

RECYCLING OF GLASS FROM END OF LIFE VEHICLES: ENVIRONMENTAL IMPACT ASSESSMENT OF DIFFERENT SCENARIOS

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ABSTRACT

This study examines the environmental impacts of the current end of life vehicle (ELV) recycling practice in Belgium of shredding and compares this with selective glass dismantling and recycling, using life cycle assessment (LCA). Different policy scenarios are assessed for ELV recycling in Flanders, showing the vulnerable balance between benefits from improved recycling and burdens from additional transport requirements.

INTRODUCTION

In the European Directive 2000/53/EC concerning ELV, targets are established for the reuse, recycling and recovery of ELV. Annex I of this Directive presents some treatment operations to promote recycling, including the removal of glass. As the way in which the glass should be removed is not specified, each EU member state can make their own interpretation.

In 2011 about 170,000 ELV were treated in Belgium. In the current recycling practice, ELV glass remains in the vehicle and is shredded together with the other materials. A series of post shredder technologies (PST) separate the different materials, leaving a mineral rest fraction which contains most of the glass, stones, concrete porcelain, etc. This fraction is of insufficient purity to be reused as cullet in glass production. Instead, it is used as building material, e.g. landfill cover. An alternative treatment route for ELV glass would be selective dismantling prior to shredding, which might also significantly increase the environmental benefits of ELV recycling (Belconsulting, 2006; OVAM, 2008) as the resulting glass fraction can be processed by glass recyclers into high quality cullet that can be reapplied in the glass industry. In addition, laminated windscreens contain a plastic polyvinyl butyral (PVB) interlayer, which can also be recycled into a replacement for PVC in carpet production (among other applications).

In this study, commissioned by the Public Waste Agency of Flanders (OVAM), the environmental impacts of both recycling routes for automotive glass are compared. It is important to note that this study departed from the current organizational and logistic situation of ELV treatment in Belgium and was performed in close collaboration with the stakeholders along the chain.

METHODS

To quantify the environmental impacts of ELV glass recycling a so-called 'gate to grave study' is performed, using attributional and comparative LCA. In order to narrow down the comparison to the burdens and benefits specifically associated with the glass flow, streamlining between the alternatives is applied. As the treatment of the ELV carcass is independent of the chosen treatment for the glass, all burdens and credits related to the treatment of the ELV carcass are excluded from the comparison. The data inventory was performed in close cooperation with all stakeholders involved in the ELV recycling chain and complemented by literature (CARE, 1999; European Commission, 2013). Background processes were taken from the Ecoinvent 2.2 database. Environmental profiles are calculated using the ReCiPe midpoint method and the software package SimaPro 7.3.3.

