ENVIRONMENTAL PRODUCT DECLARATION

as per *ISO 14025* and *EN 15804+A2*

Owner of the Declaration	QKE Qualitätsverband Kunststofferzeugnisse e.V. GKFP Gütegemeinschaft Kunststoff-Fensterprofilsysteme 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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Plastic windows (1.23 m x 1.48 m)
with double insulating glass unit

Institut Bauen und Umwelt e.V.

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ECO PLATFORM EPD VERIFIED

Presented by:

profine INTERNATIONAL PROFILE GROUP

EPPA KUNSTSTOFF FENSTERPROFILSYSTEME RAL QUALITÄTSVERBAND KUNSTSTOFFERZEUGNISSE E.V. FÜR LANGLEBIGE KUNSTSTOFFPRODUKTE

1. General Information

QKE, GKFP, EPPA

Plastic windows (1.23 m x 1.48 m) with double insulating glass unit

Programme holder

IBU – Institut Bauen und Umwelt e.V.
Hegelplatz 1
10117 Berlin
Germany

Owner of the declaration

QKE – Qualitätsverband Kunststofferzeugnisse e.V.
Am Hofgarten 1–2; 53113 Bonn
Germany

GKFP – Gütegemeinschaft Kunststoff-Fensterprofilsysteme e.V.
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EPPA – European PVC Window Profiles and related Building Products Association ivzw
Avenue de Cortenbergh 71; 1000 Brussels
Belgium

Declaration number

EPD-QKE-20220002-IBG1-DE

Declared product/declared unit

The declared unit consists of 1 m^2 of window surface area.

The reference window is a single-sash tilt and turn window 1.23 m x 1.48 m in size with double insulating glass unit and PVC-U frame material with optional surface finishing (coated, covered with PVC foil or PMMA) and possibly additionally fitted with an aluminium covering shell.

The planned replacement of individual components gasket, hardware and glazing during a 40-year service life have been included.

This declaration is based on the product category rules:

Windows and doors, 01.2021
(PCR checked and approved by the SVR)

Issue date

03.05.2022

Valid to

02.05.2027

Scope:

This declaration is an association EPD. It covers all constructional forms for PVC windows which comply with the stated characteristics. These are both conventionally blocked and bonded window designs and different profile reinforcement and surface design variants.
Data from the production plants of the following system suppliers and window manufacturers was included:

aluplast – Ettlingen (DE)
Deceuninck – Bogen (DE), Calne (GB), Hooglede-Gits (BE), Jasin (PL), Roye (FR)
GARGIULO – Nehren (DE)
GEALAN – Bukarest (RO), Guopstos (LT), Rzgów (PL), Tanna (DE)
hapa – Herrieden (DE)
Internorm – Sarleinsbach (AT), Traun (AT)
profine – Berlin (DE), Marmoutier (FR), Pirmasens (DE)
REHAU – Srem (PL), Wittmund (DE)
Salamander –Türkheim (DE), Wloclawek (PL)
SCHÜCO – Weißenfels (DE)
TMP – Bad Langensalza (DE)
VEKA – Burgos (ES), Burnley (GB), Sendenhorst (DE), Skierniewice (PL),Thonon-les-Bains (FR)

The weighted mean of the data from eleven member companies with 27 production sites in nine countries was used as a database for manufacturing the plastic profiles. The production quantity thus recorded corresponds to approximately 80% to the European production of the profile manufacturers who are organized in the EPPA, GKFP and QKE associations.

This association EPD can be used by the member companies of the three associations EPPA, GKFP and QKE as well as window manufacturers who use this company's plastic profile systems.

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.

The EPD was created according to the specifications of *EN 15804+A2*. In the following, the standard will be simplified as *EN 15804*.

Verification

The standard *EN 15804* serves as the core PCR
Independent verification of the declaration and data according to *ISO 14025:2011*
☐ internally ☒ externally

Dipl.-Ing.Hans Peters
(chairman of Institut Bauen und Umwelt e.V.)

Dr. Alexander Röder
(Managing Director Institut Bauen und Umwelt e.V.))

Name of verifier
(Independent verifier)

2. Product

2.1 Product description/Product definition

Single-sash window 1.23 m x 1.48 m with PVC-U frame profiles, double insulating glass unit and tilt-turn hardware.

Steel, aluminium or glass fibre extruded into the PVC material can be used as reinforcement in the PVC profiles.

The profile surface can be made with different finishes: Uncoated white, covered with PVC foil, covered with PMMA (polymethylmethacrylate), coated or fitted with a separate aluminium covering shell. This results in white or coloured, smooth or structured surfaces.

The gaskets consist of soft PVC, EPDM (ethylene-propylene-dien monomer) or TPE (thermoplastic elastomere); the hardware are mainly made of steel.

The average window for this EPD is the white steel-reinforced basic variant. However, the inputs/outputs determined from the production quantities are included for profile production, whereby all surface finishing processes which are actually performed at the plants are included.

This EPD declares the average environmental quality for the PVC windows of the member companies of the EPPA, GKFP and QKE associations. Window manufacturers who use this company's plastic profile systems can also make use of the declaration. Detailed product data is available from the respective manufacturers' specific descriptions.

EU regulation no. 305/2011 (*CPR*) applies for putting the windows on the market in the EU/EFTA (with the exception of Switzerland). The product requires a declaration of performance including the harmonized product standard *DIN EN 14351-1:2016-12* Windows and doors – Product standard, performance characteristics – Part 1: Windows and external pedestrian doorsets and also CE labelling.

The respective national regulations apply to use.

2.2 Application

Windows are inserted into the outer building shell for lighting, ventilation and weather protection.

2.3 Technical Data

The figures and/or classes shown in the following table apply to the reference window on which this EPD is based. Far higher classes are being achieved depending on the design of the frame, hardware, gaskets and insulating glass unit.

