COMPARATIVE LIFE CYCLE ASSESSMENT OF THE USE OF RECOVERED GLASS IN GLASS PACKAGING FOR FOOD

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Keywords: Life Cycle Assessment (LCA), glass packaging, glass recycling.

ABSTRACT

This study is part of the European project FENIX-Giving Packaging a New Life which aims to create an efficient tool that will be used to obtain results for the environmental impact of the packaging waste management through a methodology of Life Cycle Assessment (LCA). We present here a complete Life Cycle Assessment from cradle to cradle of glass packaging intended for food use from the Spanish-Portuguese geographical framework. Results have allowed us to evaluate the full environmental impact of the glass packaging waste (pretreatment, production of packaging glass and transports) considering the current waste management practices. These data could provide useful information to establish new recycling and production strategies and waste management in the sector.

INTRODUCTION

Glass is an inorganic hard and fragile material that is obtained from the fusion of silica sand, sodium carbonate, limestone and/or other materials and it is easily recoverable due to its characteristics. Glass packaging is 100% recyclable, i.e. from a used glass packaging, we can manufacture a new one with the same characteristics than the original one. A tonne of recovered glass replaces 1.2 tons of virgin raw materials that are required in the glass manufacturing process, which implies a considerable resources use reduction.

Traditionally, the glass packaging sector has been very important in Europe in that this industry fosters the European economy and employment and is the largest producer of glass packaging in the world. It employs 40,000 people in over 140 plants throughout Europe. The glass packaging industry has created new “ecological” recycling industries which are currently contributing to the recycling of over 62% of glass used across the European Union.

The main goal of this study is to analyse the environmental impacts of the life cycle of residual glass packaging (for food use) in Spain and Portugal, including pretreatment, production of packaging glass and associated transports.

MATERIALS AND METHODS

The study has been carried out following the ISO14040 Life Cycle Assessment (LCA) methodology (International Standardization Organization, 2006).

In the first place, we identified all processes involved in the overall life cycle of glass packaging waste in Spain and Portugal. Secondly, we modelled these processes and finally, we evaluated the environmental impact of the actual glass pretreatment and glass packaging industry processes.

The system boundaries of the study is from "cradle to cradle" and have comprised pretreatment, glass packaging industry, glass rejected treatment as well as several transfers. Lengthwise the lifecycle of glass packaging, small amounts of glass are rejected as these cannot be recycled and are disposed of. The management of the rejected glass (incineration and landfill) is included.

Transportation considered in this study, includes:

a) Glass transportation: transfer of waste glass collected from glass recycling containers to the glass pretreatment plant and transfer of the cullet from the pretreatment plant to the glass packaging manufacturing plant.

b) Raw material transportation: silica sand, limestone, soda and dolomite from their origin to the glass packaging manufacturing plant.

c) Waste transportation: non-hazardous waste from pretreatment to waste treatment, Hazardous waste from glass packaging manufacturing plant to waste treatment and glass rejected.

Transports from households to the recycling bins were excluded.

The functional unit specifically established for the system under study is one tonne of waste glass being treated.

Data have been sourced from a pretreatment company and from glass packaging manufacturing plant belonging to two different consortiums. The Ecoinvent database was also used as a reference and more precisely, data base of Packaging Glass (Hischier, 2007).

The LCA software tool GaBi 4.0 has been used for LCA modeling. The environmental impacts have been estimated according to the CML 2001 method (Guinee, 2001).

RESULTS

Inventory data. Inputs/outputs of the processes can be seen in the table 1 and impact assessment Impact indicators used for this study (Figure 1) are detailed next: ozone creation potential (POCP) in kg ethane-equiv; ozone layer depletion Potential (ODP) in kg R11-equiv.; global warming potential (GWP 100 years) in kg CO2-equiv.; eutrophication potential (EP) in kg phosphate-equiv.; acidification potential (AP) in kg SO2-equiv.; abiotic depletion (ADP fossil) in MJ.