RESULTS AND DISCUSSION

Environmental profiles of the separate ELV glass recycling routes

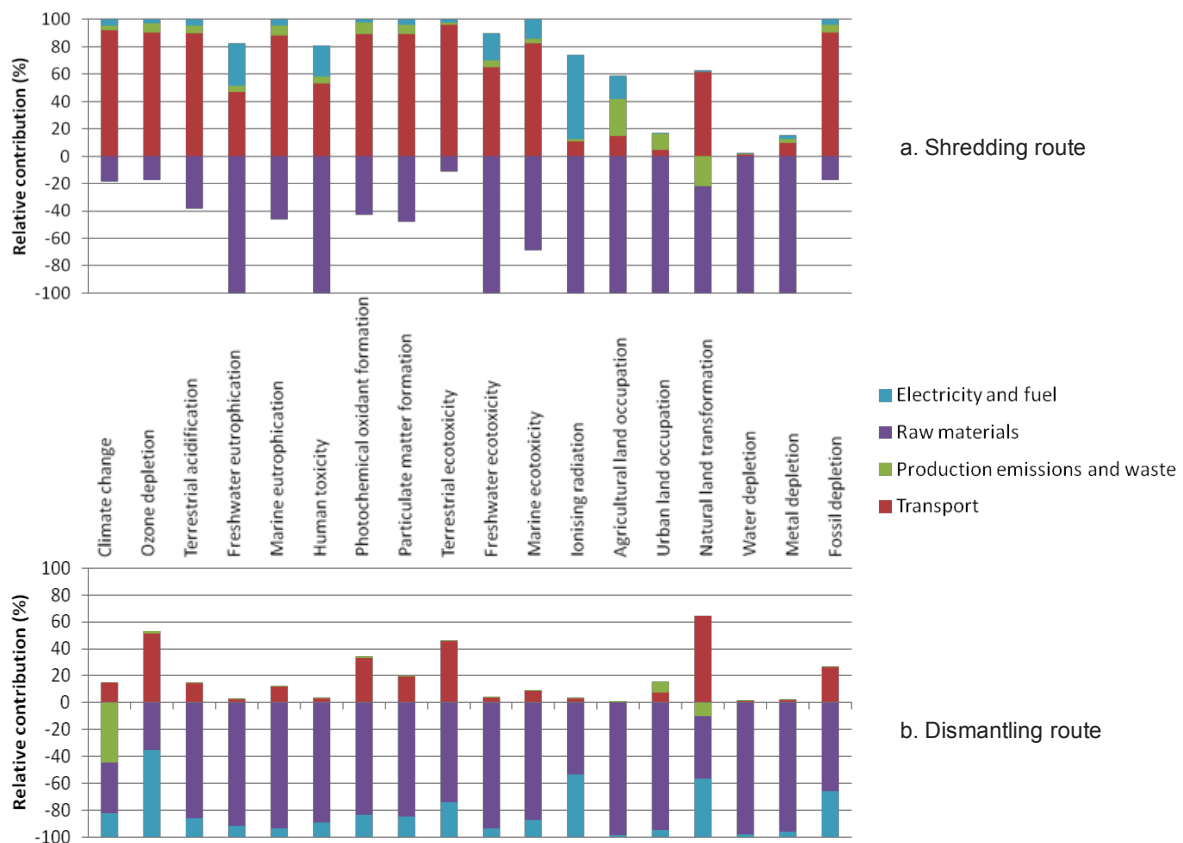


Figure 1: Comparison of the environmental profiles for shredding (a) and dismantling (b).

Figure 1 presents the environmental profiles for both treatment routes under study. The functional unit is “the treatment of 1 kg ELV glass”, starting from the depolluted ELV at the depollution center and ending at the reapplication of the recycled glass in new products. Depending on the impact category, the **shredding/PST** route has a net environmental burden

or benefit. Burdens are largely due to transport operations (diesel production and consumption) between the consecutive recycling steps. The recycling processes themselves contribute to a lesser extent and burdens are typically due to emissions occurring during electricity production and to the disposal of waste from the PST. The benefits arise from the reapplication of the mineral fraction as landfill cover, avoiding the mining of virgin sand.

Dismantling, resulting in recycled cullet and PVB, has a net environmental benefit in all impact categories. Burdens are due to transport between process stages, while the emissions of the recycling processes themselves are negligible. The benefits are mainly linked to the replacement of raw materials (mainly soda and silica sand) in glass production. PVB recycling from windscreens also contributes significantly to the environmental benefits. The energy use of recycling operations is largely compensated by energy savings in glass production, resulting in a net benefit for electricity and fuel use. One eye-catching detail is the savings in carbon dioxide process emissions due to the glass formation reaction that is avoided when recycled cullet is used in glass melting.

Scenario analysis

ELV glass is lost from ELV due to accidents or spare part removal. In addition, the way in which ELV are transported to the depollution center determines to what degree the windows will remain available for dismantling. In Belgium two main transport modes are currently in use. About half of ELV are transported using car transporters, harboring 8 vehicles. With this type of transport, the ELV typically arrive at the depollution center with windows intact. Alternatively, the ELV are transported by scrap truck, equipped with a grapnel that crushes part of the windows while loading the ELV, making them unsuitable for dismantling.