Name	Value	Unit
Possible opening types	tilt-turn	-
Glazing unit structure	4 / 16 / 4	mm
Total energy transmittance g	62	%
Heat transfer coefficient glass Ug in accordance with EN 674, EN 675	1.1	W/(m²K)
Heat transfer coefficient window Uw in accordance with EN 674, EN 675	1.2	W/(m²K)
Air permeability in accordance with EN 12207	2–4	Class
Resistance to wind load in accordance with EN 12210	B1–C5	Class
Water tightness in accordance with EN 12206	4A–9A	Class
Mechanical stress (durability) in accordance with EN 12400	10000–20000	Cycles

The construction details and the performance values in accordance with the declaration of performance apply to the specific window unit put on the market by the respective manufacturer with regard to their main characteristics in accordance with harmonized product standard *DIN EN 14351-1:2016-12*, Windows and doors – Product standard, performance characteristics – Part 1: Windows and external pedestrian doorsets.

2.4 Delivery status

This EPD relates to a reference window 1.23 m x 1.48 m in size.

2.5 Base materials/Ancillary materials

The main components of the reference window are:

Name	Value	Unit
25.87 kg insulating glass unit	45.2	mass %
16.79 kg frame material, PVC-U	29.3	mass %
11.87 kg reinforcement, steel	20.7	mass %
1.83 kg hardware, steel	3.2	mass %
0.76 kg gaskets, soft PVC, EPDM, TPE	1.3	mass %
0.13 kg screws, steel	0.2	mass %
0.05 kg setting blocks, PP	0.1	mass %

The following representative generic composition for the individual formulae used by the profile manufacturers for the PVC frame is included for the EPD:

- 81.0 mass % PVC
- 8.1 mass % filler (chalk)
- 4.9 mass % impact resistance modifier
- 2.8 mass % calcium-zinc-stabilisers
- 3.2 mass % titanium oxide pigment (TiO_2)

At least one partial product may contain materials from the *ECHA candidate list* (as of 01/04/2020) of Substances of Very High Concern (SVHC) at above 0.1 mass %: Yes, the PVC profile. This may be the case if recycled PVC window material is used in the core of the profile cross-section in the manufacture of this product. These profiles may contain lead compounds (CAS number 7439-92-1 of the ECHA candidate list as of 01/04/2020) at above 0.1 mass %.

This product contains other CMR substances (carcinogenic, mutagenic or toxic to reproduction) in categories 1A or 1B which are not on the candidate list, exceeding 0.1 percentage by mass: No.

Biocide products are added to this construction product or it has been treated with biocide products: No.

2.6 Manufacture

Plastic windows are made of the following components: PVC frame profiles with gaskets and if necessary reinforcement, insulating glass unit and hardware.

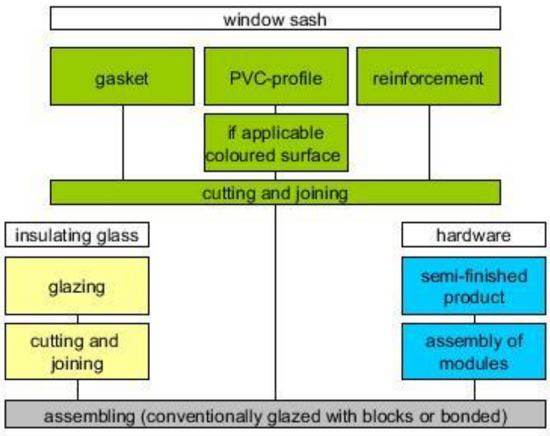

Fig. 2-1: Schematic diagram of the manufacture of a window unit

The PVC profiles are produced in an extrusion process from a mixture of PVC powder and additives. The latter protect the PVC against damage during processing and give the profile the necessary characteristics such as impact resistance, colour and weather resistance.

The PVC powder for producing the frames is a widely available mass plastic and is manufactured by polymerisation. Due to its chemical structure, PVC contains a considerable proportion of the halogen chlorine.

Coloured surfaces can be produced by fitting an aluminium covering shell, applying a foil, coating or by co-extrusion with a PMMA layer. Gaskets are either attached to the window profile in a co-extrusion process during extrusion or rolled in subsequently.

The window profiles are supplied to window manufacturers in standard lengths. There they are sawn to the lengths required for respective windows. As far as necessary, steel reinforcement is pushed in and screwed in place. The profiles are then welded, the hardware attached and the glazing and glazing beads inserted.

The steel to produce the hardware is mainly manufactured from iron ore in a furnace process through reduction with coke.

The raw material basis for the manufacture of the glazing is formed by quartz sand and the addition of various fluxing and oxidation agents (soda ash, sodium sulphate, potassium carbonate, etc.). In a further processing step, the melted raw glass is placed in a tin melt from which a flat glass ribbon is continuously drawn (float glass process).

Quality assurance

GKFP e.V. member companies are subject to external quality control as part of voluntary self-commitment. Those plastic window profile systems which may be labelled with *RAL-GZ 716* are listed on the association's website at gkfp.de/en:
gkfp.de/en/product-overview/profile-systems-with-ral-quality-mark

Those window manufacturers which use the RAL quality mark in accordance with *RAL-GZ 695* are also subject to external monitoring. A list is available on the Gütegemeinschaft Fenster, Fassaden und Haustüren e.V. website (window.de/guetegemeinschaft-fenster) at: ral-fachbetriebe.fenster-können-mehr.de/

2.7 Environment and health during manufacturing

Individual measures at production plants such as the implementation of an environmental or energy management system in accordance with *ISO 14001* or *ISO 50001* are to be found in individual company profiles.

2.8 Product processing/Installation

The finished windows are transported to the construction site and built into the building structure. Galvanised steel screws are used for installation. The use of installation foam (polyurethane) is possible.

2.9 Packaging

Cardboard, polyethylene wrap and foam pads are used to transport the individual components to the window manufacturer. The frame profiles are generally transported in reusable steel cassettes and occasionally in disposal wooden pallets.

Reusable racks are normally used to deliver the windows together with foam pads and polyethylene stretch film, cardboard and polypropylene load-securing belts and aluminium or steel clamps.

If not reused, metal packaging material is recycled; other packaging is generally thermally recycled or otherwise disposed of in landfill.

Waste code according to the *European Waste Catalogue*:

- 15 01 01 Cardboard
- 15 01 02 Plastics
- 15 01 03 Solid wood and wood-based materials
- 15 01 04 Metals

2.10 Condition of use

Plastic windows are very long-lasting and durable. Their material composition does not change during use.

