Velfac Windows

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CPD Article

Published on 12 December 2018 10:15

Cradle to Grave: The Comparison of Window Life Cycles

Windows play a significant role in buildings and are available in a wide range of designs and frame materials.

Throughout this article we will aim to understand the frame materials available within the window industry; uPVC, aluminium, timber and composite aluminium/timber.

We will review their impact on the environment, the energy consumption during the manufacturing processes and the overall lifecycle of each material from cradle to grave.

We will also consider the expected durability and maintenance requirements of each material along with the economic benefits.

Key Learning outcomes

- Understanding different materials from which a window can be made.
- Understanding the energy consumption and environmental effects of manufacturing each material.
- Understanding the lifecycle of each material.
- Understanding the maintenance requirements of each material.

1.0 Window materials and environmental impact

uPVC
Polyvinyl chloride (PVC) is a common, strong lightweight plastic material used in construction, made up of repeating units of vinyl chloride. This is typically used in building materials (not inclusive of windows - such as drainpipes, light fittings etc), as it has been plasticized to make it softer and more flexible. uPVC is an unplasticized version of PVC which allows it to be more rigid for the process of becoming a window.

The production of uPVC requires the use of fossil fuels and chlorine gas. uPVC decomposes very slowly and as a waste product it contains environmentally dangerous substances such as cadmium and lead based stabilisers. Whilst the recycling of PVC is a complex procedure due to the presence of the associated polymers and reinforcement materials, it has been shown that uPVC can withstand repeated recycling and can still be used for window profiles.

Aluminium
Aluminium is the most abundant metal in the Earth's crust and it is obtained mainly from bauxite. Properties such as strength, lightness and resistance to corrosion have led to aluminium being a preferred choice of material within the construction industry.

Production generates large amounts of environmentally dangerous pollutants; however, a benefit of aluminium is that it can be recycled repeatedly with little deterioration in quality, whilst using about 7% of the energy needed for its primary production.

Timber
Timber is wood prepared for use as a building material.

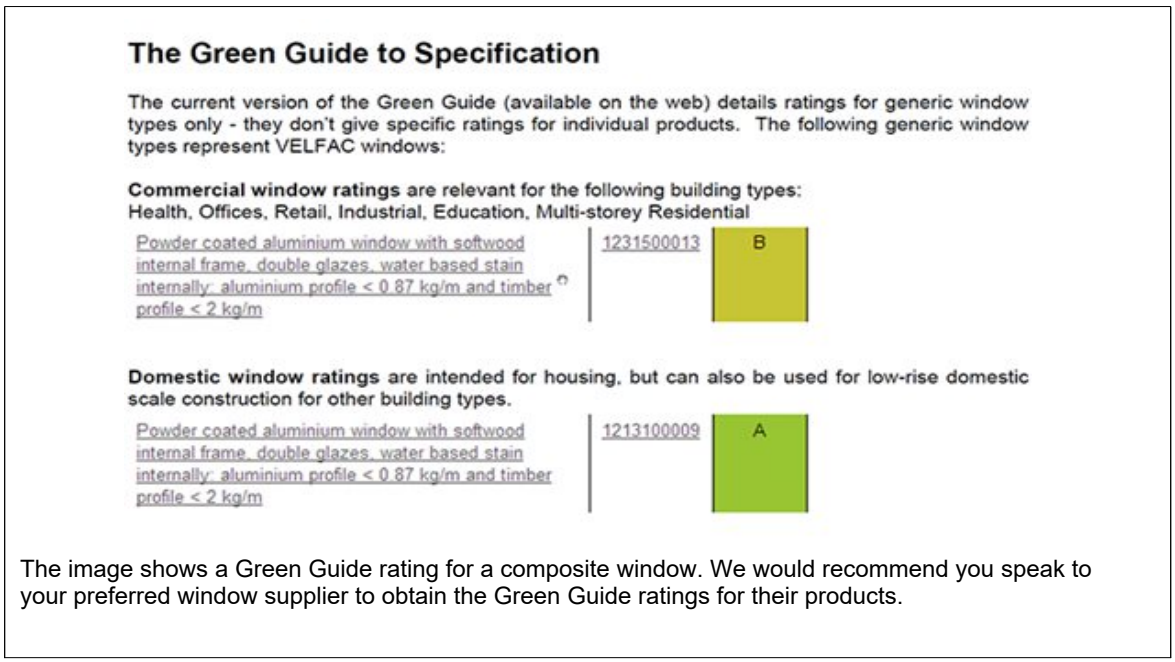
Timber is categorised as either softwood or hardwood, softwood is commonly used for timber structures due to its relatively low cost and ease of workmanship. Hardwoods are typically used for exposed structures where durability is key.

