Report: Comparison between environmental impact of window frames consisting of different materials

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SHR operates according to NEN-EN-ISO/IEC 17025:2005 "General requirements for the competence of testing and calibration Laboratories.

Contents

1 Assignment

The NBvT, the Dutch trade organisation for the timber industry, commissioned SHR to compare the environmental impact of window frames produced of different materials (wood, PVC, steel, aluminium), and to make an inventory of the data available in the NMD, Nationale MilieuDatabase, the Dutch National Environmental Database.
In the NMD data are available of the environmental impact of materials (basic profile) and products (EPD) used in buildings and constructions. These data are used in calculation tools to calculate the environmental impact of a complete building. By changing the materials and products, an optimal combination for the building or construction can be calculated.

The EPD data in the NMD are divided into three categories:
1. Verified data assembled for a specific product and producer.
2. Verified data assembled for a branch average product
3. Unverified data that were generated when no verified data were available.

The NMD started with a high share of unverified category 3 data, but in the last few years many were replaced by verified category 2 data . Also, more specific basic profiles of raw materials were included. Commissioned by Centrum Hout specific basic profiles of timber produced on four different continents (Europe, Africa, Tropical Asia and South America) were made (SHR reports 140028.001,-002, -006, -007). These data have been used by the NBvT to produce EPD's (environmental product declaration) for wooden window frames: a fixed frame, a frame with a turning window and a frame with till and turn window (Agrodome, 1016, div).

In order to characterize the environmental impact of wood as a building material for windows, this study compares wood with other materials.

2 Comparison of EPD's of different martials

2.1 Available information

For this study, the Agrodome EPD's of windows (produced of European softwood, African hardwood, South American hardwood, Accoya and of Meranti), were used. The EPD's describe three window types : a fixed window frame without turning elements, a frame with a turning window and a frame with a turn and till window.). As EPD's of the turning window and the windows made of Accoya still need verification, these products are not included in this report.
These EPD's have been compared with verified EPD's open for the public of windows made of steel, aluminium, PVC and preservative treated wood.

Comparison of these EPD's is not straight forward. In all EPD's involved the calculations include production, maintenance, disassembly and waste management. Locks and hinges and the necessary coatings are also included. As a result of the materials used, the weight of the different frames vary. Also the expected or technical lifespan differs for different materials the frames are made of.

Ranging from 25 years for a window made of European softwood to 75 years for windows made of tropical hardwoods. The life spans of windows made of the other materials vary between 40 and 60 years.

However, there are other more fundamental differences. The EPD's of PVC, steel, aluminium and preservative treated wood were based on the European standard (NEN EN15804) only, whereas the wooden windows EPD's were based also on the Dutch 'Bepalingsmethode'. As a result, the main difference between the EPD's lies in the dimensions and whether or not glazing is included. All EPD's compared were scaled towards 1 m^2 window frame. In the EPD's of PVC, steel, aluminium, and preservative wood, the calculations were made on a standard 1.23 x 1.48 m area of a turn and till window including glazing. The wooden windows EPD's did not included glazing and were based on the largest dimensions realistically used: 3.30 x 1.50 m for a fixed frame and 1.40 x 1.80 m for a frame with till and turn window. This results in an open glazing area of 4.33 m^2 and 2.11 m^2 for the fixed frame and the till and turn window respectively. For the other windows based on the European standard the open area is estimated at 1,5 m^2 (1.11 x 1.36 m).
A summary of the bases of the calculations of the EPD's is given in appendix 1.

2.2 Comparison of data

The EPD's calculate the environmental impact of different life cycle stages (see Table 1). Individual stages can sometimes be combined as (A1, A2, A3, + A5), (B1 to B7) or (C1, C3, C4, + D).

