ENVIRONMENTAL PRODUCT DECLARATION

as per ISO 14025 and EN 15804

Owner of the Declaration	QKE Qualitätsverband Kunststofferzeugnisse e.V. EPPA European PVC Window Profiles and Related Building Products Association ivzw
Programme holder	Institut Bauen und Umwelt e.V. (IBU)
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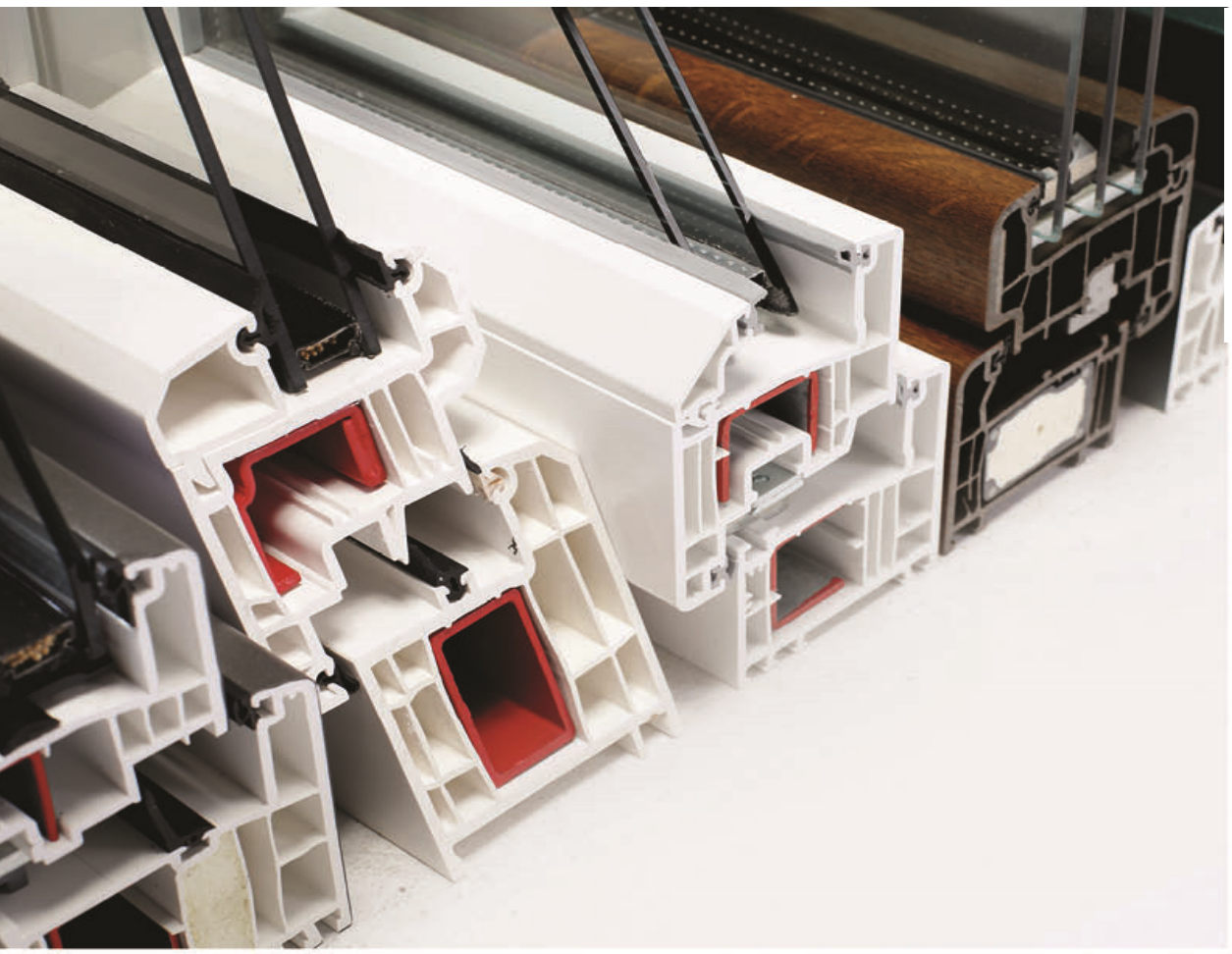
Valid to	16/03/2021

PVC-U plastic windows
with the dimensions 1.23 x 1.48 m
and insolated double-glazing
QKE e.V.
EPPA ivzw

www.bau-umwelt.com / https://epd-online.com

Institut Bauen und Umwelt e.V.

ECO PLATFORM EPD EN 15804 VERIFIED



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EPPA

QUALITÄTSVERBAND KUNSTSTOFFERZEUGNISSE E.V.
FÜR LANGLEBIGE KUNSTSTOFFPRODUKTE

1. General Information

QKE - EPPA

Window (1.23 m x 1.48 m) with insolated double-glazing

Programme holder
IBU - Institut Bauen und Umwelt e.V.
Panoramastr. 1
10178 Berlin
Germany

Owner of the Declaration
QKE - Qualitätsverband Kunststofferzeugnisse e.V.
Am Hofgarten 1-2; 53113 Bonn
Germany

EPPA - European PVC Window Profiles and Related Building Products Association ivzw
Avenue de Cortenbergh 71; 1000 Brussels
Belgium

Declaration number
EPD-QKE-20150313-IBG1-EN

Declared product / Declared unit
PVC-U single-sash window, with the dimensions 1.23 m x 1.48 m, insulated double-glazing and variable profile surface (white, painted, laminated with PVC foil or coated with PMMA).