Timber can be defined as a renewable material. Environmental concerns have led to the introduction of sustainable forest management. This ensures that for every tree that is felled, at least another two are planted. PEFC/FSC ratings should be sought when using timber products.

Alu-Timber composite
Composite windows are made from a combination of aluminium and timber.

The theory behind a composite product is that it combines two materials to provide a product which performs better than a singular material.

Whilst the energy process for creating the external aluminium sash is extensive, this is somewhat compensated by the low energy manufacturing process of the internal timber mainframe. Studies have shown that up to 93% of composite window systems can be reused.



The image shows a Green Guide rating for a composite window. We would recommend you speak to your preferred window supplier to obtain the Green Guide ratings for their products.

2.0 Maintenance

uPVC
uPVC windows have relatively low maintenance requirements, the faces of uPVC windows should be cleaned every 6 months with alkaline detergents to maintain their appearance. Hinges and ironmongery should be kept free from dirt and debris and can be wiped down with a dry soft cloth.

Aluminium
Aluminium windows are light and durable. Depending upon use, all aluminium windows will require periodic maintenance over time. Some will require more maintenance than others however general cleaning and periodic lubrication of working parts is all that is required to keep the window in good shape.

Aluminium can become damaged under corrosive conditions especially in coastal or industrial areas. Aluminium windows are therefore generally coated in a polyester powder coat (PPC) or anodized to reduce any corrosive effects.

Timber

Timber windows have the benefit of being the most energy efficient type of window, both in manufacture and thermal performance, they do however require a more intensive maintenance programme compared to other systems.

According to the “wood window alliance advice note maintenance guidelines 2016”: In a moderate climate a white or light-coloured surface coated timber window with a factory-finished opaque system will normally require re-treating after 8 - 10 years. Depending on the degree of exposure, the climate conditions, and where the window is setback in relation to the front façade this can be further reduced in extreme climates.

Alu/Timber composite

Composite windows benefit from providing the thermal performance and warm feel of a timber window, whilst providing the durability and maintenance of an aluminium window.

Apart from a general cleaning and lubrication routine (annually), a less aggressive maintenance schedule is required as the external aluminium section of the window protects the timber from the elements. At some point the internal timber frame will require re treating with a water-based diffusion-open paint but generally this would only be required 15+ years after manufacture, depending on the level of care towards the window taken by the occupants of the building.

Operations and maintenance information should be available upon request from your chosen window supplier.

3.0 Lifecycle and Energy Costs

Window Service life

There is no standard procedure to compare the lifecycle of frames using different materials however Dr G.F. Menzies of the institute for building and urban design at Heriot Watt University provided the “lifecycle assessment of timber, modified timber and aluminium-clad timber windows” in June 2013. In this assessment on Page 34 it was concluded that the expected service life for windows are:

- uPVC - Between 25-35 years.
- Timber - Between 56-65 years.
- Modified Timber - Between 68-80 years.
- Alu-timber windows - Between 71-83 years.

The report identified using Net Present Value (NPV) analysis, that for mild exposures timber windows offer the lowest lifetime cost option, for moderate and severe exposures more durable modified timber, aluminium and Alu-timber composite provide more favourable lifetime cost outcomes.