Table 1. Life cycle stages

Product stage			Construction process stage		Use stage							End-of-life stage				Benefits and loads beyond the system boundaries
A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4	D
Raw material supply	Transport	Manufacturing	Transport	Construction / installation	Use	Maintenance	Repair	Replacement	Modification / refurbishment	Operational energy use	Operational water use	De-construction	transport	Waste management	Disposal	Reuse Recovery `Recycling potential

The Environmental impact is calculated over different impact categories. Here again differences can be found between de EPD's made according to the European standard and the EPD's for the NMD
The European standard recognizes 6 (7) impact categories, the NMD 11 categories (see Table 2).
In order to be able to compare the different EPD's the impact of the wooden frames has been calculated over 7 and over 11 impact categories.

Table 2. Impact categories. Present in European and Dutch standards (Y = yes) and the Dutch assigned shadow price.

Impact category	Unit	In European standard	In Dutch standard	Shadow price [€/kg]
Abiotic depletion, non fuel	kg Sb eq.	Y	Y	€ 0,16
Abiotic depletion, fuel	kg Sb eq.		Y	€ 0,16
Global warming (GWP100)	kg CO2 eq.	Y	Y	€ 0,05
Ozone layer depletion (ODP)	kg CFK-11 eq.	Y	Y	€ 30
Photochemical oxidation	kg ethylene eq.	Y	Y	€ 2
Acidification	kg SO2 eq.	Y	Y	€ 4
Eutrophication	kg PO4- eq.	Y	Y	€ 9
Human toxicity	kg 1,4- DB eq.	-	Y	€ 0,09
Fresh water aquatic ecotoxicity	kg 1,4- DB eq.	-	Y	€ 0,03
Marine aquatic ecotoxicity	kg 1,4- DB eq.	-	Y	€ 0,0001
Terrestrial ecotoxicity	kg 1,4- DB eq.	-	Y	€ 0,06

As the Wooden NBvT windows do not include glazing it was suggested to subtract the glazing from the impact of the other window frames. To obtain data of glazing, two EPDs were used. One from Saint-Gobain, describing double glazing including metal and plastic spacers (SSG Climaplus 4-16-4). The other was mentioned in the IFT Rosenheim EPDs of the steel and aluminium windows and consisted of only 1mm float glass. Information can be found in Appendix 3.
The float glass can be used when multiplying the data by 8 (2 panes of 4 mm each) although, the metal spacers used to produce double glazing and the production of double glazing from glass panes are, in that case, not included. The Saint-Gobain data were thought to be useable as presented. However when subtracting the impact of1,5 m^2 double glazing from the impact of the steel, aluminium, PVC and preservative treated wood window, negative impacts were found where these were not expected. As a result the subtraction of the impact of the glazing was omitted and only the original data are presented. However, the difference in functional unit (with or without glazing) has to be kept in mind.

The total environmental impact divided over the different impact categories of the windows is summarized in Tables 3 and 4. Table 3 shows the impact of the till and turn windows, Table 4 the impact of the NBvT wooden windows, fixed and till and turn.
To facilitate easy comparison, the Dutch 'Bepalingsmethode' assigns shadow costs to each impact category. The height of the shadow costs per kg equivalent is included in Table 2. The total shadow costs of 1 m^2 window is included in Tables 3B and 4B. Based on the Saint Gobain data, the shadow costs of double glazing was calculated as € 4.33 for 1 m^2 and € 6.49 for 1,5 m^2 in the European turn and till windows

As the European method does not include 4 of the impact categories of the Dutch standard, two summations of the shadow costs have been made. One including only those categories that that all EPD's have in common (categories 1 – 7) and the other including all 11 categories.

The expected technical life span of the windows differ. For fair comparison the shadow costs of the different windows have been calculated for a total life span of 75 years, the standard in the ‘Bepalingsmethode’.

Considering a life span of 75 years, of all NBvT wooden window frames the European softwood window has the highest impact. The difference is due to difference in expected life span of the wood species. The softwood frame needs to be replaced every 25 years, implicating a three times higher environmental impact.
The Environmental impact of the windows made of materials other than wood is much higher compared to the environmental impact of the wooden window frame. Even when considering the shadow costs of the double glazing. The main impact difference lies in Global Warming. Energy input in processing being an important factor.

Table 3A. Environmental impact of 1 m² till and turn windows. Total impact of all life cycle stages A, B, C, D.

