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FOAMS AND SUSTAINABLE BUILDINGS: A COMPARATIVE LCA STUDY

In this work the environmental impact of various insulation and foam cores have been evaluated by method of the Life Cycle Assessment (LCA). The benefits of novel polyethylene terephthalate (PET) foams are demonstrated well, especially when the PET foam is made of post consumer material, r-PET. Furthermore, the potential of environmentally friendly foams is evaluated for green building scenarios, such as the LEED certification.

¬ Introduction

The goal of this study was to evaluate existing insulation and foam cores in terms of environmental impact (carbon footprint), and compare them with the novel polyethylene terephthalate (PET) foams. Life Cycle Assessment (LCA) is the most common tool used to evaluate how green the product is, what the real environmental impact of the said product is. Polymeric foams have always had a significant role in building and construction as insulation materials, where especially highly insulating polyurethanes (PUR/PIR) and low cost polystyrenes (EPS/XPS) have been widely used. However, recently also the structural characteristics of certain rigid foams have been gaining more and more interest in building sector as foam cores in sandwich structures due to their light weight and relatively good mechanical properties.

For core foams the requirements are often quite different from the requirements of insulation foams, the focus being shifted more to mechanical properties such as compression and shear strength, and in several applications also on fatigue and ageing, and on various impact and creep properties. Typically higher density foams are preferred due to their mechanical superiority. Depending on the foam material, the mechanical properties may be adjusted to meet the demand by adjusting the density and the cellular structure of the foam.

¬ Polyethylene Terephthalate

Polyethylene Terephthalate (PET) is considered as an engineering plastic due to its excellent mechanical and thermal properties. However due to its large demand in textile, bottle and packaging industry it has become a commodity plastic in terms of price and availability. Furthermore thanks to bottle industry, it is also the most recycled plastic material in the world and so called post consumer PET material (r-PET) is available globally with annual capacity of 5 million tons (EU 1 million).

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PET - PolyEthylene Terephthalate:

- REACH compliant
- ROHS compliant
- No EU listed & banned hazardous substances
- No heavy metals
- No carcinogens & mutagenes
- No phtalates, no formaldehyde residues
- No CFC's
- Recyclable
- Good aging properties: no molding, no rotting, no wetting
- No fibers
- Excellent fatique

PET is thermoplastic by nature, and therefore easy to be processed again and again. Even though PET is sensitive to multiple processing cycles, the most novel technologies enable upgrading of the post consumer material to the level of virgin material. As PET is known for its extremely good barrier properties, it is also by nature an excellent insulation material and provides good protection against moisture born damage and condensation.

Core Material	PET	XPS EPS	PUR PIR	PVC	Balsa
Recyclability	+++	+	--	---	---
Aging	++	-	--	+	-
Thermal Conductivity	+++	++	+++	++	+

Foaming of PET to relatively low densities (<300 kg/m^3) is very novel in foaming industry, but developments in polymer upgrading and extruder technology have enabled production of low density (down to 60 kg/m^3) foams with very fine cellular structure. These foams have mechanical properties at least comparable to existing core and insulation foams, but also provide a unique feature by being fully recyclable and furthermore may be made fully out of post-consumer material. This work will evaluate by means of Life Cycle Assessment the environmental benefits of using PET foams in sandwich structures.

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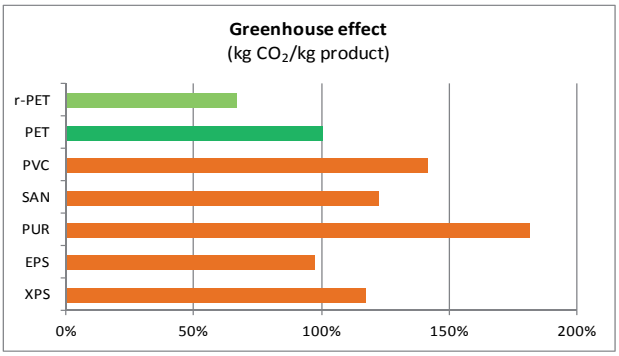
¬ Life Cycle Assessment

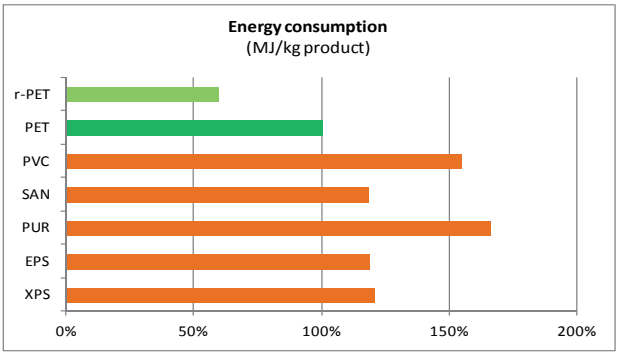
Life Cycle Assessment (LCA) is a method where the whole life cycle of the product is evaluated. In order for the assessment to be complete, a wide range of data is required, from manufacturing of raw materials to final waste scenario, and from transport of raw materials and finished goods to travel of individual employees and heating of office buildings. Several commercial software and databases exist for this purpose, and in this study SimaPro 7.2 was used with EcoIndicator 95 v2.1. The LCA of PET foam is based on actual data from Armacell Benelux from 2011 and for other foams data has been collected from publications and databases.