All planned replacements of the components - sealings, fittings and glazing - are included in the declared unit.

This Declaration is based on the Product Category Rules:
Windows and doors, 11.2015
(PCR tested and approved by the SVR)

Scope:
This EPD is an association EPD. The weighted average from the manufacturers' specifications submitted by eleven member companies from 21 sites in seven countries was used as the data basis for the manufacture of plastic profiles. The recorded production volume represents a share of approximately 70% of the production of all system houses affiliated with the QKE and EPPA associations and therefore nearly 60% of European production.

The scope covers different configurations of both profile reinforcement and surface treatment. Window constructions using glazing blocks as well as bonded glazing systems are included. This EPD thus covers all designs for PVC-U windows that conform to the stated requirements. This document is translated from the German Environmental Product Declaration into English. It is based on the German original version EPD-QKE20130313-IBG1-DE. The verifier has no influence on the quality of the translation.

The following companies were involved in the collection of data:

System houses:
aluplast GmbH, D - Karlsruhe
Deceuninck nv, B – Hooglede-Gits
GEALAN Fenster-Systeme GmbH, D- Oberkotzau
Internorm Bauelemente GmbH, A – Traun
hapa AG, D - Herrieden
L.B. Profile GmbH, D – Herbstein
profine GmbH, D – Pirmasens
Rehau AG + Co., D – erlangen
Schüco Polymer Technologies KG – Weißenfels
Stöckel GmbH, D - Vechtel
VEKA AG, D – Sendenhorst

Window manufacturers:
BE Bauelemente GmbH, D – Leopoldshöhe-Greste
Internorm Bauelemente GmbH, A – Traun
Stöckel GmbH, D - Vechtel
TMP Fenster + Türen GmbH, D – Bad Langensalza
WERU GmbH, D – Rudersberg
Wirus Fenster GmbH & Co. KG, D – Rietberg

Issue date
17/03/2016

Valid to
16/03/2021

The owner of the declaration shall be liable for the underlying information and evidence; the IBU shall not be liable with respect to manufacturer information, life cycle assessment data and evidences.

Verification

The CEN Norm /EN 15804/ serves as the core PCR
Independent verification of the declaration according to /ISO 14025/
☐ internally ☒ externally

Prof. Dr.-Ing. Horst J. Bossenmayer
(President of Institut Bauen und Umwelt e.V.)

Dr. Burkhart Lehmann
(Managing Director IBU)

Dr. Eva Schmincke
(Independent verifier appointed by SVR)

2. Product

2.1 Product description

The declared product is a single-sash tilt & turn window with the dimensions 1.23 x 1.48 m and insulated double-glazing.

The windows consist of a PVC frame profle with a transparent glass filling. A variety of materials are used to reinforce the frame profiles: profiles made from steel or aluminium, polyurethane foam or glass fibre extruded into the PVC-U material.

The surface of the frame can vary in design: laminated with PVC foil, coated with PMMA (polymethyl metha acrylate) or painted. These can produce white or coloured, textured or smooth surfaces.

The seals are made from plasticised PVC, EPDM (ethylene propylene diene monomers) or TPE (thermoplatic elastomers), the fittings from steel.

For the window a reference service life of 40 years is assumed. The respective useful lives of the components - glazing, seals and fittings - is shorter, however, which means that these will need replacing during the reference service life of the window unit. These planned replacements of individual components are also included in the declared unit.

This EPD does not relate to a specific product from one manufacuturer, but confirms the average environmental quality for all PVC-U windows from member companies of the EPPA und QKE associations.

Further specific data can be found in the relevant manufacturer's product description.

2.2 Application

Windows are used in the outer shell of buildings for lighting, ventilation and protection from the elements.

2.3 Technical Data

Technical construction data

Name	Value	Unit
Pane construction	4 / 16 / 4	mm
Heat transfer coefficient glass Ug according to /EN 674/, /EN 675/	1.1	W/(m²K)
Total energy transmittance g	62	%
Heat transfer coefficient window Uw according to /EN 674/, /EN 675/	1.3	W/(m²K)
Watertightness according to /EN 1027/, /EN 12208/	4A - 9A	Class
Mechanical stress (Durability) according to /EN 1191/, /EN 12400/	10 000 - 20 000	Cycles

For further technical construction data, only the minimum requirements that apply to quality-assured windows according to /RAL-GZ 695/ are cited below.

Depending on the design of frame, seals and fittings, considerably higher performance classes can be achieved by the windows produced.

- Min. air permeability according to /EN 1026/, /EN 12207/: Class 2
- Min. resistance to wind load according to /EN 12211/, /EN 12210/: Class B1

Further specific data can be found in the relevant manufacturer's product description.

2.4 Application rules

Placing on the market within EU/EFTA (with the exception of Switzerland) is subject to the /Construction Products Regulation/ (EU) Nr. 305/2011. The products must have a declaration of performance compliant with the harmonized product standard /EN14351-1/ and the CE marking.

Usage is governed by the relevant national rules.

2.5 Delivery status

This EPD relates to plastic windows with the dimensions 1.23 x 1.48 m. The face area is 1.82 m².