GLASS PRETREATMENT						PRODUCTION OF PACKAGING GLASS					
Inputs						Inputs					
	Units	Quantity		Units	Quantity		Units	Quantity		Units	Quantity
Waste Glass	Ton	1	Raw Material (Manufacturing Oils ...)	Ton	0,0005	Power grid mix	KW/h	883,012	Soda	Ton	0,244
Power grid mix	KW/h	5,81				Natural Gas	KW/h	3764,358	Dolomite	Ton	0,045
Outputs						Cullet (external)	Ton	0,968	Cullet (internal)	Ton	0,384
Cullet	Ton	0,968	PET	Ton	0,0035	Silica Sand	Ton	0,933	Raw Material (Manufacturing Oils...)	Ton	0,001
Aluminum	Ton	0,0011	Plastic	Ton	0,0043	Limestone	Ton	0,209	Water	M^3	1,008
Cardboard	Ton	0,0025	Steel	Ton	0,0041	Outputs					
HDPE	Ton	0,0018	Tretrapack	Ton	0,0004	Waste Water	M^3	1,008			
LDPE	Ton	0,0015	Other	Ton	0,0112	Hazardous waste	Ton	0,0001	Reject Material (Cullet Internal)	Ton	0,384
Organic Waste	Ton	0,0009	Emissions	--	--	End Products (glass)	Ton	2,155			
						Glass rejected	Ton	0,153	Emissions*	--	--
TRANSPORT											
Waste Glass from glass recycling containers to pretreatment				Km.	300	Limestonefrom supplier to recycling plant				Km.	200
Non hazardous waste from pretreatment to waste treatment				Km.	40	Soda from supplier to recycling plant				Km.	490
Cullet from pretratment to recycling plant				Km.	100	Dolomite from supplier to recycling plant				Km.	100
Silica Sand from supplier to recycling plant				Km.	250	Hazardous waste from recycling plant to waste treatment				Km.	200