2.11 Environment and health during use

The environment and health are not negatively affected by the PVC frame material. This also applies to the window element as long as the use of solvent-free components is guaranteed downstream in the supply chain.

2.12 Reference service life

The service life for the product and its components is assumed as follows in accordance with *BBSR 2017*:

- 40 years for the plastic window
- 30 years for the insulating glass unit
- 30 years for the building hardware
- 20 years for the gaskets

One replacement of gaskets, hardware and glazing is included in the EPD since the service life for the components is less than that of the finished product.

2.13 Extraordinary effects

Fire

Depending on the design and surface finish, plastic windows can achieve classes E to B in accordance with *EN 13501-1* with regard to reaction to fire.

Name	Value
Building material class	E–B
Smoke production	s3
Flaming droplets	d0

Water

No effects which are detrimental to the environment occur in the event of unforeseen water exposure, such as flooding.

The watertightness of the window is influenced by the design implementation and durability of the frame profile, gasket and hardware. Different classes of water tightness are achieved accordingly (see 2.3).

Mechanical destruction

No negative effects for the environment occur on unforeseen mechanical destruction.

2.14 Re-use phase

Material recycling is easily possible and technically realised for all window components. The PVC frame material is maintained in a controlled closed circuit and reused in window profiles after reprocessing. The steel used for hardware and reinforcements can also be recycled without any loss of quality. Material recycling is also easy for the glazing but usually associated with a loss in quality.

2.15 Disposal

The individual components of the plastic window can be incinerated as non-dangerous waste (without energy recovery) or disposed of in landfill.

Waste code according to the *European Waste Catalogue*:

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

2.16 Further information

Further information is available via the websites of the associations

www.eppa-profiles.eu
www.gkfp.de/en
www.qke-bonn.de

and also those of the system houses and window manufacturers.

3. LCA: Calculation rules

3.1 Declared unit

The declared unit consists of 1 m^2 of window area on a reference window (similar to *EN 14351-1* and *EN 17213*). Its frame area ratio F_F in relation to the overall surface area is around 28%.

Name	Value	Unit
Declared unit	1	m^2
Reference window: Width x height	1.23 x 1.48	m
Frame area ratio	27.8	%
Mass	57.3	kg
Conversion factor reference window up to 1 m^2	0.5493	-
Declared unit mass	31.4	kg
Conversion factor to 1kg	0.0318	-

The balanced production volume used for average calculation is based on the information from the companies named in 1 'Scope'. The underlying production process varies only slightly from one manufacturer to another. It is therefore assumed that the data is representative and robust.

3.2 System boundary

The complete lifecycle from cradle to grave is examined for the declared unit. The production stage (Modules A1–A3), the construction stage (A4, A5), the use stage (B1, B2), the disposal stage (C1–C4) and benefits and loads beyond the system boundary (D) are relevant but not the further modules of the use stage (B3, B4).

Manufacturing

The aggregated illustration in the form of A1–A3 is used for manufacturing. This includes the provision of raw materials and energy, the production of steel reinforcement, glazing, hardware and PVC profile, transport of the components to the window manufacturer, the energy consumption needed for this and accruing production waste. The consumption for heating the production plants and also the attached rooms is also specifically included. However, investment goods (machines, buildings, etc.) remain ignored.

Transport from the window manufacturer to the construction site is included in Module A4 and also the auxiliary and operating materials used for installation and the disposal of packaging waste in Module A5 in accordance with *EN 17213*.

Use phase

The transmission heat losses during the use phase are included in Module B1 and the replacement of window components mentioned in 2.12 in Module B2.

Disposal

All processes which relate to the removal, dismantling or demolition of the window out of the building and which are not to be regarded at building level are calculated into Module C1.

Redistribution transports from the construction site to waste treatment fall in Module C2. Waste management processes, especially energy recovery from waste, are included in Module C3. This also includes sorting for recycling.

Disposal and also thermal waste treatment are allocated to Module C4.

Credits

Finally, Module D shows the reuse, recovery and recycling potentials beyond the system boundary.

3.3 Estimates and assumptions

Average transport distances from background date will be assumed insofar as no specific information on transports is available. This especially concerns Module A2.

Dust and emissions accruing during production or disposal are examined by means of generic data.

With regard to replacing components during use and also the dismantling of the window it is assumed that the expenses are equivalent to those of installation.

3.4 Cut-off criteria

All known inputs and outputs are included in the lifecycle. Data gaps are filled with conservative assumptions and generic data. The input flows ignored are each below 1% of the total mass or the total flow of the primary energy. In total, they each represent less than 5% of the total mass or 5% of the total energy.

3.5 Background data

The modelling of the lifecycle is performed in the *GaBi* LCA software. The background data especially for the raw materials and the production of PVC, insulating glass unit and hardware originate from the *ecoinvent 3.7* database. As specific, current and representative data as possible is used. The data used is not more than ten years old.

3.6 Data quality

Data from twelve companies with 28 production plants in nine countries are used as primary profile extrusion and window manufacturing data, see 1 'Scope'. This data collected for 2019 was checked for plausibility and consistency. Further average information originates from the associations. The quality of the specific data is therefore to be regarded as extremely good.

At least 80% of all contributions to the core indicators of each impact category result from five background data records. Their representativeness is predominantly to be regarded as good to excellent. Data records with lower representativeness are only used in individual cases. The quality of the background data is therefore to be estimated as good overall.

3.7 Period under review

The primary data was collected for 2019.

Averages weighted with the production volume are used for production data for profile extrusion and window manufacture.

3.8 Allocation

No co-products accrue when producing the window and in further processes (Modules A1–A3). No co-product allocation is therefore necessary in foreground processes. Co-products for which an allocation is present in background data records accrue in the pre-chain for PVC, for example when producing vinyl chloride.

Energies used, auxiliary and operating materials and also waste (Modules A1–A3) are each recorded at plant level and distributed to the products across the produced mass.

Recyclates deployed (Modules A1–A3) are included in terms of a closed loop so that no allocation takes place.

