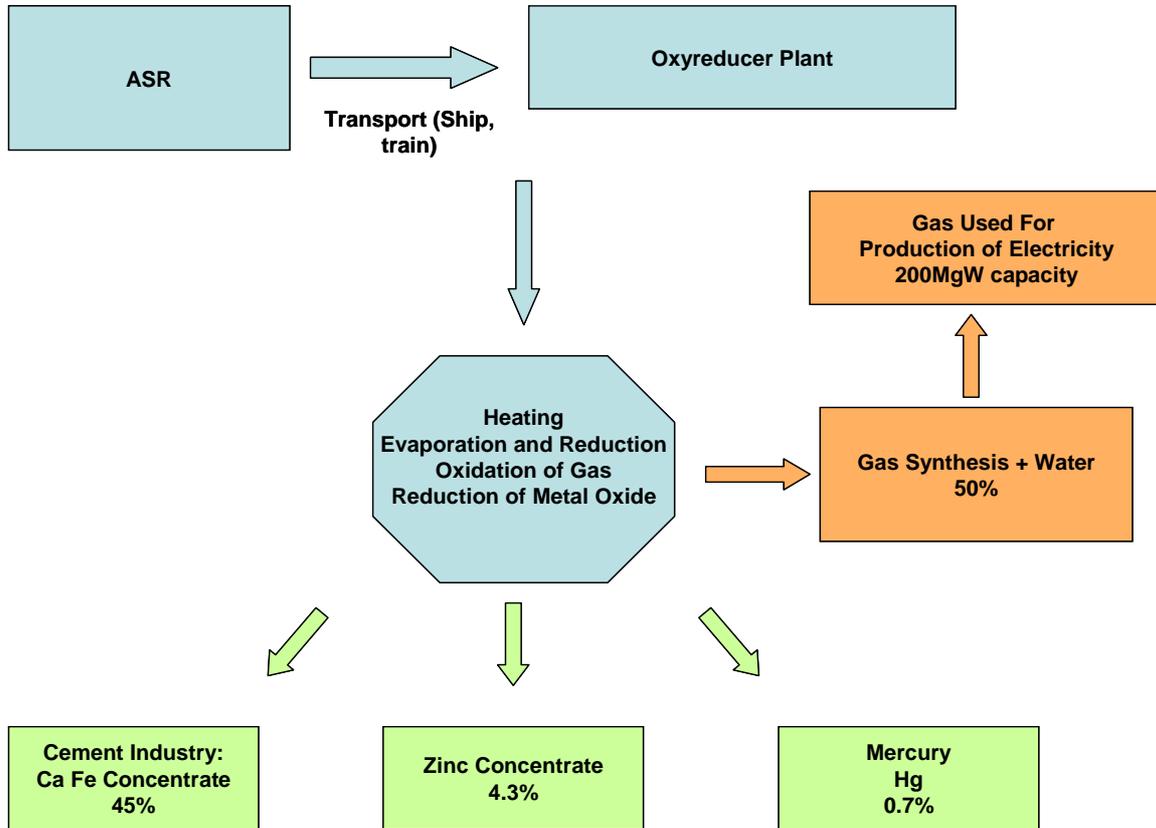
Comparison with Knibb, Gormezano and Partners report<sup>4</sup> – indicative gate fee of 180 to 280 euro excluding income from material sales and energy.

<sup>2</sup> Economical Aspects of Automobile Recycling – CITRON solution's for ASR, Christoph Guenther, no date (post 2000).

<sup>3</sup> Note – under future EU policy, mercury wastes will need to be disposed of (at possible cost) and will not be able to be resold.

<sup>4</sup> Recycling Infrastructure and Post Shredder Technologies, Knibb, Gormezano and Partners, prepared for ACEA, June 2004.

Figure 12 - Proposed waste processing and electricity plant mass-balance flow



## 7 THE TWINREC PROCESS

TwinRec is a thermal technology developed by the Japanese company Ebara. At present there are no plants in Europe. Several shredder and other operators in Japan (where landfill capacity is very limited and costs very high) have invested in the technology and there are currently 17 operational lines.