Impact category	Unit	PVC	Pres. treated wood, no aluminium	Pres. treated wood with aluminium	Aluminium	Steel	Meranti	African hardwood	European softwood	South American hardwood
Abiotic depletion, non fuel	kg Sb eq.	5.37E-03	4.72E-04	5.26E-04	2.71E-02	5.50E-03	1.72E-04	1.89E-04	1.33E-04	3,19E-04
Abiotic depletion, fuel	kg Sb eq.						1.40E-01	1.54E-01	8.88E-02	2,30E-01
Global warming (GWP100)	kg CO2 eq.	1.05E+03	1.51E+02	1.78E+02	6.90E+02	5.83E+02	2.25E+01	2.39E+01	1.47E+01	3,04E+01
Ozone layer depl. (ODP)	kg CFK-11 eq.	1.29E-04	1.36E-05	1.52E-05	1.08E-05	1.28E-06	2.00E-06	2.53E-06	8.79E-07	3,88E-06
Photochemical oxidation	kg ethylene eq.	2.56E+00	4.07E-02	5.00E-02	7.99E-02	9.55E-02	1.76E-02	1.91E-02	8.58E-03	2,42E-02
Acidification	kg SO2 eq.	3.11E-01	8.36E-01	9.50E-01	8.00E-01	1.01E+00	1.51E-01	1.35E-01	6.72E-02	1,35E-01
Eutrophication	kg PO4- eq.	1.39E-01	2.44E-01	2.88E-01	1.14E-01	1.16E-01	2.11E-02	2.39E-02	1.19E-02	2,39E-02
Human toxicity	kg 1,4- DB eq.						1.82E+01	1.80E+01	1.36E+01	2,06E+01
Fresh water aquatic ecotox.	Kg 1,4- DB eq.						4.23E-01	4.51E-01	2.02E-01	5,31E-01
Marine aquatic ecotoxicity	kg 1,4- DB eq.						1.13E+03	1.15E+03	6.94E+02	1,41E+03
Terrestrial ecotoxicity	kg 1,4- DB eq.						1.95E-01	2.47E-01	1.59E-01	2,75E-01
Total renewable energy	MJ	1.45E+02	1.17E+03	1.15E+03	7.90E+01	2.44E+02	6.85E+02	6.36E+02	1.44E+02	6,43E+02
Total non renewable energy	MJ	1.69E+04	2.33E+03	2.73E+03	1.06E+04	2.03E+03	5.51E+02	6.34E+02	3.95E+02	8,40E+02
Total Energy	MJ	1.70E+04	3.50E+03	3.89E+03	1.07E+04	2.27E+03	1.25E+03	1.28E+03	5.50E+02	1,50E+03
Water, fresh water use	m3	7.21E+01	1.67E+00	1.87E+00	8.06E+02	3.06E+02	1.12E+02	1.07E+02	9.52E+01	1,20E+02
Waste, non hazardous	kg	1.22E+03	8.67E+01	9.03E+01		2.48E+02	3.86E-01	3.78E-01	3.76E-01	3,83E-01
Waste, hazardous	kg	2.80E-01	1.22E+01	1.60E+01		1.20E-01	2.41E-01	2.35E-01	2.35E-01	2,39E-01
Including glazing		Yes	Yes	Yes	Yes	Yes	No	No	No	No
Original dimensions [m]		1.23 x 1.48	1.23 x 1.48	1.23 x 1.48	1.23 x 1.48	1.23 x 1.48	1.4 x 1.8	1.4 x 1.8	1.4 x 1.8	1.4 x 1.8
Expected life span [years]		50	40	60	50	50	75	75	25	75