A typical referred result from LCA is the carbon footprint (the amount of CO_2 emission) produced per unit of the product in evaluation. In this case the carbon footprint of different foams has been compared and the results are shown below in kilograms of CO_2 per one kilogram of foam produced. Here the 100% (PET) correspond to 3,23 kg CO_2 emission.



The light green indicates the amount of CO_2 produced per 1 kg of PET foam made of virgin resin and the dark green the CO_2 produced for PET foam made of post-consumer material. The results indicate that PET foam has a low carbon footprint in comparison.

Similar comparison has been done in respect to total energy consumed and total solid waste produced during the whole life cycle of various plastic foams. The 100% correspond to 71 MJ per produced kilo PET.



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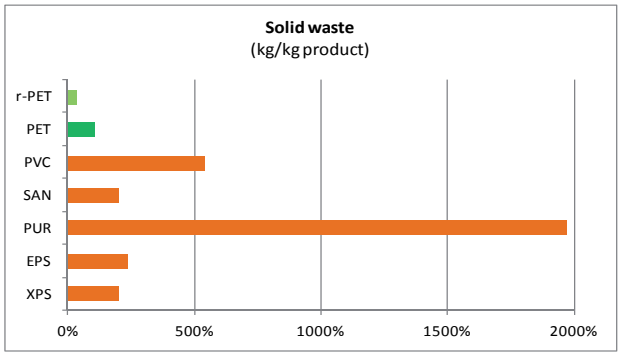
Here the 100% correspond to 0,03 kg waste per produced kilo PET.



Again PET foams exhibit very good environmental characteristics, using less energy in production and producing significantly less waste than comparative materials. In case the foam is used for applications where insulation properties are crucial, the LCA values become very attractive, as the product actually saves the environment after being installed. In such scenario the better the thermal conductivity, the better the results will be.

¬ Green building directives & LCA

Green building (also known as green construction or sustainable building) refers to a structure and process that is environmentally responsible and resource-efficient throughout a life cycle of a building: from building site to design, construction, operation, maintenance, renovation and demolition. Achieving a green building typically requires close cooperation of the design team, architects, engineers, and the client at all project stages.

Several national and international green building directives have been introduced recently, and the American LEED is most widely used of them. LEED (Leadership in Energy and Environmental Design) provides third-party verification of green buildings. It addresses the entire lifecycle of a building by focusing on 6 crucial criteria: site location, water use, energy performance, materials and resources, indoor quality, and innovation & design.

LEED projects have been successfully established in 135 countries and international projects make up more than 50% of the total LEED registered square footage. Several national directives, such as QSAS for Qatar are almost identical to LEED.

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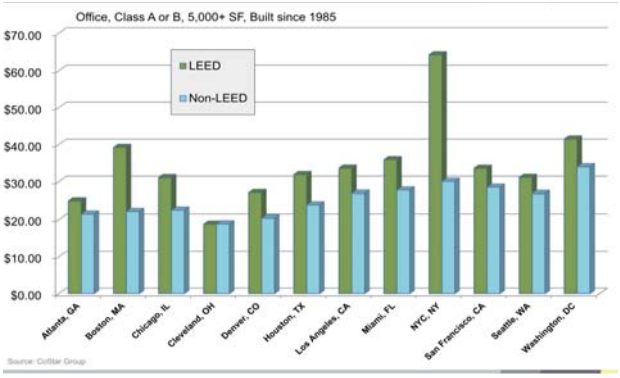
Typically for any commercial buildings and neighborhoods, in order to earn LEED certification, a project must satisfy all LEED prerequisites and earn a minimum 40 points on a 110-point LEED rating system scale:

40 = minimum for certification
50 = silver certificate
60 = gold certificate
80 = platinum certificate

Below diagram depicts the value of LEED certification. Office rental prices throughout USA were reviewed and it was shown that LEED certified buildings are considered more valuable than non-LEED certified buildings.



In respect to environmentally friendly core and insulation foams, such as PET foams, the following LEED criteria may be positively influenced:

- improved insulation efficiency (max. 19 points of 35)
- use of resource and recycled material (max. 7 points of 13)
- potential in innovation & design (max. 4 points of 5)
- LCA data (max. 7 points)

This makes total potential of 37 points out of 100.

¬ Summary

The environmental impact of novel polyethylene terephthalate (PET) foam has been analyzed by means of Life Cycle Assessment (LCA) and compared with traditional core and insulation foams. The results indicate that in all relevant categories the PET foam outperforms existing materials. The impact on LEED certification remains to be defined, but it is not expected to be insignificant.

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green foams by Armacell