NK Windows – PVC and the Environment

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PVC (polyvinyl chloride) is a common, strong and lightweight plastic with an extremely wide range of use cases. It is made softer and more flexible by the addition of plasticisers. If no plasticisers are added, it is known as uPVC (unplasticised polyvinyl chloride), PVC-U, rigid PVC, or vinyl siding in the U.S.

PVC's long history

First produced commercially in the late 1920s, PVC has become one of the most widely used polymers in the world and represents a highly efficient conversion of raw materials. Due to its versatility, PVC is used across a broad range of industrial, technical and everyday applications from window profiles and pipes to credit cards, water bottles and blood bags.

PVC is widely used in medical applications globally.

The first commercially available windows were installed in Germany in 1959. While the technology for producing these windows has naturally advanced over the years with, for example, the introduction of better performing acrylic-based impact modifiers, some of these earlier uPVC windows are actually still in use. Additionally, over 60% of European homes now have uPVC windows and doors.

PVC family and the environment

uPVC is part of the wider PVC family of polymers.

PVC is a versatile and resource efficient thermoplastic with the widest range of applications of any of the plastics family making it useful in virtually all areas of human activity. PVC products can be rigid or flexible, opaque or transparent, coloured and insulating or conducting. PVC should not be viewed as a single product or compound - but rather a family of products tailor-made to suit the needs of each application with attributes to suit.

Viewed across its life cycle, PVC is highly competitive in terms of its environmental impact. Several recent eco-efficiency and Life Cycle Assessment (LCA) studies on the most common applications show that, in terms of energy requirements and GWP (Global Warming Potential), PVC is at least equal to alternative products. In many cases, it shows advantages both in terms of total energy consumption and lower CO^2 emissions.

A unique advantage of PVC compared to other materials is the possibility of changing the formulation, to improve the safety and eco-efficiency of the final product, while maintaining the same level of technical performance.

French physicist and chemist Henri Victor Regnault accidentally discovered PVC in 1838. Its chemistry has been understood since the end of the 19th century and produced commercially since the late 1920s.

Feedstock is byproduct

The core materials for PVC production – chlorine and ethylene – are both by-products of other manufacturing processes. Chlorine is a by-product of caustic soda production with source raw materials of seawater and rock salt. Ethylene is a by-product of the petroleum refining industry i.e. PVC is not directly dependent on crude oil. Additionally, the high chlorine content of PVC (57% by weight) provides its impressive fire resistance and retardation characteristics.

PVC historical criticism

Historic criticism of PVC has come in 3 basic areas:

1. Hazards involved in the production process
2. The additives used in giving PVC its many different properties
3. Hazards associated with the disposal of PVC products at their end of life

The chemistry of PVC has been understood since the end of the 19th century. The plastic was first commercially produced in Europe in the late 1920s and since then has undergone continuous development and improvement. PVC's adaptability comes from its molecular structure. This makes possible many different blends of ingredients providing a range of properties, enabling the PVC industry to respond to the commercial and technical needs of many market sectors. This adaptability also allows the industry to respond to environmental requirements.

Like many other materials, the manufacture of PVC involves the use of potentially hazardous chemicals. Such manufacturing methods are very closely regulated in Europe. The European PVC industry, under the auspices of the European Council for Vinyl Manufacturers (ECVM), have signed a European Industry Charter, committing to tighter limits on emissions from PVC production facilities. As part of the Vinyl 2010 Voluntary Commitment, compliance with the Charter is being audited by an independent Norwegian foundation, Det Norsk Veritas (DNV). Today, PVC is probably the world's most researched plastic/polymer.

Manufacturing facts: Extremely strict European guidelines govern PVC manufacture and workers' exposure.

Application facts: A substantial volume of research and experience support the fact that PVC can be safely used even in the most sensitive of applications (such as medical devices).

End of life facts: PVC is one of the most recyclable of polymers but can be disposed of, if required, quite safely.

Life cycle assessment (LCA)

LCA is a method used to evaluate the environmental burdens associated with a product, process, or activity which includes the identification of energy, materials and substances used and emissions and wastes released to the environment, over the whole life cycle of the product, process or activity. In short LCA is the compilation and evaluation of the inputs, outputs and the potential environmental impacts of a product system throughout its life cycle.

