Life Cycle Assessment of Window Assemblies Graham GThurm™ Composite vs. Aluminum Window Assemblies

1. Introduction

In cooperation with Covestro, Graham Architectural Products has designed the GThurm™ window, an innovative new window frame assembly that incorporates polyurethane materials from Covestro and fiber glass. Graham's GThurm™ window sash/frame lineal is manufactured with its G2RP® composite material, a pultruded continuous strand fiber glass combined with polyurethane for durability and structural integrity. Graham also manufactures window sash/frame products made of conventional aluminum materials.

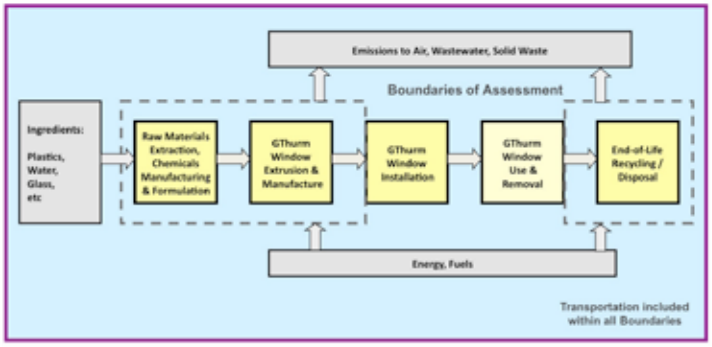
A Life Cycle Assessment (LCA) conducted by Covestro and Graham compared environmental impacts of making the GThurm™ window versus an aluminum window frame. The LCA helps in understanding the life cycle phases that contribute most significantly to the product life cycle, and provides a basis for more detailed study. Because of limited life cycle data availability, the study was based on both literature data as well as primary data collected from the plant site. This summary extracts key results from the study *Life Cycle Assessment of the GThurm™ Window vs. Aluminum Window Assemblies*, which was conducted and critically reviewed according to the globally recognized standards for LCA: ISO 14040 and ISO 14044.

2. Product Life Cycle Description

The key raw materials are fiber glass strands, MDI and a polyol blend. A pultrusion process is used to manufacture the frame, where the reinforcement material composed of fiberglass roving is in a continuous strand form. The fiberglass is wetted by the polyurethane liquid resin. The resin saturated fiberglass is then pulled through a heated die system, where the polyurethane resin combines with fiberglass to form a window lineal. After the lineal sections are hardened, the final lineals are further pulled down the pultrusion line and cut with saws into desired lengths. Glass panes and ancillary fittings are then added in the assembly operation of the window manufacturing plant. After packaging and shipment to the building site, the windows are installed. At end-of-life, the GThurm™ window frame and glass can be removed from the building site and transported to a landfill, or the glass can be removed and transported to a recycling center.

... composite window frames with polyurethane materials from Covestro.

3. LCA System Boundaries



Life Cycle Flow Diagram for GThurm™ Window Assembly

4. Functional Unit

The functional unit of this LCA is one 30 inch by 60 inch operable window (fixed over awning configuration) with double glass glazing of ¼ inch per sheet.

5. Product Specifications

Item	Data	Source
Window dimensions	30" by 60"	Graham Architectual Products, 2011
Glass thickness	2 x 1/4"	
Glass mass*	37.0 kg	
Aluminum frame mass*	20.0 kg	
GThurm™ frame mass*	16.3 kg	
Recycled aluminum used in window frame	40%	

