Sustainability assessment of windows and curtain walls

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Executive Summary

1.1 General Overview

This study assesses and compares the sustainability aspects of different window and curtain wall framing materials: Aluminium, timber, timber-aluminium and PVC for windows and aluminium, timber and timber-aluminium for curtain walls. The whole life cycle, from manufacturing to use phase and to end of life, is considered. For the modelling of the use phase, standardized room types for residential and office use for two different climate zones (Berlin and Rome) are used as basis for the study. A 3.75 m² double casement window is set as reference for residential buildings. The office curtain wall is defined as a 3-axis mullion-transom construction of about 14 m².

Based on the overall sustainability assessment, this study shows that each framing material presents pros and cons. Indeed, while one material may dominate the economic dimension, it may appear less environment-friendly or may present lower social or technical quality. As a result, no framing material appears as the most sustainable solution for windows or curtain walls.

From an environmental perspective, this study demonstrates that the energy demand during the building operating phase still largely dominates the overall environmental impact of windows or curtain walls on their whole life cycle, as already shown in older studies[1][2][3]. Therefore, from a building sustainability perspective, the optimisation of the contribution of windows and curtain walls to the energy performance of the building appears more essential than selecting a specific framing material.

Influence of windows and curtain walls on Green Building Rating Scheme (GBRS)

The facade assessment is based on sustainability criteria deducted from EN 15643/1 (Sustainability of construction works - Sustainability assessment of buildings) that are broadly used in the European Real Estate sector and which is the most comprehensive scheme in term of indicators and product-level contribution. According to relevant Green Building Rating Schemes, the facade is a crucial part of the building assessment since it contributes up to 10% to the overall sustainability rating of buildings.

Thermal Comfort and Energy Demand during Use Phase

Regarding the thermal comfort and energy demand, the chosen framing systems show very similar characteristics. Only the thermal transmittance differs primarily because of their profile width. As a result,

[1] Richter K., Künniger T. and Brunner K. (1996) Ökologische Bewertung von Fensterkonstruktionen verschiedener Rahmenmaterialien (ohne Verglasung). EMPA-SZFF-Forschungsbericht, Schweizerische Zentralstelle für Fenster- und Fassadenbau (SZFF), Dietikon.

[2] Windsperger A., Steinleichner S. (1997), Piringer M., Ökologische Betrachtung von Fensterrahmen aus verschiedenen Werkstoffen, Institüt für industrielle Ökologie, Wien, St Pölten

[3] Kreissig J., Baitz M., Betz M., Straub W (1998)., Ganzheitliche Bilanzierung von Fenstern und Fassaden, Universität Stuttgart-IKP, VFF, Frankfurt

only tiny differences of approximately 1.5% for their energy demands are obtained during the use phase, within the same climate zone.

Environmental Assessment over the whole Life-Cycle (LCA)

A life cycle assessment is performed to evaluate the environmental impacts of curtain walls and windows. Combining the manufacturing, end-of-life and use phases, the LCA shows similar global warming potential (GWP) for the four types of windows or for the three types of curtain walls whatever their location, Berlin or Rome. For both locations, the use phase, i.e. the energy demand of the reference room, largely dominates the overall GWP results.

Economical Assessment over the whole Life-Cycle (LCC)

According to the life cycle costing assessment, aluminium appears as the best performing material among the curtain wall systems under comparison. Its investment costs and the overall life cycle costs are lower than with timber or timber-aluminium.

For residential use, PVC windows show the lowest investment cost. For the chosen scenario, PVC windows also appear as having the lowest life cycle cost.

1.2 Sustainability Performance

An in-depth set of indicators are derived from the common Green Building Rating tools and are used to evaluate the sustainability performance of the different profile materials.

Environmental Quality

The energy demand during the use phase determines to a large extent the global warming potential (GWP) of curtain wall and window systems. For curtain walls, this use-phase energy demand contributes to approximately 90% on overall results whatever the façade systems and framing materials. For windows, this use phase contribution reaches approximately 98% for all studied systems

Regarding potential risks to local environment, timber is considered as more problematic than aluminium and PVC due to the use of dangerous substances, such as biocides solvents in timber frames. Aluminium and PVC systems reach high quality level in green building certifications schemes regarding the risks of local environment. The use of tin as stabilizer of PVC frames is not considered due to its low share in the current window market.