A Life Cycle Assessment of PVC and of Principal Competing Materials[1] study commissioned in 2004 by the European Commission provides highly valuable insight to environmental impacts of PVC, aluminium and wood through the production, use and disposal phases in the EU. The overall goal of the study was to compile an overview of the publicly available information on Life Cycle Assessments (LCA) on PVC and competing materials.

Findings include:

- The very high use of energy for the electrolysis of aluminium makes it a very environmentally unfriendly option contributing to global warming emissions. Additionally, aluminium's eutrophication and acidification emissions are worst in class compared to PVC and wood window frame options.
- The coating of wooden window frame surfaces causes significant eco-toxicity emissions. Even water based paint systems do not manage to substitute solvents entirely, and not all possible paint systems give enough

1 http://www.pvc.org/upload/documents/PVC-final-report-lca.pdf

protection for window applications. Regular re-applications of surface treatment during the use phase are required for it to maintain its technical and thermal properties.

- Conversely PVC window frames contribute considerably less to environmental problems and require no coating or environmentally unfriendly maintenance. See Appendices A and B for tabulated comparisons.

PVC vs aluminium

Aluminium is produced from the non-renewable ore, bauxite. Primary, aluminium production requires a great deal of energy (225MJ/kg) and it generates huge amounts of environmentally dangerous pollutants like carbon dioxide, acidic sulphur dioxide, along with polyaromatic hydrocarbons (PAHs) fluorine and dust.

Bauxite mining for aluminium production comes at considerable environmental cost

Aluminium windows are light and durable made of extruded profiles but because they are highly heat conductive they are not well suited to temperate climates and houses fitted with them require additional energy consumption for heating and cooling and often suffer condensation problems.
Although New Zealand does produce aluminium, all raw materials are imported: bauxite/alumina from Australia, crude oil from Alaska USA, and coal from China and Korea – again adding to the environmental impact of aluminium windows.

Aluminium production is extremely resource hungry

PVC vs wood

Most people believe using wood is the most environmentally friendly option for window frames because of the "natural is better than synthetic" assumption. As discussed above, if wooden frames are to maintain their technical and thermal properties they require regular treatment using chemicals very environmentally unfriendly.
Interestingly, DEFRA (Department for Environment Food & Rural Affairs - UK government) commissioned a study on the life cycle analyses of PVC and timber in window profiles. In analysing the various impacts across the lifecycle, it was found that there are only marginal differences in the environmental performance between the two. Although trees are not a scarce resource, the facts around de-forestation, particularly the logging of ancient or old-growth forests warrant further understanding. The logging of these forests can lead to a decrease in biodiversity, as habitats are destroyed in the logging process. Tree plantations are grown, in their place, for the intense farming of timber and wood products. This itself can lead to soil erosion and nutrient degradation, vulnerability to pest attack, reduction in water supply, over use of fertilisers and social impacts. Additionally, caution needs to be taken in accepting claims of an increase in forested areas. Scandinavia presents an interesting example relating to the misconceptions surrounding so-called 'sustainable forestry'. Eco watchdog, Friends of the Earth comment: "More trees are not a good

thing when they are replacing valuable wildlife habitats. Scandinavia has now just 5% of its original old-growth forest remaining, yet this is still being logged. Also almost 50% of Finland's peat bogs have been drained, mostly for planting managed forests."

Habitat destruction and removal of ancient forests for timber have devastating environmental impacts, despite re-planting.

Conclusion

The European PVC industry is highly regulated, highly evolved and stacks up very favourably against aluminium and wood. Development of PVC has come along way since its inception nearly 190 years ago, but particularly since year 2000 due to various European safety initiatives and regulations. It is safe in manufacture, use and disposal.
Conversely, despite attempts to develop alternative production methods for aluminium, it is still manufactured the same way it was 100 years ago – at significant cost to the environment. Alternative production methodologies have not proven to be commercially viable.
Wooden window frames require regular chemical-based maintenance for them to maintain performance. Additionally, there are a number of poorly understood (by the public) environmental costs associated with timber frames including habitat destruction, loss of ancient forests, erosion, over fertilisation and alluvial run-off.