2.6 Base materials / Ancillary materials

The base materials of the declared unit are:

Name	Value	Unit
Glazing	47.1	mass%
Frame material PVC-U	28.2	mass%
Reinforcement steel	18.9	mass%
Fittings steel	4.5	mass%
Seals PVC	1.0	mass%
Glazing blogs / screws	0.3	mass%

The raw materials and additives used to manufacture the PVC-U frame material can be found in the following overview:

PVC formulation

- 81.0 mass% PVC
- 8.1 mass% Filler (chalk)
- 4.9 mass% Impact resistance modifiers
- 2.8 mass% Calcium/zinc stabilisers
- 3.2 mass% Pigment titanium oxide (TiO_2)

Recycled material obtained from used windows is used to manufacture proprietary profiles. These profiles can contain more than 0.1 % lead compounds. These are treated as SVHC (Substances of Very High Concern) in accordance with /REACH/.

2.7 Manufacture

Plastic windows are made from a variety of individual components: each window consists of a PVC-U frame with seals, the glazing, the fittings and, where required, the reinforcement.

PVC-U profiles for window frames are manufactured in an extrusion process from a mixture of PVC powder and additives. These protect the PVC from damage during processing and give the profile the necessary properties (impact resistance, colour, weathering stabiblity etc.).

The PVC powder used to manufacutre the frames is a widely used bulk plastic and is obtained through polymerisation. Due to its chemical structure, PVC contains a high proportion of the halogen chlorine.

The majority of window frames are made from white rigid PVC-U profiles. Some frames are manufactured from profiles that are also laminated with PVC film, coated with PMMA or painted.

Seals are generally attached to the window profiles in a coextrusion process and consist of plasticised PVC, EPDM or TPE.

The window profiles are delivered in standard lengths to the window manufacturers, where they are sawn to the length actually required for the particular window. Where necessary, steel reinforcement is inserted and screwed in.The profiles are then welded, the fittings attached and the pane and glass retaining strips fitted. the window can now be supplied and fitted.

The steel for manufacturing fittings is largely optained from iron ores in a blast furnace process by means of reduction with coke.

The basic raw material for manufaturing the glazing is quartz sand to which various fluxing agents and oxidants (Soda ash, sodium sulphate, potash etc.) havebeen added. In a further proceeding step, the molten raw glass is floated on molten tin, from which a flat strip of glass can be continously produced (float glass process).

Quality monitoring

The member companies of QKE e.V. are subject to external quality monitoring within the framework of voluntary self-regulation. Plastic window systems that bear the RAL quality mark according to /RAL-GZ 716/ are listed on the website at gkfp.de.

2.8 Environment and health during manufacturing

Of all the constituents of PVC formulations, only the calcium/zinc stabilisers have to be classified and marked as follows in accordance with /GHS/:

H302: Harmful if swallowed
H318: Causes serious eye damage
H317: May cause an allergic skin reaction
Pictogram: Corrosive and irritating

2.9 Product processing/Installation

The finished windows are transported to the construction site and installed. Screws made from zinc-plated steel and polyurethane foam are required for each window unit for installation.

2.10 Packaging

The profiles – if they are not going to be processed further at the same site – are transported to the window manufacturer, usually on reusable steel pallets. Disposable wooden pallets are used in isolated cases. Cardboard, PE film and foam pads are also used when transporting the individual components to the window manufacturer.

Polyethylene foam pads, a cardboard edge protector, polypropylene load retaining straps, aluminium or steel clamps and PE stretch film are used as packaging materials for each window unit for assembly.

2.11 Condition of use

Plastic windows are durable and long lasting. There is no change in the material composition while the product is being used.

2.12 Environment and health during use

PVC-U frame materials do not have a negative influence on the environment and health. If the use of solvent-free components is ensured further down the supply chain, this also applies for the final window product.

2.13 Reference service life

The reference service life of the declared PVC-U plastic window is 40 years according to /BBSR/. The technical life of certain individual components is thus exceeded; as a result, there will be three replacements of seals and one replacement of fittings and glazing during service life.

2.14 Extraordinary effects

Fire

Plastic windows are classified in classes B - E for fire behaviour (depending on the surface characteristics), s3 for smoke gas development and d0 for burning droplets in accordance with /EN 13501-1/.

Fire protection

Name	Value
Building material class	B - E
Burning droplets	d0
Smoke gas development	s3

Plastic windows therefore meet the requirements of B2 "normal combustibility" according /DIN 4102-1/ as a minimum.

Water

No negative effects on the environment are to be expected in the event of unforeseen exposure to water, such as in the case of flooding.

Mechanical destruction

No negative effects on the environment are to be expected in the event of unforeseen mechanical destruction.

2.15 Re-use phase

The most important processes in the reuse phase of PVC-U are the recycling of materials and landfilling. In addition, PVC can also be thermally utilised.

A large amount of the steel used in the fittings and reinforcement is also recycled for materials.

Glazing can also be recycled very well. Otherwise it is mostly disposed of in landfill sites, but a small amount is also sent for incineration.

2.16 Disposal

The individual components of the window can be disposed of after use as a nonhazardous waste. The waste codes according to European Waste Catalogue /EWC/ are as follows:

- 17 02 02 Glass
- 17 02 03 Plastic
- 17 04 05 Iron and steel

2.17 Further information

Possible sources for further information are available from the associations' websites

www.qke-bonn.de
www.eppa-profiles.eu

and the websites of the system houses and window manufacurers.