Our research could not locate any direct information confirming the expected lifespan of an aluminium window however it could be assumed that it would be the same if not better than that of an Alu-timber composite window.

Window Energy Performance

A large economic aspect of windows is the energy cost in the form of heat loss through them, particularly in cold climates.

- uPVC windows have good thermal resistance and provide good energy efficiency achieving between 1.5 W/m2k and 0.8W/m2k.
- Timber windows have excellent thermal resistance and are the most energy efficient type of window achieving between 1.2W/m2k and 0.7W/m2k.
- Aluminium windows have low thermal resistance, unless they are provided with thermal breaks, achieving between 1.9W/m2k and 1.0W/m2k.
- Composite windows exhibit similar thermal properties to that of timber windows achieving between 1.6W/m2k and 0.8W/m2k.

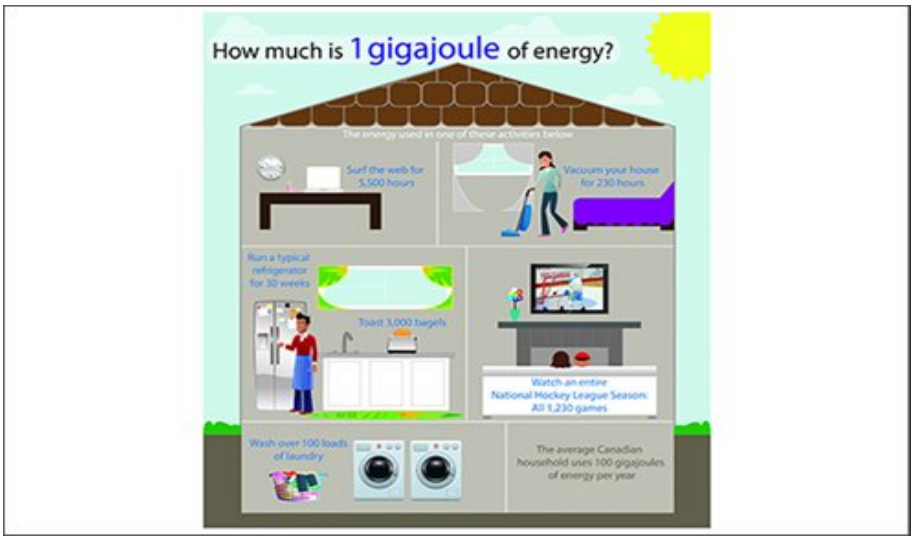
The U-values above are given as a general guide employing double or triple glazing and the use of Argon gas. Variations can apply with the use of different gasses and additional thermal performance materials

Manufacturing Energy Consumption

An embodied energy analysis was carried out by M. Asif BSc MSc, A. Davidson BSc and T.Muneer PhD DSc CEng MImechE FICBSE. “LIFE CYCLE OF WINDOW MATERIALS - A COMPARATIVE ASSESSMENT” Napier University, Edinburgh. Page 9.

The test was carried out on a standard window size of 1.2m × 1.2m to ascertain the amount of energy required in manufacturing of each window type:

- Aluminium windows have an embodied energy of 6GJ.
- uPVC windows have an embodied energy of 2980MJ.
- Alu- timber composite windows have an embodied energy of 1460MJ.
- Timber windows have an embodied energy of 995MJ.



How much is 1 gigajoule of energy?