TwinRec is designed to combine material recycling (metals, mineral components, ash) with energy recovery. The TwinRec gasifier, besides detoxification of the organic material, separates the remaining metals and large inert particles from the combustibles and fine ash, maximising total metal recovery from ELVs. The combustible gas and fine char are used to vitrify the ashes and fine particles turning these into a recyclable, inert construction material. The excess energy is recovered with a steam boiler available for direct steam and heat use or for power generation in a steam turbine.

The gate fee is estimated to be in the range of €120-€200<sup>5</sup>. This includes investment costs, processing costs, average profit, final disposal costs (e.g. landfill) and takes into account revenue from selling of metal fractions and energy recovery.

Figure 13 below shows the process and mass-balance. Figure 14 show the associated costs. Table 6 summarises indicative costs.

**Table 6: TwinRec Costs**

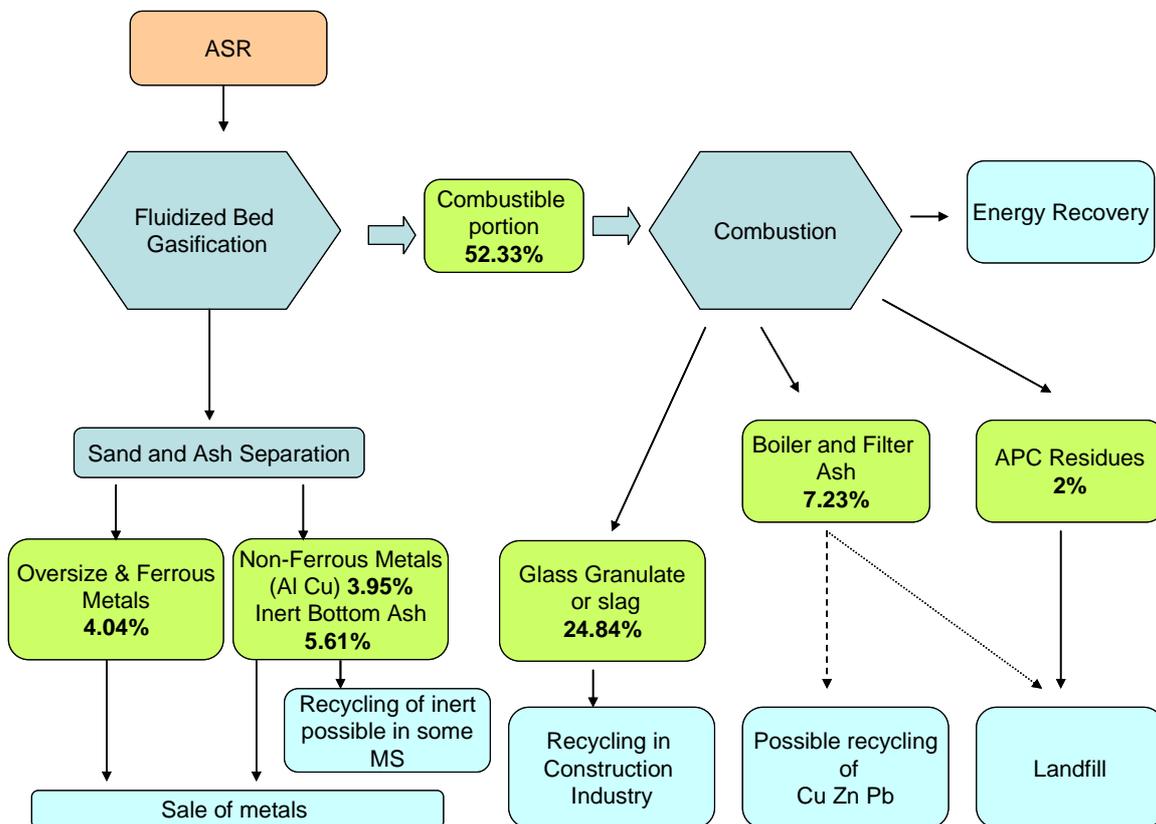
<b>Costs</b>				
Processed tons per year	98,438	196,875	299,063	398,438
Total Investment (€)	39,720,000	73,560,000	104,370,000	138,310,000
Capital costs (€/y)	4,744,917	8,735,500	12,330,000	16,339,083
Capital costs (€/t)	<b>48</b>	<b>44</b>	<b>41</b>	<b>41</b>
Labour costs (€/y)	944,505	1,215,530	1,626,966	2,103,708
Labour costs (€/t)	<b>10</b>	<b>6</b>	<b>5</b>	<b>5</b>
Maintenance (incl energy and waste disposal) (€/y)	5,310,874	10,528,028	15,844,286	21,095,497
Maintenance (incl energy and waste disposal) (€/t)	<b>54</b>	<b>53</b>	<b>53</b>	<b>53</b>
Material sales				
<i>Metals</i>	-1,023,750	-2,047,500	-3,110,250	-4,143,750
Total material sales (€/t)	<b>-10</b>	<b>-10</b>	<b>-10</b>	<b>-10</b>
<b>Total cost per ton (€/t)</b>	<b>101</b>	<b>94</b>	<b>89</b>	<b>89</b>
<b>Probable gate fee</b>				
	<b>121</b>	<b>112</b>	<b>107</b>	<b>106</b>