3. LCA: Calculation rules

3.1 Declared Unit

The declared unit is a window 1.23 x 1.48 m (reference window in accordance with /EN 14351-1/) with a mass of 55 kg.The frame proportion is 25.7%. Planned replacements of the glazing, fittings and seals during a service life from 40 years are included.

Declared unit

Name	Value	Unit
Declared unit	55 kg	Reference window 1.23m x 1.48m, frame portion 25% to 35%

3.2 System boundary

The entire life cycle of the product "from cradle to grave" is considered.

Manufacture

The aggregate view in the form of modules A1-A3 is used for manufacturing. This includes the supply of raw materials, the manufacture of the steel reinforcement, flat glass, fittings and PVC-U profile, all transportation to the window manufacturer, the energy requirements for constructing the windows, and any production waste generated. In particular, consumption for the heating and illumination of production rooms and their adjacent premises is also included.Capital goods (machinery, buildings etc.) are not considered.

Transportation from the manufacturer's gate to the construction site is taken into account in module A4. All processes relating related to the installation of the window in the building are considered in module A5.

Usage

The transmission heat losses occurring during the usage phase are taken into account in module B1. The measures described in 2.13 for replacing window components are taken into account in module B4.

Disposal

All processes relating to the removal, dismantling or demolition of the window from the building, including an initial sorting on the construction site, are accounted for in module C1.

Redistribution transportation from the construction site for the recovery of heat, recycling of materials and disposal in landfill are considered in module C2. Module C3 considers waste treatment, including sorting for recycling.

Landfilling and thermal recycling fall under module C4.

Credit

Finally, module D shows the potential for re-use, recovery and recycling derived from modules C3 and C4.

3.3 Estimates and assumptions

Apart from the assumptions and estimates described in section 4, no further assumptions or estimates are made that will impact or influence the outcome.

3.4 Cut-off criteria

The disregarded input flows are smaller than 1% of both the total mass and the total flow of primary energy. Taken together, they form less than 5% of the total mass or 5% of the total energy.

3.5 Background data

The primary data for profile extrusion and window manufacturing were provided by the members of the declaring associations (see Scope).The background data for raw materials as well as the manufacturing of the PVC, glazing and fittings and all other data originate from the /ecoinvent 2.2/ database.

This database does not allow calculation of the net flows for fresh water consumptions, so the assumptions are based on the /Ecological Scarcity Method/.

3.6 Data quality

The data for the products examined was collected through analyses of internal production and environmental data, by collating LCA-related data within the supply chain for 2013, and on the basis of average data submitted by the associations. The data collected was checked for plausibility and consistency.

The quality of the background data for glass production is considered to be of the greatest importance because the manufacture of glass makes a significant contribution to the production stage A1-A3.

3.7 Period under review

All primary data was collected in 2013.

3.8 Allocation

The data from profilextrusion and window manufacturing is based on the average weighted by production volume.

3.9 Comparability

Basically, a comparison or an evaluation of EPD data is only possible if all the data sets to be compared were created according to /EN 15804/ and the building context, respectively the product-specific characteristics of performance, are taken into account.

4. LCA: Scenarios and additional technical information

The following technical information forms the basis for the declared modules, or can be used to develop specific scenarios in the context of a building assessment if modules are not declared (MND).

Usage (B1) see Chapter 3.2 Usage

The net heat losses caused by the window are taken into account here. These consist of the transmission heat losses and the solar heat gains from the window. The impacts in the use phase depend to a very large extent on the actual climatic and technical circumstances of a specific building. The calculations off the heat losses and gains and the results of the impact assessment are based on parameters for average Central European conditions.

The energy demand during the use phase at the reference location is calculated from the transmission heat losses and the solar heat gains according to /DIN V 18599-2/.

Name	Value	Unit
degree day factor Central Europe	3641	K*d
Solar irradiation	209	kWh/m2

The provision of heating energy was modeled according to the data for German heating requirements: 49% gas, 30% heating oil and 13% district heating. The remaining 8% are added in equal shares to the cited energy sources.

Replacement (B4), renovation (B5)

The replacement of individual components that have reached the end of their technical life according to /BBSR/ is considered in module B4.

Name	Value	Unit
Replacement cycle glazing	1	Number/RSL
seals	3	Number/RSL
fittings	1	Number/RSL

Reference service life

The reference service life of the window as well as the technical service life of individual components according to /BBSR/ is set as follows:

Name	Value	Unit
Reference service life window unit	40	a
isolated glazing	30	a
fittings	25	a
seals	12	a

End of lifetime (C1-C4)

At the end of their useful life windows and window components can be easily collected, sorted and recycled. Otherwise they are disposed of in landfill or in waste incineration plants for heat recovery.

Recycling rates and disposal methods are country specific and vary widely between European countries. For module C four scenarios in total are assessed:
C-0 present average recovery
C-a priority landfill
C-b priority incineration
C-c priority recyling

For C-a und C-b the rates of material recycling of glass and metal are assumed to be the same as today C-0), while the remaining share is not led for recycling is allocated completely to landfill (C-a) and incineration (C-b). The result for scenarios a-c are presented in chapter 6.4.