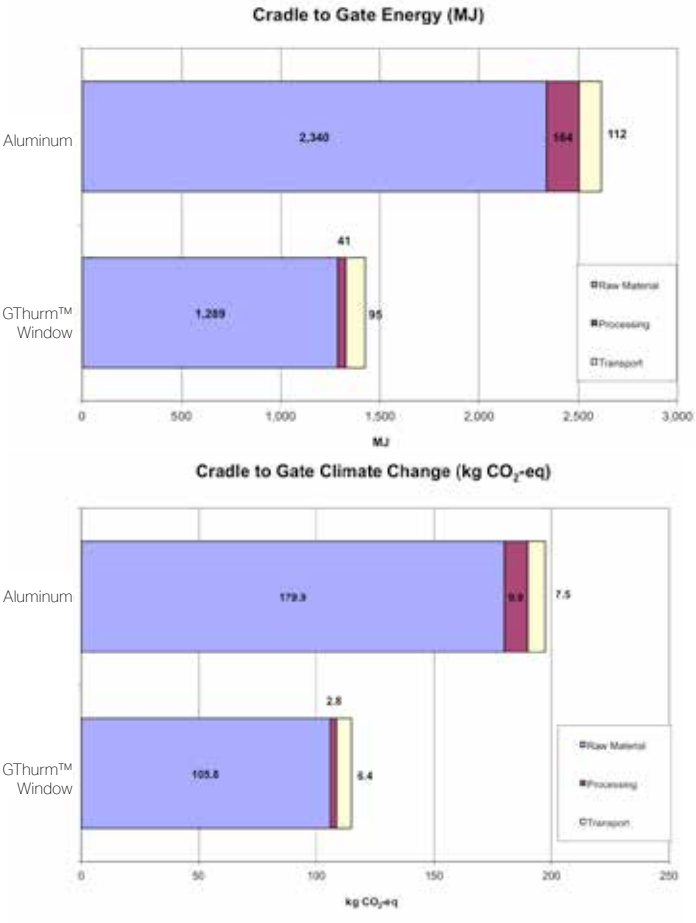
* 10% scrap rate not included

6. End-of-Life Scenarios

Scenario	GThurm™ Window Assembly	Aluminum
Landfill	Both glass and frame	Only glass
Recycle	Only glass	Both glass and frame

7. Life Cycle Assessment Results

(based on 40% recycled aluminum)

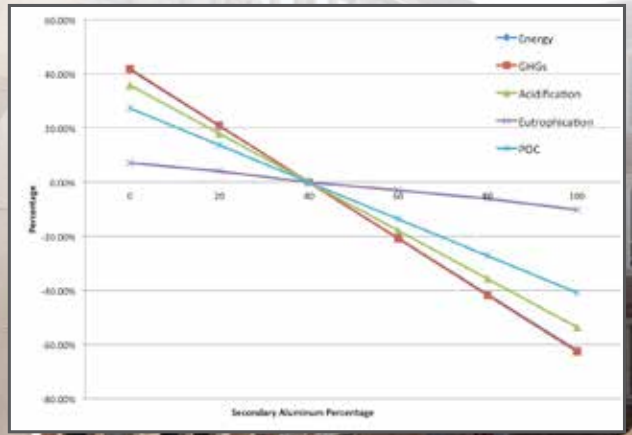


Cradle-to-Gate Comparisons for Aluminum & GThurm™ Windows

(Top: Energy, Bottom: Climate change)

8. Sensitivity Analysis

The percentage of recycled aluminum used has a significant impact on the life cycle results. Break-even points occur when the life cycle energy and impacts (climate change, acidification, eutrophication and smog creation) for aluminum and GThurm™ windows are equal. Sensitivity analysis shows that the break-even points are reached for amounts of recycled aluminum used at 84% (energy break-even), 80% (climate change break-even), 70% acidification break-even), 12% (eutrophication break-even) and 57% (smog creation break-even).



Sensitivity Analysis of Secondary Aluminum Percentage for Aluminum Window

The Break-even Point Analysis

(Recycled Aluminum Weight%)

Energy	Climate Change	Acidification	Eutrophication	Smog Creation
84%	80%	70%	12%	57%

9. Conclusions

When the aluminum window has a 40% secondary aluminum content, the GThurm™ window has lower energy and environmental impacts compared to an aluminum window for both the cradle-to-gate and overall life cycle. For both windows, raw materials have the most significant energy and environmental impacts, making up about 90% of the cradle-to-gate life cycle impacts and overall life cycle impacts.

The comparison of use phase thermal performance of each window was not included in the scope of this study, as such a comparison involves complex whole building energy analysis and associated energy simulation tools for buildings. Such analysis is not part of traditional LCAs, but would need to be performed to determine the impact of window use phase thermal performance for a specific type of building and geographical location.

10. References

American Chemistry Council (2010) *Cradle-to-Gate Life Cycle Inventory of Nine Plastic Resins and Four Polyurethane Precursors*

Covestro LLC and Graham (Feb. 2012) *Life Cycle Assessment of the GThurm™ Window vs. Aluminum Window Assemblies*

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