Aluplast – NK Windows uPVC supplier

NK Windows partner with German-based Aluplast GmbH for uPVC profile systems. They are world-leaders in the field and focus solely on uPVC for window and door systems. Their products are used around the globe. The raw materials used by Aluplast for window profiles are based on a calcium-zinc chemical stabiliser that is strictly lead-free. With this eco-friendly stabiliser and Aluplast's involvement in "VINYL 2010", that among other things dictates the use of recycled materials in their plastic profiles, Aluplast offers window systems that can be fabricated and recycled in an ecologically sound way.
www.aluplast.net

aluplast®
Kunststoff-Fenstersysteme

Appendix A

Title: Ganzheitliche Bilanzierung von Fenstern und Fassaden, 1998

Publisher: Verband der Fenster- und Fassadenhersteller e. V., Bockenheimer Anlage 13, D-60322 Frankfurt, Germany

Functional unit: 1 window construction including glass and fittings, size and function specified

Objective: To describe the environmental impacts, with all relevant influencing factors during the whole life cycle of windows and facades.

Table 1: Potential environmental impacts related to the production, use and recycling of window frames normalised to 100% of the highest contributing material in production per impact.

				Wood	
		PVC production	**Aluminium production**	**Wood production**	**Wood use**
Environmental Impacts	**Global warming potential** (GWP)	51%	100%	25%	1%
	Nutrification	51%	100%	46%	1%
	Acidification	55%	100%	58%	1%
	Summer smog	18%	28%	100%	15%
	Municipal waste	100%	74%	34%	4%
	Hazardous waste	11%	9%	100%	1%
	Primary energy (non-renewable)	55%	100%	34%	2%
	Primary energy (renewable)	7%	69%	100%	0%

Appendix A – continued

The following examples are given as clarification of the percentages in the table above. In the production phase, the aluminium frame contributes most in terms of GWP (100%), whereas PVC contributes only 51% as much of this impact and wood only 25% as much.

Notes:

Aluminium:

- Considerable share of the global warming emissions comes from the use of energy for the electrolysis of aluminium during production.
- Considerable share of eutrophication and acidification emissions comes from PA 6.6 fittings (PA 6.6 is a specific polyamide made from adipic acid and hexamethylenediamine)

Wood:

- The coating of the wood surface causes significant emissions in the category of eco-toxicity. Even water based paint systems do not manage to substitute solvents entirely, and not all possible paint systems give enough protection for window applications. Regular re-applications of surface treatment during the use phase are required for it to maintain its technical and thermal properties.

PVC:

- No coatings are required and maintenance of the PVC surface requires pH neutral soapy wash only.

Appendix B

Title: Erarbeitung einer Vergabegrundlage für ein nationales Umweltzeichen Fenster, 2000

Publisher: Institut für Kunststoffprüfung und Kunststoffkunde (IKP), University of Stuttgart, Hauptstr. 113, D-70771 Echterdingen, Germany

Description: The study shows LCA analyses of PVC, aluminium and wood window frames over the whole life cycle in aggregated impact categories.

Table 2: The focus of the study was to identify environmental weak-points in the life cycle to give a basis for the awarding of ecolabels (according to ISO 14024) for window constructions. Table 2 provides an overview of the findings of the study.

	Impacts	**PVC**	**Aluminium**	**Wood**
Production	**Total primary energy**	Medium	Highest: 60-70% higher than PVC	Lowest: half of PVC
	Global warming	Medium	Highest	Lowest: half of PVC
	Acidification	Medium	Highest: approx. 50% higher than wood & PVC	Medium
	Nutrient enrichment	Medium	Highest: approx. 50-100% higher than wood & PVC	Medium
	Photochemical ozone formation	Lowest: equal to aluminium	Lowest	Highest: more than double aluminium & PVC
Disposal	**Total primary energy**	Low	Highest	Low
	Global warming	Low	Highest	Low
	Acidification	Low	Important	Negligible
	Nutrient enrichment	Low	Important	Negligible
	Photochemical ozone formation	Low	Low	Negligible

Appendix B continued

Notes:

- The main impacts are in the production of the materials/window frames for all materials.
- The aluminium frame has the highest consumption of primary energy due to the electrolysis process, and consequently global warming, acidification and nutrient enrichment. The other materials are almost equal in these impacts.
- Generation of summer smog is highest for wood frames and lowest for aluminium and PVC.
- The coating of the wood surface causes significant emissions in the category of eco-toxicity. Even water based paint systems do not manage to substitute solvents entirely, and not all possible paint systems give enough protection for window applications. Regular re-applications of surface treatment during the use phase are required for it to maintain its technical and thermal properties.