The functional unit for the policy scenario comparison is defined as “the treatment of an average ELV”. As the transport between the last owner of the ELV and the depollution center has an influence on the amount of glass that can be dismantled, the system boundary is expanded to include the transport step towards the depollution center. Streamlining is applied for the EoL treatment of all non-glass related parts in the ELV, which are assumed to be treated in the same way, regardless of the scenario. Three different policy scenarios for ELV glass recycling are assessed .

- 0: Business-as-Usual: current practice of shredding all automotive glass together with the rest of the ELV;
- 1: Dismantling when possible: all automotive glass that arrives intact at the depollution center is dismantled, using the current transport modes to the depollution center.
- 2: Maximal dismantling of ELV windows: for the ELV that used to be transported to the depollution center by scrap wagon, the transport mode is adapted in order to assure that ELV windows remain intact during transport. As this change affects the transport of the full ELV, the impacts of the ELV carcass treatment are different from scenarios 0 and 1. In order to maintain equivalence between the scenarios, a streamlining correction is applied to scenario 2 to account for this transport change.

The results of the scenario comparison are shown in **Error! Not a valid bookmark self-reference.**. The environmental impacts of scenario 0 (BAU) are relatively small compared to

scenarios 1 and 2. While scenario 1 generates environmental benefits on all impact categories, the result of scenario 2 is mixed as benefits are significantly reduced or transformed into burdens, due to the altered transport.

Table 1: Comparison of the environmental impacts of the studied scenarios

Impact category	Unit	Scenario comparison		
		Scenario 0 (per ELV)	Scenario 1 (per ELV)	Scenario 2 (per ELV)
Climate change	kg CO2 eq	0,3	-6,6	-4,0
Ozone depletion	kg CFC-11 eq	3,8E-08	-1,1E-07	5,8E-07
Terrestrial acidification	kg SO2 eq	7,1E-04	-0,020	-0,016
Freshwater eutrophication	kg P eq	-3,2E-06	-0,0011	-0,0014
Marine eutrophication	kg N eq	2,8E-05	-0,0011	-9,3E-04
Human toxicity	kg 1,4-DB eq	-0,0042	-1,2	-1,3
Photochemical oxidant formation	kg NMVOC	8,2E-04	-0,009	0,005
Particulate matter formation	kg PM10 eq	2,3E-04	-0,0054	-0,0018
Terrestrial ecotoxicity	kg 1,4-DB eq	6,2E-05	-2,6E-04	1,0E-03
Freshwater ecotoxicity	kg 1,4-DB eq	-4,9E-05	-0,027	-0,031
Marine ecotoxicity	kg 1,4-DB eq	2,2E-04	-0,021	-0,016
Ionising radiation	kg U235 eq	-0,015	-0,64	-0,85
Agricultural land occupation	m2a	-5,5E-04	-0,21	-0,28
Urban land occupation	m2a	-0,010	-0,024	-0,022
Natural land transformation	m2	-1,0E-04	-3,3E-04	5,1E-04
Water depletion	m3	-0,039	-0,15	-0,18
Metal depletion	kg Fe eq	-0,011	-0,21	-0,25
Fossil depletion	kg oil eq	0,10	-1,1	-0,025

CONCLUSIONS

This study shows that the dismantling of ELV glass has significant environmental benefits over the current practice of shredding the glass together with the ELV. Environmental burdens of recycling are mainly related to transport operations (and the associated assumptions made), while the benefits associated with the avoided raw materials determine the net environmental result. A careful balance should be made between the benefits of closing the glass loop and the additional transport impacts that are generated by doing so, in order to avoid burden-shifting. If improvements in PST technology would achieve in a glass fraction that meets the requirements of the glass industry, the overall environmental profile of the shredding route could be improved significantly.

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