<sup>5</sup> Mr Selinger, Ebara, personal communication

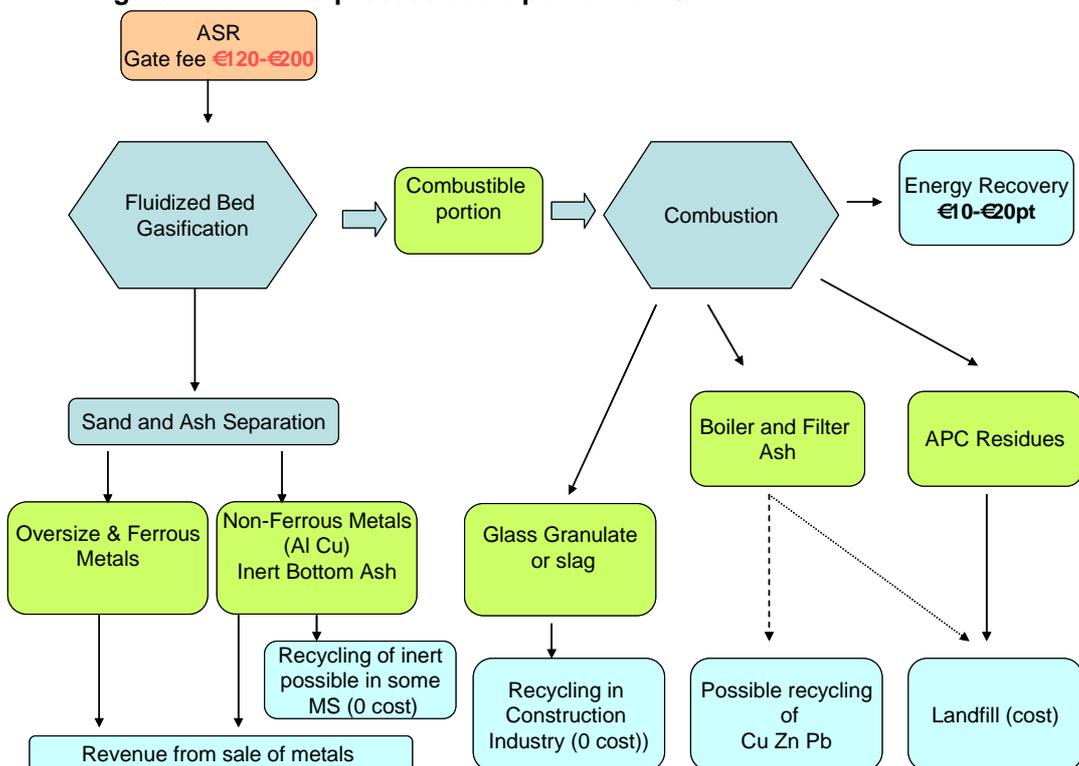
Source of data – From: *Recycling Infrastructure and Post Shredder Technologies*, Knibb, Gormezano and Partners, prepared for ACEA, June 2004

Note: The above costs do not include energy recovery. The indicative gate fee with energy recovery is €80-€100 per tonne.