In Module D, benefits and loads result from recycling PVC and metals as well as energy recovery from waste.

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.

This LCA was compiled with the *ecoinvent* 3.7 database.

4. LCA: Scenarios and additional technical information

Characteristic product properties

Information on biogenic Carbon

The total mass of biogenic carbon materials is less than 5% of the total mass of the product and the associated packaging.

Basic information

The downstream technical information is the basis for the declared modules or can be used for the development of specific scenarios in the context of a building assessment if modules are not declared (MND).

Statements mainly relate to one declared unit.

Transport to the construction site (A4)

Name		Value	Unit
Specific fuel consumption per tonne kilometre	7.5 t truck	0.132	l/(t*km)
	40 t truck	0.023	l/(t*km)
Transport distance	7.5 t truck	9	km
	40 t truck	69	km

Installation into the building (A5)

The auxiliary and operating materials (e.g. fixing materials, sealants) are included in the window's LCA in accordance with *EN 17213* but not the energy consumption during installation which is to be regarded at building level in the EPD, which is why this data is for information only.

Name	Value	Unit
Polyurethane installation foam	0.180	kg
Screws	0.077	kg
Electricity consumption	0.085	kWh

Use phase (B1)

The net heat losses caused by the window are included here. These consist of the transmission heat losses and the solar gains. Since these depend very strongly on actual climatic condition at the place of installation and the technical circumstances of individual building, the environmental effects stated in this EPD are merely to be regarded as examples.

The following conditions are assumed: The calculations for heat losses and gains and the results of the impact assessment are based on parameters of average European conditions. The energy demand during the use phase at the reference location is calculated in accordance with *DIN V 18599-2*. The following applies:

Name	Value	Unit
EU degree day factor	2135	K*d
Solar radiation	155	kWh/m²a

The provision of heat energy is modelled as follows with German energy needs:

49 % Gas
25 % Heating oil
14 % District heating
12 % Other (e.g. biomass, electricity).

Maintenance (B2)

The service life for the window is calculated as 40 years in accordance with *BBSR 2017*. The replacement of individual components after reaching the end of their technical useful life (see 2.12) is included in B2 in accordance with *EN 17213*:

Name	Value	Unit
Replacement cycle : Glazing	1	Number/RSL
Gaskets	1	Number/RSL
Hardware	1	Number/RSL
Electricity consumption	0.085	kWh
Polyurethane installation foam	0.180	kg
Screws	0.077	kg

End-of-life (C1–C4)

The recycling quotas and disposal routes are country-specific and deviate strongly from one another in the European area. The LCA is based on the following assumptions:

Name	Value	Unit
Collection quota across all materials	95	%
* thereof to recycling	-	
Glass	65	%
PVC	59	%
Steel/aluminium	92	%
Other	0	%
* incineration quota of the material to be disposed of	-	
Glass	25	%
PVC	35	%
Steel/alumnium	0	%
Other	20	%
Transport distance	22	km
Dismantling electricity consumption	0.085	kWh

Reuse, recovery and recycling potential (D), relevant scenario information

The energy resulting from thermal and material recycling (thermal energy and electricity) and the recycling material accruing are credited in this module as follows:

10.10 kg net flow secondary glass
4.03 kg net flow secondary PVC
2.50 kg net flow secondary Steel
3.69 MJ exported electrical energy
8.15 MJ exported thermal energy

5. LCA: Results

The net heat losses caused by the window are included for B1 use phase. The LCA results shown here are for information only as the losses depend very strongly on actual climatic conditions at the installation location and the technical circumstances of individual buildings.

DESCRIPTION OF THE SYSTEM BOUNDARY (X = INCLUDED IN LCA; ND = MODULE OR INDICATOR NOT DECLARED; MNR = MODULE NOT RELEVANT)

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	X	MNR	MNR	MNR	ND	ND	X	X	X	X	X

RESULTS OF THE LCA – ENVIRONMENTAL IMPACT according to EN 15804+A2: 1 m² of a reference window with double insulating glass unit

Core Indicator	Unit	A1-A3	A4	A5	B1	B2	C1	C2	C3	C4	D
GWP-total	[kg CO_2-Eq.]	8.00E+1	3.97E-1	1.48E+0	6.09E+1	3.52E+1	1.10E-3	9.07E-2	4.10E+0	1.72E+0	-7.07E+0
GWP-fossil	[kg CO_2-Eq.]	7.92E+1	3.96E-1	1.44E+0	5.43E+1	3.41E+1	1.09E-3	9.04E-2	4.08E+0	3.08E-1	-6.95E+0
GWP-biogenic	[kg CO_2-Eq.]	7.87E-1	1.10E-3	3.54E-2	6.57E+0	1.08E+0	8.69E-6	2.19E-4	1.61E-2	1.41E+0	-1.01E-1
GWP-luluc	[kg CO_2-Eq.]	6.03E-2	1.63E-4	7.97E-4	9.34E-3	3.30E-2	2.36E-7	3.16E-5	5.01E-4	2.16E-5	-2.27E-2
ODP	[kg CFC11-Eq.]	1.34E-5	9.17E-8	2.01E-8	7.74E-6	3.54E-6	5.34E-10	2.08E-8	1.09E-7	2.56E-8	-2.54E-6
AP	[mol H^+-Eq.]	4.60E-1	1.18E-3	5.88E-3	9.45E-2	2.48E-1	1.07E-5	5.08E-4	2.65E-3	6.64E-4	-3.45E-2
EP-freshwater	[kg P-Eq.]	3.13E-2	3.20E-5	2.17E-4	2.98E-3	1.03E-2	6.82E-8	6.37E-6	2.38E-4	2.59E-5	-3.97E-3
EP-marine	[kg N-Eq.]	8.86E-2	2.53E-4	1.89E-3	1.66E-2	4.88E-2	4.06E-6	1.86E-4	8.48E-4	3.84E-3	-6.51E-3
EP-terrestrial	[mol N-Eq.]	8.48E-1	2.74E-3	1.11E-2	1.76E-1	4.90E-1	4.45E-5	2.03E-3	6.87E-3	2.48E-3	-6.23E-2
POCP	[kg NMVOC-Eq.]	2.76E-1	1.07E-3	3.97E-3	6.61E-2	1.45E-1	1.27E-5	5.80E-4	1.93E-3	1.09E-3	-2.01E-2
ADPE	[kg Sb-Eq.]	1.26E-3	1.68E-6	7.72E-6	1.05E-4	8.08E-4	2.06E-9	3.13E-7	3.66E-6	2.54E-7	-5.86E-4
ADPF	[MJ]	1.38E+3	6.26E+0	2.13E+1	7.95E+2	4.76E+2	3.52E-2	1.40E+0	7.72E+0	1.90E+0	-1.54E+2
WDP	[m^3 world-Eq deprived]	4.29E+1	3.43E-2	1.07E+0	2.18E+0	1.53E+1	1.83E-3	6.93E-3	4.21E+0	9.73E-2	-6.15E+0