Rates for collecting and recovery for C-0:

Name	Value	Unit
Collection rate for all materials	95	%
* thereof are recycled	-	
glass	65	%
PVC	59	%
steel/aluminium	92	%
others	0	%
* incineration quote of the material to be disposed	-	
glass	25	%
PVC	35	%
steel / aluminium	0	%
others	20	%

Re-use, recovery and recycling potential (D), relevant scenario

The energy (thermal energy and electricity) respectively the recycled material resulting from thermal and material utilization are credited here.

5. LCA: Results

The results apply to all kind of profile reinforcements and surfaces listed in the scope for window systems with glazing blocks as well as bonded glazing systems.

DESCRIPTION OF THE SYSTEM BOUNDARY (X = INCLUDED IN LCA; MND = MODULE NOT DECLARED)

PRODUCT STAGE			CONSTRUCTION PROCESS STAGE		USE STAGE							END OF LIFE STAGE				BENEFITS AND LOADS BEYOND THE SYSTEM BOUNDARIES
Raw material supply	Transport	Manufacturing	Transport from the gate to the site	Assembly	Use	Maintenance	Repair	Replacement	Refurbishment	Operational energy use	Operational water use	De-construction demolition	Transport	Waste processing	Disposal	Reuse-Recovery-Recycling-potential
A1	**A2**	**A3**	**A4**	**A5**	**B1**	**B2**	**B3**	**B4**	**B5**	**B6**	**B7**	**C1**	**C2**	**C3**	**C4**	**D**
X	X	X	X	X	X	MND	MND	X	MND	MND	MND	X	X	X	X	X

RESULTS OF THE LCA - ENVIRONMENTAL IMPACT: window (1,23 x 1,48 m) with insulated double glazing

Parameter	Unit	A1-A3	A4	A5	B1	B4	C1	C2	C3	C4	D
GWP	[kg CO_2-Eq.]	1.16E+2	8.18E-1	1.96E+0	7.18E+2	6.87E+1	0.00E+0	2.56E+0	8.08E-1	7.32E+0	-3.48E+1
ODP	[kg CFC11-Eq.]	7.30E-6	1.34E-7	2.49E-8	1.06E-4	6.54E-6	0.00E+0	4.22E-7	1.07E-7	1.56E-7	-1.05E-6
AP	[kg SO_2-Eq.]	5.67E-1	3.21E-3	7.84E-3	9.95E-1	4.46E-1	0.00E+0	1.01E-2	5.79E-3	8.93E-3	-1.18E-1
EP	[kg $(PO_4)^{3-}$-Eq.]	6.46E-2	6.55E-4	1.59E-3	1.14E-1	4.93E-2	0.00E+0	2.07E-3	1.25E-3	2.40E-3	-1.41E-2
POCP	[kg ethene-Eq.]	3.14E-2	1.06E-4	4.44E-4	7.83E-2	1.95E-2	0.00E+0	3.38E-4	1.59E-4	6.15E-4	-1.32E-2
ADPE	[kg Sb-Eq.]	1.14E-3	2.48E-6	1.28E-5	1.49E-4	1.06E-3	0.00E+0	7.86E-6	6.12E-7	2.16E-5	-1.19E-4
ADPF	[MJ]	1.85E+3	1.31E+1	3.27E+1	1.13E+4	9.42E+2	0.00E+0	4.13E+1	1.20E+1	2.26E+1	-6.09E+2

Caption	GWP = Global warming potential; ODP = Depletion potential of the stratospheric ozone layer; AP = Acidification potential of land and water; EP = Eutrophication potential; POCP = Formation potential of tropospheric ozone photochemical oxidants; ADPE = Abiotic depletion potential for non-fossil resources; ADPF = Abiotic depletion potential for fossil resources

RESULTS OF THE LCA - RESOURCE USE: window (1,23 x 1,48 m) with insulated double glazing

Parameter	Unit	A1-A3	A4	A5	B1	B4	C1	C2	C3	C4	D
PERE	[MJ]	1.11E+2	1.78E-1	1.70E+0	5.01E+1	6.34E+1	0.00E+0	5.48E-1	2.30E-1	1.90E+0	-1.88E+1
PERM	[MJ]	1.28E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0
PERT	[MJ]	1.12E+2	1.78E-1	1.70E+0	5.01E+1	6.34E+1	0.00E+0	5.48E-1	2.30E-1	1.90E+0	-1.88E+1
PENRE	[MJ]	1.91E+3	1.39E+1	3.81E+1	1.15E+4	1.06E+3	0.00E+0	4.38E+1	1.32E+1	3.26E+1	-5.13E+2
PENRM	[MJ]	3.01E+2	0.00E+0	0.00E+0	0.00E+0	3.42E+1	0.00E+0	0.00E+0	0.00E+0	0.00E+0	-2.23E+2
PENRT	[MJ]	2.21E+3	1.39E+1	3.81E+1	1.15E+4	1.09E+3	0.00E+0	4.38E+1	1.32E+1	3.26E+1	-7.36E+2
SM	[kg]	3.92E-2	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0
RSF	[MJ]	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0
NRSF	[MJ]	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0
FW	[m^3]	4.57E-1	5.12E-4	8.71E-3	9.79E-2	1.20E-1	0.00E+0	1.64E-3	3.43E-4	8.43E-3	-2.49E-1