**Figure 13 Twin Rec process mass-balance flow**



**Figure 14 TwinRec process costs per tonne ASR**



## 8 THE SVZ SCHWARZE PUMPE PROCESS

The SVZ (Sekundaerrohstoff-Verwertungszentrum Schwarze Pumpe GmbH) pilot plant uses the BGL-G (British gas Lurgi slagging-bed-gasifier) process to carry out “feedstock recycling”. This process uses high-temperature gasification of waste materials, including SR, to produce a synthetic gas and a vitrified slag.

The gas forms a building block for various chemical products, and is used for the large scale production of base chemicals such as methanol, ammonia and formic acid. The slag produced by the process can be used as road undercover, dyke barriers and cavity filling in mines. Potential further uses are under development.

Large-scale trials (930 tons of SR) of the process were conducted. The entire operation includes pre-treatment and pelletization of the SR with MSW, a gasification stage to produce syngas, and gas cleaning and reforming which lead to catalytic methanol production. Auxiliary units were tested to look at waste water and waste gas/liquid recovery.

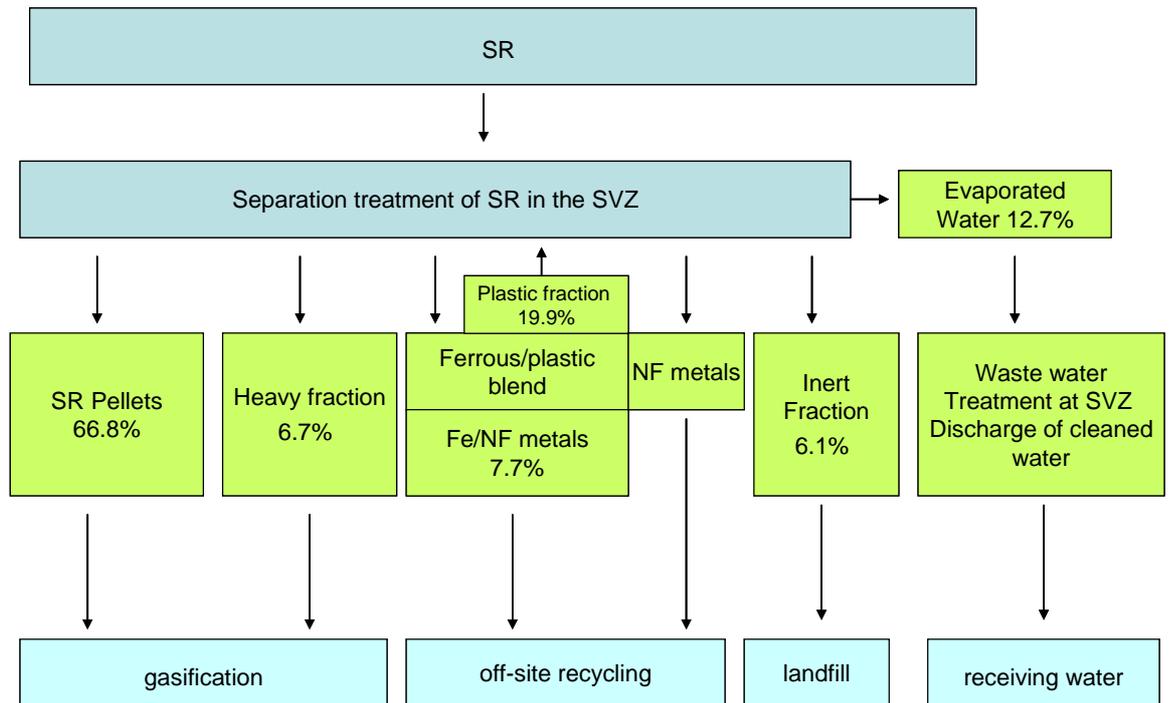
The trials concluded that up to 146,000t/a of SR could be treated within the existing facilities. There are plans to increase the operation to take on up to 170,000t/a of SR<sup>6</sup>.