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; WDP = Water (user) deprivation potential

RESULTS OF THE LCA – INDICATORS TO DESCRIBE RESOURCE USE according to EN 15804+A2: 1 m² of a reference window with double insulating glass unit

Indicator	Unit	A1-A3	A4	A5	B1	B2	C1	C2	C3	C4	D
PERE	[MJ]	7.19E+1	9.69E-2	9.62E-1	2.29E+1	3.07E+1	6.99E-4	1.92E-2	6.94E+0	9.70E-2	-1.09E+1
PERM	[MJ]	9.26E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	-9.26E+0	0.00E+0	0.00E+0
PERT	[MJ]	8.12E+1	9.69E-2	9.62E-1	2.29E+1	3.07E+1	6.99E-4	1.92E-2	-2.32E+0	9.70E-2	-1.09E+1
PENRE	[MJ]	1.14E+3	6.26E+0	2.14E+1	7.95E+2	4.76E+2	3.52E-2	1.40E+0	1.73E+2	1.90E+0	-3.92E+1
PENRM	[MJ]	2.37E+2	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	-1.22E+2	0.00E+0	-1.14E+2
PENRT	[MJ]	1.38E+3	6.26E+0	2.14E+1	7.95E+2	4.76E+2	3.52E-2	1.40E+0	5.07E+1	1.90E+0	-1.54E+2
SM	[kg]	7.32E+0	0.00E+0	4.31E-2	0.00E+0	1.21E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	1.81E+1
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]	9.98E-1	7.99E-4	2.49E-2	5.08E-2	3.55E-1	4.26E-5	1.61E-4	9.80E-2	2.27E-3	-1.43E-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 – WASTE CATEGORIES AND OUTPUT FLOWS according to EN 15804+A2: 1 m² of a reference window with double insulating glass unit

Indicator	Unit	A1-A3	A4	A5	B1	B2	C1	C2	C3	C4	D
HWD	[kg]	7.56E-6	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
NHWD	[kg]	1.68E-1	0.00E+0	0.00E+0	0.00E+0	4.34E+0	2.58E-1	0.00E+0	0.00E+0	7.98E+0	0.00E+0
RWD	[kg]	6.60E-3	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
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]	3.56E+0	0.00E+0	0.00E+0	0.00E+0	9.20E+0	0.00E+0	0.00E+0	2.02E+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]	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	3.68E+0	0.00E+0	0.00E+0
EET	[MJ]	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	8.15E+0	0.00E+0	0.00E+0

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

RESULTS OF THE LCA – additional impact categories according to EN 15804+A2-optional: 1 m² of a reference window with double insulating glass unit

Indicator	Unit	A1-A3	A4	A5	B1	B2	C1	C2	C3	C4	D
PM	[Disease Incidence]	4.36E-6	2.74E-8	1.07E-7	7.54E-7	2.46E-6	2.33E-10	8.14E-9	1.67E-8	1.39E-8	-2.35E-7
IRP	[kBq U235-Eq.]	9.10E+0	3.33E-2	2.83E-2	2.36E+0	2.93E+0	1.75E-4	7.29E-3	1.07E-1	1.33E-2	-9.75E-1
ETP-fw	[CTUe]	3.14E+3	5.19E+0	5.81E+1	4.58E+2	2.26E+3	1.90E-2	1.12E+0	1.95E+2	1.73E+1	-2.75E+2
HTP-c	[CTUh]	2.47E-7	1.87E-10	1.55E-9	1.14E-8	4.49E-8	5.41E-13	4.70E-11	6.60E-10	1.07E-10	-1.02E-8
HTP-nc	[CTUh]	1.40E-6	4.30E-9	2.65E-8	1.85E-7	6.05E-7	8.41E-12	1.09E-9	5.12E-8	3.07E-9	-2.13E-7
SQP	[-]	2.99E+2	5.38E+0	1.93E+0	1.25E+2	1.34E+2	7.88E-2	1.19E+0	2.73E+0	4.13E+0	-2.95E+1

Caption	PM = Potential incidence of disease due to PM emissions; IR = Potential Human exposure efficiency relative to U235; ETP-fw = Potential comparative Toxic Unit for ecosystems; HTP-c = Potential comparative Toxic Unit for humans (cancerogenic); HTP-nc = Potential comparative Toxic Unit for humans (not cancerogenic); SQP = Potential soil quality index

Important

EP fresh water: This indicator was implemented in co-ordination with the characterization module (EUTREND model, Strujis et al., 2009b, as in ReCiPe; http://eplca.jrc.ec.europa.eu/LCDN/developerEF.xhtml) calculated as "kg P-Eq".

Disclaimer 1 – applies to the indicator IR "Potential Human exposure efficiency relative to U235"
This impact category mainly deals with the possible impact of low-dose ionizing radiation on human health in the nuclear fuel cycle. It does not consider neither impacts due to possible nuclear accidents, occupational exposure nor due to radioactive waste disposal in underground facilities. The potential ionizing radiation emanating from the soil, from radon and from some construction materials is also not measured by this indicator.