Caption	PERE = Use of renewable primary energy excluding renewable primary energy resources used as raw materials; PERM = Use of renewable primary energy resources used as raw materials; PERT = Total use of renewable primary energy resources; PENRE = Use of non-renewable primary energy excluding non-renewable primary energy resources used as raw materials; PENRM = Use of non-renewable primary energy resources used as raw materials; PENRT = Total use of non-renewable primary energy resources; SM = Use of secondary material; RSF = Use of renewable secondary fuels; NRSF = Use of non-renewable secondary fuels; FW = Use of net fresh water

RESULTS OF THE LCA – OUTPUT FLOWS AND WASTE CATEGORIES: window (1,23 x 1,48 m) with insulated double glazing

Parameter	Unit	A1-A3	A4	A5	B1	B4	C1	C2	C3	C4	D
HWD	[kg]	1.31E+1	1.03E-2	1.07E-1	1.71E+0	1.23E+1	0.00E+0	3.36E-2	5.77E-3	2.67E+0	-2.00E+0
NHWD	[kg]	2.92E+1	1.31E-1	2.11E-1	1.18E+1	2.95E+1	0.00E+0	4.31E-1	4.35E-2	1.54E+1	-7.97E+0
RWD	[kg]	2.97E-3	1.07E-5	2.10E-5	2.96E-3	2.01E-3	0.00E+0	3.25E-5	1.57E-5	1.41E-4	-2.42E-4
CRU	[kg]	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0
MFR	[kg]	2.78E+0	0.00E+0	0.00E+0	0.00E+0	1.77E+1	0.00E+0	0.00E+0	3.55E+1	0.00E+0	0.00E+0
MER	[kg]	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0
EEE	[MJ]	1.22E-1	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	4.76E+0	-4.89E+0
EET	[MJ]	3.78E-1	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	1.48E+1	-1.51E+1

Caption	HWD = Hazardous waste disposed; NHWD = Non-hazardous waste disposed; RWD = Radioactive waste disposed; CRU = Components for re-use; MFR = Materials for recycling; MER = Materials for energy recovery; EEE = Exported electrical energy; EEE = Exported thermal energy

6. LCA: Interpretation

6.1 Summary

The parameters of global warming potential (GWP) and the use of non-renewable primary energy (PENRT) represent the indicators of environmental impacts and use of resources. They are dominated by the use-phase-based provision of energy to compensate for the transmission heat losses caused by installing the window (module B1). If the use phase is taken out of the equation, virtually all environmental impacts are caused by modules A1-A3 (manufacturing) and B4 (replacements, particularly of the glazing). By contrast, the impact of the end of life stage (modules C1-C4), covering demolition and waste treatment, is negligible. The recycling potential and the combustion process in the end-of-life scenario and the resulting credit of electricity and thermal energy lead on paper to negative values in the effects categories of module D.

It should be pointed out that the itemisation of module B1 for windows is optional. However, due to its significant influence on the building's overall energy consumption, a balancing of its use phase is reasonable. For optimisation of the environmental performance of the window it is clear from an overall consideration that the priority is to reduce transmission heat losses which, in turn, depend on the heat transfer coefficient Uf. Furthermore, solar gains (for example by orientation and shadowing) must be optimized. By contrast, the choice of the frame material is of minor significance.

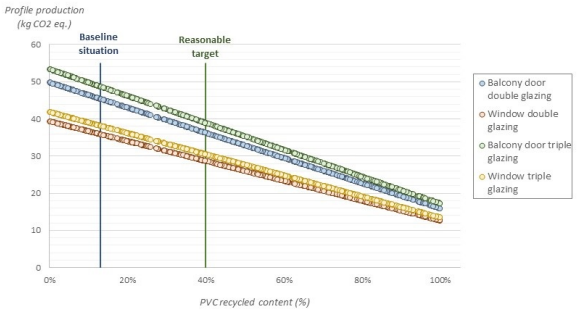
6.2 Production stage

Apart from the production of PVC raw material, production of the insulating glass and fittings accounts for the largest shares in all impact categories. Approximately 45% of the environmental impacts of the production stage are caused by manufacturing of the insulating glass and fittings components.

6.3 Sensitivity concerning the use of recycled PVC

In the manufacture of PVC-U window profiles PVC raw material is partly replaced by recycled material obtained from old windows. A sensitivty analysis made for the profile production shows that due to the reduction of raw material the emission of CO2 and therefore the global warming potential GWP is reduced significantly (see figure 1).

However, the input of material from old windows is limited. Firstly, the amount of available recycled material is limited, and secondly the use of virgin material is necessary due to product performance requirements. Accordingly, a maximum proportion of 40% of recycled material relative to the annual production tonnage of PVC-U window profiles is likely to be the practical limit. For profile manufacture this means a potential GWP saving of a further 22% (compared with an approximate 28% saving compared with the use of pure vigin material).



Figures 1

6.4 Scenarios for EoL / rates of disposal

In addition to the basic variant three other scenarios were assessed to specify the influence of thermal and material recycling (see chapter 4).