The mass-balance flow for the process is shown below. SVZ have been unable to provide an estimation of the cost of the process.

---

<sup>6</sup> Full scale industrial recovery trials of shredder residue in a high temperature slagging-bed-gasifier in Germany, SVZ, Tecpol and PlasticsEurope, June 2005.

Figure 15 SVZ Schwarze-Pumpe mass-balance flow



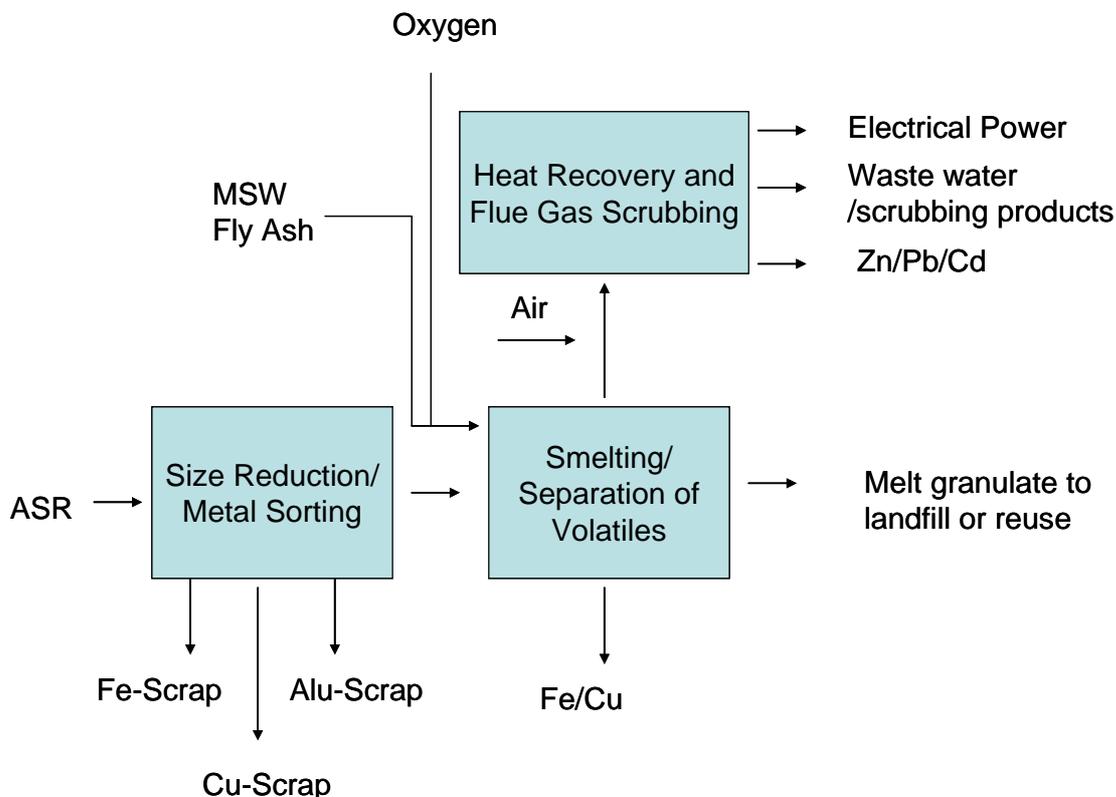
## 9 THE RESHMENT PROCESS

The Reshment process was developed by CTC Umwelttechnik of Switzerland. An agreement had been made with The Swiss Auto Recycling Foundation to invest in the technology for the treatment of Switzerland's ASR. However this agreement recently fell through. There are currently no pilot or operational plant for this technology.