4.0 Performance of frame materials against weathering and environmental impacts

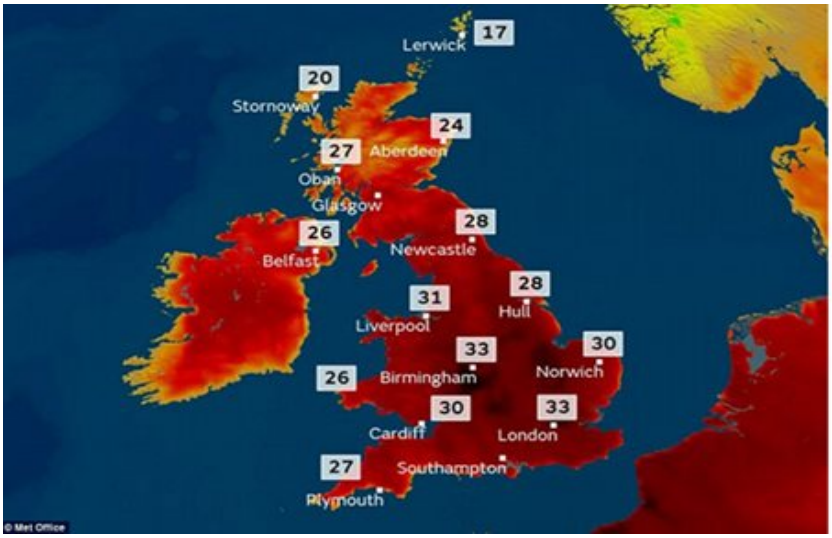
An accelerated testing programme was carried out by M. Asif BSc MSc, A. Davidson BSc and T.Muneer PhD DSc CEng MImechE FICBSE. “LIFE CYCLE OF WINDOW MATERIALS - A COMPARATIVE ASSESSMENT” Napier University, Edinburgh. Pages 10-13 The test was aimed at comparing the performance of frame materials against weathering and environmental impacts. Since every material has its own degradation parameters, the environmental factors affecting the materials, and the intensity of these degradation factors, differ from material to material. For example, timber and PVC can undergo biological attacks but aluminium has no such threats. Some of the tests carried out were for all materials simultaneously to assess their comparative performance to common degradation factors, while the rest of the tests were focussed on individual materials to assess their performance under particular conditions.

- Uncoated aluminium samples exhibited corrosive effects under humid and high temperature conditions. Powder coated and anodised samples remained unaffected.

- Small timber samples exhibited warping and crevice-opening effects upon exposure to moisture and temperature. However complete timber window units and other sample that had received proper surface treatments revealed no such flaws. UV testing resulted in little discoloration of timber samples.

- PVC samples remained unaffected under humid conditions; however, PVC deteriorated significantly as a result of temperature/humidity and UV tests. The latter test resulted in severe discoloration.

- Aluminium-timber composite samples did not receive any deteriorating impacts under any of these conditions as aluminium itself remained uncorroded due to its coating layers and it kept the wood underneath protected from adverse conditions.



Environmental change is leading to extremes in temperature across Europe and the UK. Consideration needs to be given on how this will impact on materials.

5.0 Conclusion

Throughout the article we have aimed to provide a balanced understanding of the four most common types of window construction we see in the industry today, and consider how each type of window varies in relation to energy consumption, environmental impact, lifecycle and maintenance.

This underlying message of sustainable design is becoming more and more apparent over recent years. It was noted in 2009 by the international energy agency that the worlds energy demands had doubled from the previous 40 years and the ever-increasing amounts of fossil fuels used to meet this demand has had, and is still having, a severe impact on the climate (IPCC 2007). In 2016 the domestic sector alone accounted for 29% of final energy consumption in the UK, and 37 million tonnes of carbon per annum was produced UK-wide with buildings accounting for over 40% of all UK carbon dioxide emissions. Couple this with as many as 250,000 new homes needed each year to cope with a growing population, it is no surprise that reducing these emissions is currently a key focus, and improving energy efficiency has been identified as being the cheapest, cleanest and safest way of doing this.

It should be the supplier's responsibility to ensure that their window system embodies sustainable design and manufacture, with every component of the window system chosen to limit the impact on the environment, and promote the lifecycle of the window.

By understanding this, along with taking project specific requirements into account such as building location, acoustics, M & E requirements, specifiers and contractors can make informed decisions on the appropriate materials and window systems chosen for use on their projects.

Without sustainability at the forefront of our minds it hard to know what our world will become.