Table 1. Inventory data of the processes considered in the system boundaries

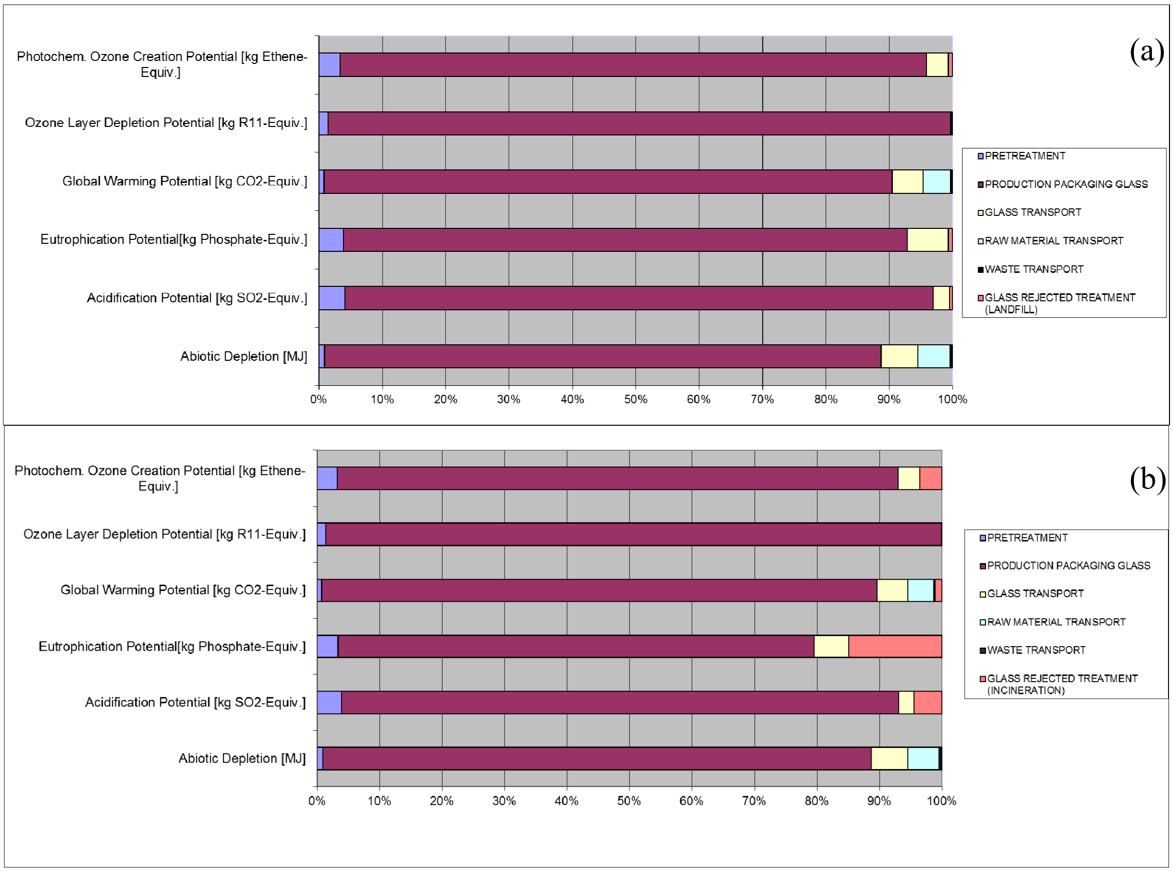

Figure 1. Contribution of different life cycle stages to the environmental impacts of the glass. (a) Glass rejected treatment by landfill or (b) by incineration.

DISCUSSION

The results from the analysis of the glass packaging life cycle environmental impacts confirm that glass packaging manufacturing process is a major "hot spot" contributing between the 85% and 95% to those impacts. Particularly, glass packaging industry contributes up and above of 85% to the Global Warming (551.04 kg de CO2 equiv. emitted). The production stage of the glass packaging has the highest climate change effect because very high temperature furnaces are used for their production with very high energy requirements. Road transportation of glass, raw material and waste has the second highest effect and contribute up to the 5-10% of the total impacts especially in global warming and abiotic depletion. Pretreatment and glass rejected treatment (landfill) shows similar low contributions (below 1%) in all the impacts studied because these processes need lower energy requirements. Nevertheless, when incineration is the treatment of choice for the rejected glass instead of landfill, the results show a considerable increase in the environmental impact of this process (between 1-15%). This is specifically remarkable in the case of eutrophication potential, acidification potential and ozone creation potential.

CONCLUSIONS

This study shows that glass packaging industry has the greatest impact in all environmental factors studied and this is related to the high energy consumption of this process. However, when incineration is chosen instead of landfill during the glass treatment process, this also has a significant impact on the environment up to 15% .The use of recycled glass as input in the production process facilitates a reduction in the consumption of other raw materials of primary origin (1 tonne of recycled glass saves 1.2 tonnes of raw materials as silica sand, limestone, soda, dolomite…) and a substantial reduction in energy consumption. This is due to the fact that recycled broken glass or calcin are made up of the same composition as smelting glass and eliminates the cost related to chemical reactions involved in the smelting process (2.5%-3% saving on energy per 10% of recycled glass). Note that in this study the percentage of glass that is recycled is 44%. But this is not sufficient as to prevent the production of packaging glass process from having the greatest environmental impact. So it seems clear that the implementation of incentive schemes to promote selective collection practices as well as the proper use of glass waste collection points that will allow the collection of greater amount of recycled glass could lead to a significant reduction of the environmental impacts associated with the life cycle of the glass packaging. These results provide useful information to establish new recycling, production strategies and waste management in the life cycle glass packaging aimed specifically to those processes that generate greater environmental impacts.

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