The Reshment process uses a combination of mechanical treatment and thermal treatment of ASR to recover the metal fraction and produce a vitrified material which can be recycled in the road construction industry.

In the first phase, the shredder residue is mechanically separated, allowing fractions of copper, aluminium and scrap metal to be recycled. In the second phase the residual product is mixed with fly ash (originating from waste incineration plants). Streams of circulating air are used to separate shredder residue dust containing fractions of zinc, lead and cadmium, which are also suitable for re-use. The remaining shredder residue, mostly plastics, undergoes thermal cleaning below 2000 degrees Celsius. What remains is a 'glazed' product with immobilised contaminants which can be used as raw material for road construction etc.

**Figure 16 Reshment process mass-balance flow**



Indicative costs are summarised below, based on the calculations carried out by Knibb, Gormezano and Partners.

**Table 7 Reshment Costs**

<b>Costs</b>						
Processed tons per year	75,000	112,500	150,000	187,500	225,000	262,500
Total Investment (€)	39,704,490	44,590,809	51,567,725	57,770,000	66,706,636	75,143,017
Capital costs (€/y)	4,840,107	5,416,928	6,286,318	7,015,333	8,116,691	9,111,019
Capital costs (€/t)	<b>65</b>	<b>48</b>	<b>42</b>	<b>37</b>	<b>36</b>	<b>35</b>
Labour costs (€/y)	1,474,193	1,474,193	1,474,193	1,474,193	1,654,954	1,654,954
Labour costs (€/t)	<b>20</b>	<b>13</b>	<b>10</b>	<b>8</b>	<b>7</b>	<b>6</b>
Production costs (including maintenance, utilities and waste disposal) (€/y)	3,720,030	4,930,107	6,276,309	7,539,025	8,959,615	10,307,696
Production costs (including maintenance, utilities and waste disposal) (€/t)	<b>50</b>	<b>44</b>	<b>42</b>	<b>40</b>	<b>40</b>	<b>39</b>
Material sales						
<i>Metals</i>	-1,053,000	-1,579,500	-2,106,000	-2,632,500	-3,159,000	-3,685,500
<i>Smelt residue</i>	-478,260	-717,390	-956,520	-1,195,650	-1,434,780	-1,673,910
Total material sales (€)	-1,531,260	-2,296,890	-3,062,520	-3,828,150	-4,593,780	-5,359,410
Total material sales (€/t)	<b>-20</b>	<b>-20</b>	<b>-20</b>	<b>-20</b>	<b>-20</b>	<b>-20</b>
<b>Total cost per ton (€/t)</b>	<b>113</b>	<b>85</b>	<b>73</b>	<b>65</b>	<b>63</b>	<b>60</b>
<b>Probable gate fee</b>	<b>138</b>	<b>104</b>	<b>90</b>	<b>81</b>	<b>78</b>	<b>75</b>

Source of data – From: *Recycling Infrastructure and Post Shredder Technologies*, Knibb, Gormezano and Partners, prepared for ACEA, June 2004

## 10 CONSULTTEES AND REFERENCES

### 10.1 Consultees

1. **Citron:** Mr Sagarra
2. **VW Sicon:** Mr Guschall and Mr Schuelke
3. **Sult:** Mr Albrecht
4. **Ebara (TwinRec):** Mr Selinger
5. **R-Plus:** Mr Fahrner
6. **SVZ Schwarze-Pumpe:** Mr Picard
7. **Galloo:** Olivier Francois
8. **Forschungszentrum Karlsruhe GmbH:** Dr Reinhardt

### 10.2 References

Guenther, C., *Economical Aspects of Automobile Recycling - Citron's solution for ASR* no date, ca. 2001.

Knibb Gormenzano & Partners, for the ACEA, *Recycling Infrastructure and Post Shredder Technologies*, Final Report, June 2002.

SVZ, Tecpol & Plastics Europe, *Full Scale Industrial Recovery trials of shredder residue in a high temperature slagging-bed-gasifier in Germany*, June 2005.

Swiss Auto Recycling Foundation, *The Reshment Process* in Info newsletter no. 7, April 2002