Disclaimer 2 – applies to the indicators ADPE, ADPF, WDP, ETP-fw, HTP-c, HTP-nc, SQP "abiotic depletion potential for non-fossil resources", "abiotic depletion potential for fossil resources", "water (user) deprivation potential, deprivation-weighted water consumption", "potential comparative toxic unit for ecosystems", "potential comparative toxic unit for humans – cancerogenic", "Potential comparative toxic unit for humans - not cancerogenic", "potential soil quality index".
The results of this environmental impact indicator shall be used with care as the uncertainties with these results are high or because there is limited experienced with the indicator.

6. LCA: Interpretation

6.1 Summary

Many of the environmental impact and resource use indicators are dominated by the manufacturing phase (Modules A1–A3). In addition, the energy consumption needed to compensate heat losses through the window (Module B1), maintenance (Module B2) and to a lesser extent waste treatment (Module C3) take a major share of the indicators.

The impacts within the system boundary can be compensated by recovery and recycling potentials beyond the system boundary (Module D).

Within Modules A1–A3 the insulating glass unit, the metal components and the PVC dryblend contribute to the results to a similar extent.

Sensitivity observations show that different window designs (e.g. with regard to reinforcement material or also in relation to the dimensions) and also the surface design influence the environmental impacts of the manufacturing phase at least within the range up to ± 10%.

The largest contribution in Module B2 originates from the replacement of the glazing.

The declaration of Module B1 is optional for windows. However, since these have a significant influence on the energy household of a building it makes sense to assess their use phase. The values declared for B1 apply to the exemplary application case specified in Section 4 and are for information only. Optimisation would involve reducing transmission heat losses determined by the heat transfer coefficients and to optimise the solar gains (e.g. through alignment and shadows).

6.2 Sensitivity to the use of PVC recyclate

The impacts described above caused by the PVC frame material used change with the PVC recyclate ratio. The environmental impacts decrease in Modules A1–A3 if fresh PVC material is replaced by recyclate. In case of a share of 40% the effects here decrease by 6% on average (range -3% to -25%).

Furthermore, an increase in the proportion of recyclate in the profile results in assessment differences in Module C3 (PENRM indicator) and also smaller benefits in Module D due to the reduced quantity of PVC recyclate which crosses the system boundary. This drops on average by 24% with a 40% share of recyclate (range -51% to +9%).

Fig. 6-1 shows how greatly the total GKWP indicator in Module A1–A3 is reduced by an increase in recyclate content. The recyclate content determined for 2019 was approximately 21%.

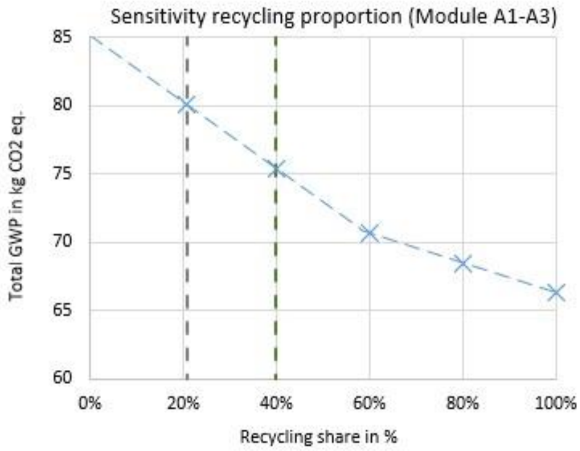

Fig. 6-1: Total GWP of the window manufacturing module (A1–A3) depending on the recyclate content

The use of PVC recyclate in the profile is, however, limited. On the one hand because unlimited amounts of recycling material are not available and on the other due to the profile design, where design or quality-related requirements can make the use of fresh material necessary.

A maximum of 40% PVC recyclate in relation to the annual tonnage of profile production appears technically realisable under these framework conditions. Individual profiles can contain a significantly higher proportion of recyclate in spite of this.

6.3 Isolated view of the impact indicators and their influencing factors

6.3.1 Environmental impacts

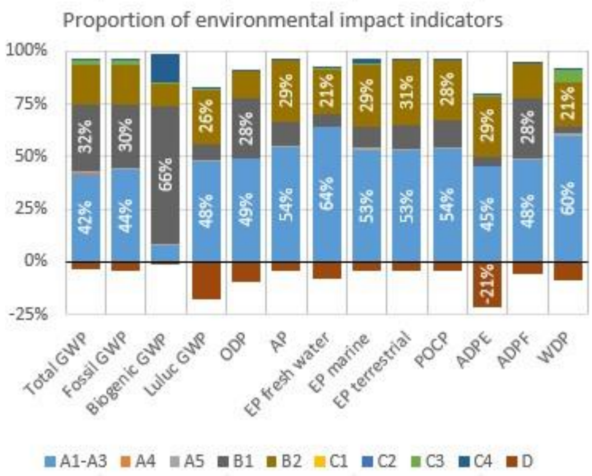

Abb. 6-2: Indicators to describe the environmental impacts, distribution per module

Global warming potential (GWP)
Greenhouse gas emissions are above all attributable to production, energy consumption in the use phase and maintenance. The most relevant greenhouse gases are carbon dioxide (fossil 83%, biogenic 9%) and methane (fossil 8%, biogenic 1%). The effects of land use changes are extremely low.

Depletion potential of the stratospheric ozone layer (ODP)
Impacts on ozone depletion mainly result from the production phase and energy consumption in the use phase. Emissions of halon 1301, halon 1211 and tetrachloromethane are mainly responsible for this.

Acidification potential of land and water (AP)
Acidification potential results above all from emissions of nitrogen oxides and sulphur oxides which occur during the production phase, maintenance and the use phase.

Eutrophication potential (EP)
The impacts on the eutrophication of water and soil originates above all from the production phase, maintenance and energy consumption in the use phase. The relevant emissions are phosphates and nitrogen oxides.

Formation potential for tropospheric ozone photochemical oxidants (POCD)
Ozone formation close to the ground is above all attributable to the production, maintenance and use phases. The relevant emissions are nitrogen oxides and volatile organic compounds without methane (NMVOC).

Abiotic depletion potential for non-fossil resources (ADPE)
The consumption of non-fossil resources results above all from production, maintenance and also use to a lesser extent. Consumption can be partly compensated beyond the system boundary (substitution of primary material). The elements which make the greatest contribution are tellurium, lead, silver, gold, zinc and copper.