Rates for C-a:	**Recycling**	**Incineration**	**Landfill**
Glass	62%	-	38%
PVC-U	-	-	100%
Steel/aluminium	87%	-	13%
Others	-	-	100%

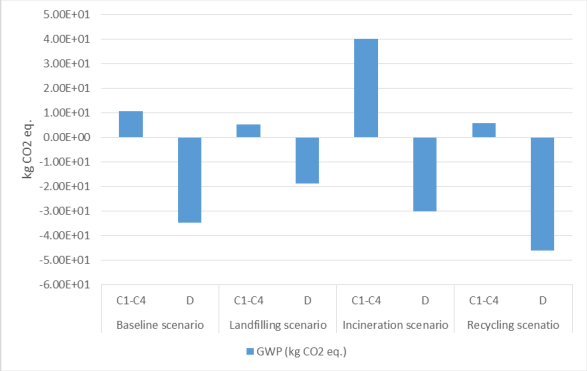
Rates for C-b:	**Recycling**	**Incineration**	**Landfill**
Glass	62%	9%	29%
PVC-U	-	100%	-
Steel/aluminium	87%	-	13%
Others	-	100%	-

Rates for C-c:	**Recycling**	**Incineration**	**Landfill**
Glass	100%	-	-
PVC-U	100%	-	-
Steel/aluminium	100%	-	-
Others	100%	-	-

The results for selected indicators are shown in the table below:

ausgewählte Parameter	C-a Schwerpunkt Deponie		C-b Schwerpunkt Verbrennung		C-c vollständiges Recycling	
	C1-C4	D	C1-C4	D	C1-C4	D
GWP	5.33E+00	-1.88E+01	4.03E+01	-3.01E+01	5.75E+00	-4.62E+01
ODP	5.31E-07	-5.12E-07	1.18E-06	-1.82E-06	7.06E-07	-1.16E-06
AP	1.58E-02	-6.45E-02	6.28E-02	-8.08E-02	2.09E-02	-1.63E-01
EP	4.54E-03	-8.16E-03	1.06E-02	-1.02E-02	5.42E-03	-1.90E-02
POCP	9.02E-04	-1.00E-02	2.56E-03	-1.12E-02	9.02E-04	-1.66E-02
ADPe	7.45E-06	-3.20E-05	1.46E-04	-3.40E-05	1.15E-05	-1.86E-04
ADPf	5.33E+01	-2.84E+02	1.65E+02	-4.53E+02	7.10E+01	-8.45E+02
PENRT	5.68E+01	-3.17E+02	2.31E+02	-5.07E+02	7.60E+01	-1.04E+03

In figure 2 the values of GWP are compared for all scenarios.



Figures 2

C-a (landfill scenario)
Compared with the basic scenario both debits and credits are lower due to there being no incineration.

C-b (incineration scenario)
The values of all impacts increase due to incineration. On the other hand, the energy generation carried by waste incineration delivers a large credit.

C-c (recycling scenario)
The largest credits are achieved by comprehensive material recovery.

6.5 Individual consideration for the impact indicators and their influence factors

6.5.1 Environmental impacts

Global warming potential (GWP)
95% of GWP is contributed by CO2 emissions. Most of it occurs from energy consumption during the in-use phase (B1) as well as raw material production (glazing, PVC-U, steel). The remaining contribution relates to methane emissions likewise associated with energy consumption from the use phase (B1).

Depletion potential of the stratospheric ozone layer (ODP)
The halon 1391 that is produced in the production of gas and heating oil as fuels makes up the bulk of this indicator (use phase B1).

Acidification potential (AP)
This category is 70% dominated by SOx emissions and 27% by NOx emissions. Their main sources are energy production (B4) and the production of raw materials (mostly glass, PVC, steel, A1-A3).

Eutrophication potential (EP)
Eutrophication potential mainly reflects NOx emissions (64%), phosphate (17%) and COD (10%). Most important contributions are heat production (B1) and glazing production (A1).

Formation potential of tropospheric ozone photochemical oxidants (POCP)
This indicator mainly comes from emissions of SOX (45%) from fossil fuels combustion (B1) and glazing production (A1). Other contributions reflect VOC emissions from fossil fuel consumption and raw material production (glass, steel and PVC)

Abiotic depletion potential for non-fossil resources (ADPE)
This refers to the consumption of rare elements. The main contributions come from the consumption of zinc (35%), chromium (18%) and tin (11%) associated with the production of zinc and tin plated stee for fittings (A1-A3).

Abiotic depletion potential for fossil resources (ADPF)
This potential refers to the consuption of natural gas, crude oil and hard coal (82%) associated with the heat generated in the use phase (B1). The other contributions come from natural gas and crude oil consumption associated with glass production (for the provision of energy) and PVC production (as both energy and raw material).

6.5.2 Use of resources

Use of renewable primary energy as energy (PERE) and as raw material (PERM)
The use of renewable energy is low on the whole. It includes the use of wood as a raw material used to build pallets, the consumption of electricity generated from renewable energy (hydropower, wind power) and heat generated by some companies from the combustion of wood od residues from their own manufacturing to produce heat.

Use of non-renewable primary energy as energy (PENRE) and as a raw material (PENRM)
Apart from the in-use phase, the main non-renewable energy consumption occurs during raw material production for glazing, PVC and steel. By contrast, profile production and window manufacturing both have a much limited consumption.
The consumption of non-renewable energy for production covers the raw materials used to generate the plastics (PVC, coatings, LDPE films, seals).

Use of secondary material (SM)
Secondary material is primarily used in profile production in the form of recycled PVC-U from old windows. A small quantity of waste paper/cardboard is also used to produce packaging materials.

Use of secondary fuels (RSF, NRSF)
There is no use of secondary fuels.