End of life collection and recycling rates reported in literature vary quite significantly, especially for PVC and wood framing materials. In this study, these variations have been captured respectively in the respective LCA scenarios used in “Mean Practice End of Life” and in “Good Practice End of Life“. Indeed, the

sustainable timber production can be secured through certificates like FSC or PEFC which are already well implemented on the market. However, at the end of life stage, wood frames are still characterised by a low level of reuse or energy recovery and end up mostly as waste in landfill. Hence, the end of life treatment of wood frames still appears as a weak point in the timber life cycle.

Aluminium frames are today systematically recycled into new aluminium products. They have currently a collection rate which is close to 100%[1] due to their high economic value resulting from their ability to be efficiently recycled. Old aluminium frames are sold on the market for a price typically comprised between 50% and 75% of the LME[2] price for primary aluminium. Recycled PVC still demonstrates some technical limitations. Indeed, when producing new profiles, the recycled PVC must be encapsulated in virgin PVC mainly for aesthetical reasons. As a result, recycled PVC cannot fully substitute virgin PVC.

In terms of sustainable use of resources, aluminium and wood are positively positioned.

Economical Quality

For offices, curtain walls made in aluminium appear as the best option mainly thanks to their durability and low maintenance need. For residential use, the lowest life cycle costs were obtained for PVC profiles since the investment costs compared to the other materials are very low. All in all, these variations in life cycle costs are limited since a maximum of 20% of overall cost variations are observed between the various solutions.

Social Quality

No significant difference is evaluated between the profile materials regarding thermal comfort. Concerning indoor air quality, timber curtain walls have negative impacts due to application of paints, biocides and solvents with longer emission decay times.

Best material regarding design possibilities ("architectural innovation") is aluminium. The mechanical properties and the design freedom of timber curtain walls are limited due to lower specific load resistance, which leads to wider and deeper window frames, mullions and transom profiles.

Technical Quality

Aluminium systems fulfil all fire safety requirements with highest quality level, while timber and PVC show severe disadvantages in terms of fire behaviour and smoke emission.

[1] Collection of Aluminium from Buildings in Europe, TU Delft study for EAA , 2004 available at http://www.alueurope.eu/publications-building/
[2] London Metal Exchange

Process quality

The process quality describes the maintenance efforts, construction processes, assemblage and the ease of product acquisition. Regarding weather resistance with high exposition to rain, solar radiation and large variation of air humidity, aluminium is the most useful material with the lowest maintenance needs. In terms of material acquisition for a building construction, wooden curtain walls require in general a longer delivery time in particular for large project developments. For residential buildings, all window systems are largely available.

Summary - In-depth Assessment

The in-depth assessment results in an overview about sustainable performance of different façade and window materials. Based on a full set of indicators, the systems are evaluated considering a typical solution as well as a best practice solution for each material. The advantages and disadvantages of examined systems are rated by credits 0 (negative), 1 (neutral) and 2 (positive). This rating scheme is taken to show an easy overview about the comprehensive performance regarding sustainable material use for curtain wall and window systems.

<u>Office buildings – façade systems</u>

Based on the quantitative methodology defined for this project, aluminium standard curtain wall reaches an overall sustainability performance summing 92% of total credits, against 80% for timber-aluminium and 76% for timber curtain wall. The aluminium curtain wall appears as the best in terms of life cycle costing and presents advantages on technical, functional and design aspects.