Abiotic depletion potential for fossil resources (ADPF)
Fossil resources are consumed above all through the use of energy in production, use and maintenance. This concerns above all natural gas, oil and coal energy carriers.

Use of water (WDP)
Use of water results above all from energy production with hydro-electric power for production, maintenance and use. Water is, however, actually consumed in the provision of the raw materials – glass, steel and PVC.

6.3.2 Use of ressources

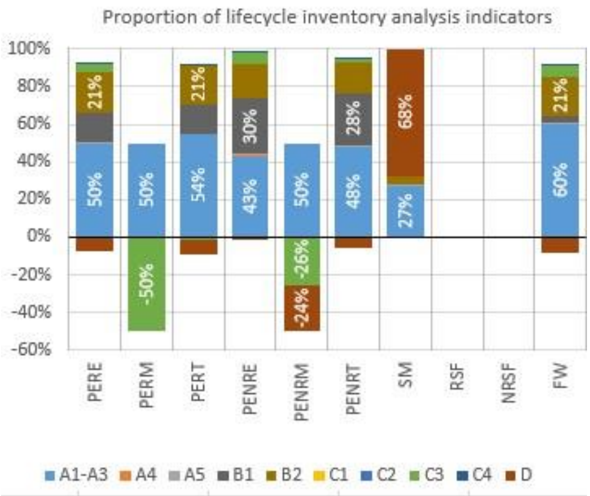

Abb. 6-3: Indicators to describe the use of ressources

Renewable primary energy as energy carrier (PERE) and for material use (PERM)
Renewable primary energy is used above all energetically in the production, maintenance and use phases. This is mainly biomass and hydro-electric and wind power. Material use, on the other hand, plays a smaller role; effects result from the stabiliser used.

Non-renewable primary energy as energy carrier (PENRE) and for material use (PENRM)
Non-renewable primary energy is also mainly used as energy; consumption of gas, oil and coal in the use, production and maintenance phases is relevant here. Material use in new PVC is of less significance.

Use of secondary materials (SM)
Secondary materials are used for the provision of metal components, especially steel, and also PVC and glass. Secondary materials in Module D are also provided for use beyond the system boundary.

Secondary fuels (RSF, NRSF)
The results are only partly significant due to methodical limitations. Secondary fuels are not used within the processes and data included.

Use of net fresh water (FW)
Use of water is used above all for energy production with hydro-electric power for production, maintenance and use. The consumption of fresh water results above all from the production of raw materials – glass, steel and PVC.

6.3.3 Output flows and waste categories

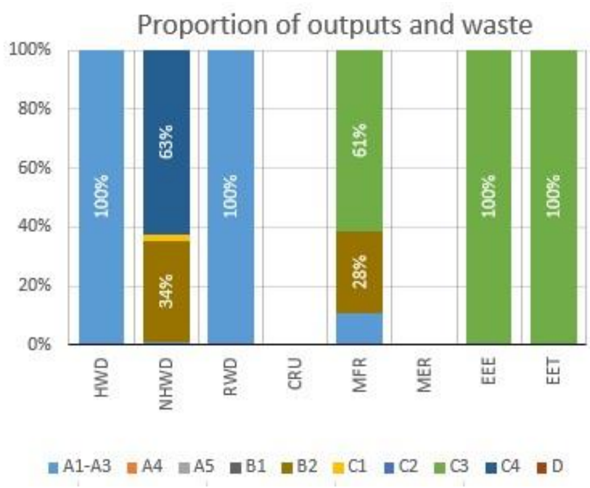

Fig. 6-4: Waste categories and output flows

Hazardous waste disposal (HWD)
The results are only partly significant due to methodical limitations. Small quantities of hazardous waste are deposited in PVC production and its pre-chains.

Non-hazardous waste disposal (NHWD)
The results are only partly significant due to methodical limitations. Non-hazardous waste accrues above all from waste disposal (Module C4) and maintenance. This is mainly deposited glass waste. On the other hand, the contribution from PVC production is extremely small.

Radioactive waste disposal (RWD)
The results are only partly significant due to methodical limitations. Contributions result from electricity shares from nuclear energy including in PVC production.

Components for reuse (CRU)
Nothing accrues.

Materials for recycling (MFR)
Materials for recycling are provided above all by waste treatment (Module C3), maintenance and to a lesser extent by recycling production waste. This is glass, metal and PVC.

Materials for energy recovery (MER)
Nothing accrues.

Exported energy (EEE, EET)
Energy in the form of electricity (EEE) and heat (EET) is recovered especially from waste treatment and exported, and here above all by incinerating PVC waste.

6.3.4 Additional impact categories

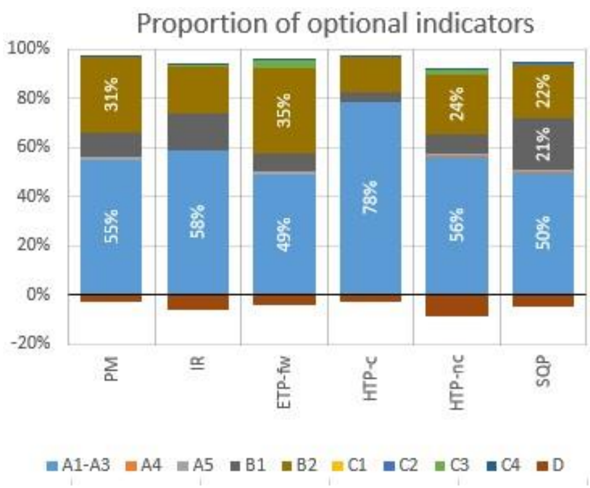

Fig. 6-5: Additional impact categories in accordance with EN 15804+A2

The distribution of further indicators to be stated optionally in individual modules of the lifecycle in accordance with *EN 15804+A2* can be seen in Fig. 6-5. There is no discussion.