Use of net fresh water (FW)
The main consumption of water comes in the manufacture of glass and PVC.

6.5.3 Output flows and waste categories

Components for re-use (CRU)
No output.

Materials for recycling (MFR)
The significant amount of materials for recycling in waste processing stems from the recycled PVC-U, glass, aluminium and steel (reinforcement and fittings). A small contribution comes from the recycling of packaging in the production stage.

Materials for energy recovery (MER)
Like with the waste flows for recycling, the combustion of old window materials accounts for the bulk of the share. The small contribution from the modules A1-A3 relates to the incineration of packaging material (cardboard and wooden pallets) at the end of its life.

Exported energy (EE)
Energy recovery in incineration most occurs – as described above – in the processing of waste (C3) and to a smaller extent at the end-of-life of packaging material (A1 – A3).

7. Requisite evidence

Fire

Fire tests on several test elements from different manufacturers using the SBI test method according to /EN 13823/ by Efectis Nederland BV, project number 2012-Efectis-R0205

Result: In accordance with the average parameters identified, plastic windows meet the following classification criteria according to /EN 13501-1:2007+A1:2009/:

Building material class: B - E
Smoke emissions: s3
Burning droplets: d0

VOC (volatile organic compounds)

Research project into VOC emissions in building products; German Federal Office for Building and Regional Planning as part of the Building the Future research initiative, file reference Z6-10.08.18.7-08.20/II2-F20-08-005; December 2010

Result: In terms of the indoor exposure, the VOC emissions fall largely well below the requirements of the assessment by the German Committee for Health-related Evaluation of Building Products /AgBB/.

8. References

AgBB: Evaluation scheme of emissions of Volatile Organic Compounds from building products; Committee for the Health-related Evaluation of Builduing Products; Germany, February 2015

BBSR: Useful lives of building components for life-cycle analysis according to BNB; Federal Institute for Construction,Urban and Regional Research; Germany, 2011

Construction Products Regulation: Regulation (EU) No 305/2011 of the European Parliament and of the council of March 2011 laying down harmonised conditions for the marketing of construction products and repealing Council Directive 89/106/EEC

DIN 4102-1: Fire behaviour of building materials and building components - Part 1: Building materials; concepts, requirements and tests; DIN 4102-1:1998

DIN V 18599-2: Energy efficiency of buildings - Calculation of the net, final and primary energy demand for heating, cooling, ventilation, domestic hot water and lighting - Part 2: Net energy demand for heating and cooling of building zones;
DIN V 18599-2:2011

EN 674: Glass in building. Determination of thermal transmittance (U value). Guarded hot plate method;
EN 674:2011

EN 675: Glass in building. Determination of thermal transmittance (U value). Heat flow meter method;
EN 675:2011

EN 1026: Windows and doors - Air permeability - Test method; EN 1026:2000

EN 1027: Windows and doors - Watertightness - Test method; EN 1027:2000

EN 1191: Windows and doors - Resistance to repeated opening and closing - Test method; EN 1191:2012

EN 12207: Windows and doors - Air permeability - Classification; EN 12207:1999

EN 12208: Windows and doors - Watertightness - Classification; EN 12208:1999

EN 12210: Windows and doors - Resistance to wind load - Classification; EN 12210:1999+AC:2002

EN 12211: Windows and doors - Resistance to wind load - Test method; EN 12211:2000

EN 12400: Windows and pedestrian doors - Mechanical durability - Requirements and classification; EN 12400:2002

EN 13501-1: Fire classification of construction products and building elements - Part 1: Classification using data from reaction to fire tests;
EN 13501-1:2007+A1:2009

EN 13823: Reaction to fire tests for building products - Building products excluding floorings exposed to the thermal attack by a single burning item;
EN 13823:2010

EN 14351-1: Windows and doors - Product standard, performance characteristics - Part 1: Windows and external pedestrian doorsets without resistance to fire and/or smoke leakage characteristics;
EN 14351-1:2006+A1:2010

ecoinvent 2.2: Ecoinvent database, v. 2.2; Swiss Centre for Life Cycle Inventories (pub.); Duebendorf, Switzerland, 2010

Ecological Scarcity Method: Swiss Eco-Factors 2013 according to the Ecological Scarcity Method - Methodological fundamentals and their application in Switzerland; Frischknecht & Büsser Knöpfel; 2013

EWC: European Waste Catalogue, established by Decision 2000/532/EC of European Commission

GHS: Globally Harmonized System of Classification and Labelling of Chemicals

RAL-GZ 695: Quality assurance of windows, doors, facades and winter gardens

RAL-GZ 716: General Quality and Test Requirements, System Description and Suitability Testing of Plastic Window and Door Profile Systems

REACH: Regulation (EC) No 1907/2006 of the European Parliment and of the Council of 18 December 2006 concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals

Institut Bauen und Umwelt
Institut Bauen und Umwelt e.V., Berlin(pub.): Generation of Environmental Product Declarations (EPDs);

General principles
for the EPD range of Institut Bauen und Umwelt e.V. (IBU), 2013/04
www.bau-umwelt.de

ISO 14025
DIN EN ISO 14025:2011-10: Environmental labels and declarations — Type III environmental declarations — Principles and procedures

EN 15804
EN 15804:2012-04+A1 2013: Sustainability of construction works — Environmental Product Declarations — Core rules for the product category of construction products

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