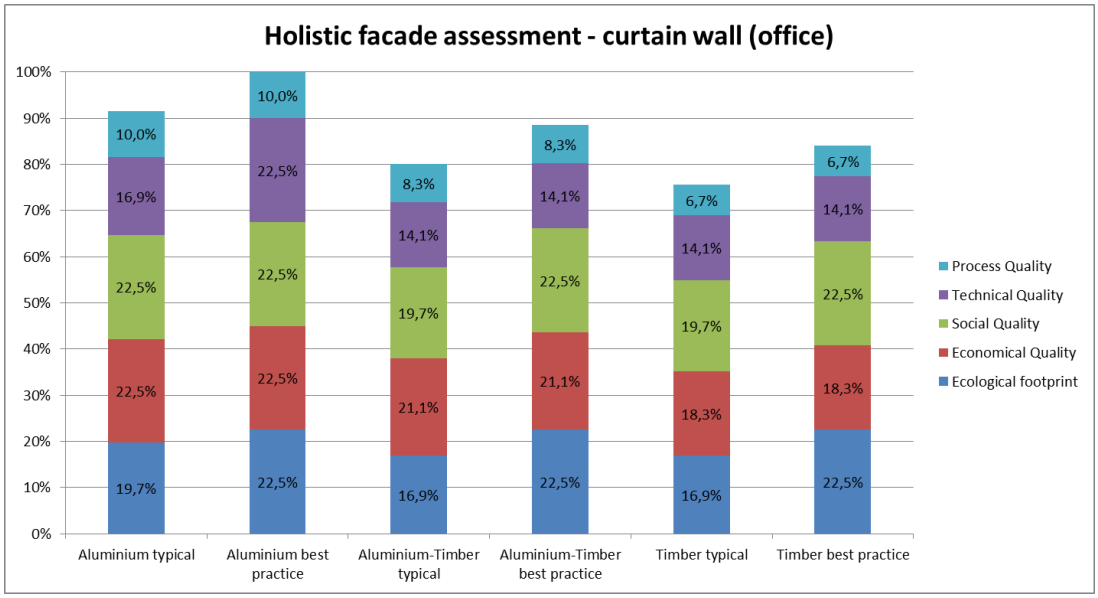

Figure 0-1: Results curtain wall assessment – Office

Residential buildings – window systems

For window systems, this methodology leads to a score of 93% for aluminium standard windows, 83% for Aluminium-Timber, 82% for timber and 84% for PVC. For the best practices, the scores vary from 99% for Al down to 87% for PVC. Considering the fraction of subjectivity associated with the criteria definition, such variation in final results cannot be considered as much significant.

The aluminium standard window appears as the best in terms of technical, functional and design aspects while PVC as the lowest life cycle costing.

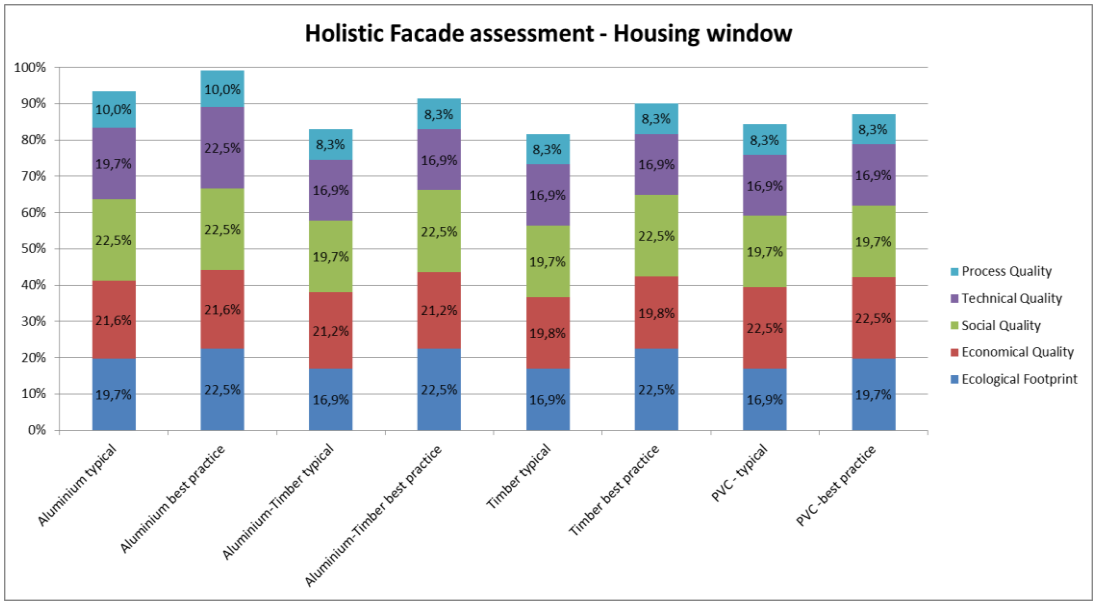

Figure 0-2: Results window assessment – Housing

The full study can be downloaded through the link below, managed by the European Aluminium Association who commissioned this study: http://eepurl.com/baYUlf.

european aluminium association

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