7. Requisite evidence

7.1 Fire behavior

Fire tests in accordance with *EN 13823* on several samples from various manufacturers by Efectis Nederland BV, project number 2012-Efectis-R0205

Results:
In accordance with the average parameters determined, plastic windows fulfil the classification criteria in accordance with *DIN EN 13501-1*: 2007+A1:2009 as follows:

Fire behaviour class: B–E
Smoke production: s3
Flaming droplets: d0

7.2 VOC emissions

7.2.1
Final Report VOC Emission Study 'Plastic Windows'

Institut für Holztechnologie Dresden gemeinnützige GmbH (IHD). NO 1516009. July 2017

The results of several examinations of indoor pollution with VOC emissions are summarised in the report.

Results:
With regard to the French *Décret n° 2011-321* VOC ordinance for building products, all window elements examined fulfilled the best possible class A+ according to *Arrêté etiquetage 2011*.
With regard to the *AgBB* German assessment schema, all PVC frame profile variants examined (white, coated, foil-covered) fulfil the requirements.

7.2.2
Research project on VOC emissions in building components

The Federal Office for Building and Regional Planning (BBR) as part of the research initiative on the future of building (Bundesamt für Bauwesen und Raumordnung im Rahmen der Forschungsinitiative Zukunft Bau), file ref. Z6-10.08.18.7-08.20/II2-F20-08-005; December 2010

Results: With regard to indoor pollution, the requirements of the assessment by the *AgBB* schema are undercut.

8. References

STANDARDS

DIN 4102-1
DIN 4102-1:1998-05, Fire behaviour of building materials and building components – Part 1: Building materials; concepts, requirements and tests.

DIN V 18599-2
DIN V 18599-2:2011-12, 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.

EN 13501-1
DIN EN 13501-1:2019-05, Fire classification of construction products and building elements – Part 1: Classification using data from reaction to fire tests.

EN 13823
DIN EN 13823:2020-09, Reaction to fire tests for building products – Building products excluding floorings exposed to the thermal attack by a single burning item.

EN 14351-1
DIN EN 14351-1:2016-12, Windows and doors – Product standard, performance characteristics – Part 1: Windows and external pedestrian doorsets.

EN 15804
DIN EN 15804:2020-03, Sustainability of construction works – Environmental product declarations – Core rules for the product category of construction products. German version EN 15804:2012+A2:2019.

EN 17213
DIN EN 17213:2020-09, Windows and doors – Environmental Product Declarations – Product category rules for windows and pedestrian doorsets.

ISO 14001
DIN EN ISO 14001:2015-11, Environmental management systems – Requirements with guidance for use.

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

ISO 50001
DIN EN ISO 50001:2018-12: Energy management systems – Requirements with guidance for use.

FURTHER REFERENCES

AgBB
Evaluation scheme of emissions of Volatile Organic Compounds from building products; Committee for the Health-related Evaluation of Builduing Products; Germany, June 2021.

Arrêté etiquetage 2011
Arrêté du 19 avril 2011 relatif à l'étiquetage des produits de construction ou de revêtement de mur ou de sol et des peintures et vernis sur leurs émissions de polluants volatils. (JORF n°0111 du 13 mai 2011. Texte n° 15).
This decree specifies the details of the VOC regulation Décret n° 2011-321 including the limit values of the classes and the type of labeling.

BBSR 2017
Federal Institute for Construction,Urban and Regional Research, 24.02.2017, Useful lives of building components for life-cycle analysis according to BNB.

Construction Products Regulation (CPR)
Regulation (EU) No 305/2011 of the European Parliament and of the Council of 9 March 2011 laying down harmonised conditions for the marketing of construction products and repealing Council Directive 89/106/EEC (OJ L 88, 4.4.2011, p. 5–43).

Décret n° 2011-321
Décret n° 2011-321 du 23 mars 2011 relatif à l'étiquetage des produits de construction ou de revêtement de mur ou de sol et des peintures et vernis sur leurs émissions de polluants volatils (JORF n°0071 du 25 mars 2011. Texte n° 16).
French regulation on the labeling of construction products with regard to their emissions of volatile pollutants (VOC emissions).

ECHA candidate list
Candidate List of substances of very high concern for Authorisation (published in accordance with Article 59(10) of the REACH Regulation), 01.04.2020. Helsinki: European Chemicals Agency (ECHA).

ecoinvent 3
ecoinvent 3.7. Version 3.7.1, 2020. Dübendorf (CH): Swiss Centre for Life Cycle Inventories.

European Waste Catalogue
European Waste Catalogue (EWC) (Commission Decision 94/3/EC).

Gabi
GaBi ts, Version 10.5, 2021. Software-System and Database. Leinfelden-Echterdingen: Sphera Solutions GmbH.

IBU 2021/1
Institut Bauen und Umwelt e.V., 2021: General Instructions for the EPD programme of Institut Bauen und Umwelt e.V., Version 2.0, Berlin: Institut Bauen und Umwelt e.V.

IBU 2021/2
Institut Bauen und Umwelt e.V., 2021: Product Category Rules for Building-Related Products and Services. Institut Bauen und Umwelt e.V. (IBU) Part A: Calculation

Rules for the Life Cycle Assessment and Requirements on the Project Report acc. to EN 15804+A2:2019. Version 1.1. Berlin: Institut Bauen und Umwelt e.V.

IBU 2021/3
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ift 2010
ift Rosenheim 2010: Research project on VOC emissions in building components. Sponsered by The Federal Office for Building and Regional Planning (BBR) as part of the research initiative on the future of building (Bundesamt für Bauwesen und Raumordnung im Rahmen der Forschungsinitiative Zukunft Bau), file ref. Z6-10.08.18.7-08.20/II2-F20-08-005; Rosenheim: ift Rosenheim, Hochschule Rosenheim.

RAL-GZ 695
RAL Deutsches Institut für Gütesicherung und Kennzeichnung e.V. 2016: Windows, facades and front doors – Quality certification (RAL-GZ 695). Bonn: RAL Deutsches Institut für Gütesicherung und Kennzeichnung e.V.

RAL-GZ 716
RAL Deutsches Institut für Gütesicherung und Kennzeichnung e.V., 2019: Plastic window profile systems – Quality certification (RAL-GZ 716). Bonn: RAL Deutsches Institut für Gütesicherung und Kennzeichnung e.V.

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