Table 3B, shadow costs of 1 m² till and turn windows

Impact category	Unit	PVC	Pres. treated wood, no aluminium	Pres. treated wood with aluminium	Aluminium	Steel	Meranti	African hardwood	European softwood	South American hardwood
Abiotic depletion, non fuel	kg Sb eq.	€ 0.00	€ 0.00	€ 0.00	€ 0.00	€ 0.00	€ 0.00	€ 0.00	€ 0.00	€ 0,00
Abiotic depletion, fuel	kg Sb eq.	€ 0.00	€ 0.00	€ 0.00	€ 0.00	€ 0.00	€ 0.02	€ 0.02	€ 0.01	€ 0,04
Global warming (GWP100)	kg CO2 eq.	€ 52.53	€ 7.57	€ 8.91	€ 34.50	€ 29.15	€ 1.13	€ 1.20	€ 0.73	€ 1,52
Ozone layer depl. (ODP)	kg CFK-11 eq.	€ 0.00	€ 0.00	€ 0.00	€ 0.00	€ 0.00	€ 0.00	€ 0.00	€ 0.00	€ 0,00
Photochemical oxidation	kg ethylene eq.	€ 5.11	€ 0.08	€ 0.10	€ 0.16	€ 0.19	€ 0.04	€ 0.04	€ 0.02	€ 0,05
Acidification	kg SO2 eq.	€ 1.24	€ 3.34	€ 3.80	€ 3.20	€ 4.03	€ 0.60	€ 0.54	€ 0.27	€ 0,54
Eutrophication	kg PO4- eq.	€ 1.25	€ 2.19	€ 2.59	€ 1.02	€ 1.04	€ 0.19	€ 0.21	€ 0.11	€ 0,22
Human toxicity	kg 1,4- DB eq.						€ 1.64	€ 1.62	€ 1.22	€ 1,86
Fresh water aquatic ecotox.	Kg 1,4- DB eq.						€ 0.01	€ 0.01	€ 0.01	€ 0,02
Marine aquatic ecotoxicity	kg 1,4- DB eq.						€ 0.11	€ 0.11	€ 0.07	€ 0,14
Terrestrial ecotoxicity	kg 1,4- DB eq.						€ 0.01	€ 0.01	€ 0.01	€ 0,02
Total of 7 impact categories		**€ 60,14**	**€ 13.19**	**€ 15.39**	**€ 38.89**	**€ 34.42**	**€ 1.98**	**€ 2.01**	**€ 1.14**	**€ 2.36**
Total all 11 impact categories							€ 3.75	€ 3.78	€ 2.45	€ 4.39
Total 7 categories for a life span of 75 years		€ 90,21	€ 24.72	€ 19.24	€ 58.33	€ 51.63	€ 1.98	€ 2.01	€ 3.42	€ 2.36
Including glazing		Yes	Yes	Yes	Yes	Yes	No	No	No	No
Original dimensions [m]		1.23 x 1.48	1.23 x 1.48	1.23 x 1.48	1.23 x 1.48	1.23 x 1.48	1.4 x 1.8	1.4 x 1.8	1.4 x 1.8	1.4 x 1.8
Expected life span [years]		50	40	60	50	50	75	75	25	75

Table 4A. Environmental impact of 1 m² wooden windows. Total impact of all life cycle stages A, B, C, D.

Impact category	Unit	Meranti		African hardwood		European softwood		South American hardwood	
		Fixed frame	Till & turn window	Fixed frame	Till & turn window	Fixed frame	Till & turn window	Fixed frame	Till & turn window
Abiotic depletion, non fuel	kg Sb eq.	3.20E-04	1.72E-04	2.30E-05	1.89E-04	9.18E-06	1.33E-04	2.75E-05	3.19E-04
Abiotic depletion, fuel	kg Sb eq.	5.94E-02	1.40E-01	6.89E-02	1.54E-01	2.98E-02	8.88E-02	6.87E-02	2.30E-01
Global warming (GWP100)	kg CO2 eq.	9.90E+00	2.25E+01	1.09E+01	2.39E+01	4.63E+00	1.47E+01	1.04E+01	3.04E+01
Ozone layer depl. (ODP)	kg CFK-11 eq.	8.95E-07	2.00E-06	1.22E-06	2.53E-06	3.41E-07	8.79E-07	1.24E-06	3.88E-06
Photochemical oxidation	kg ethylene eq.	7.72E-03	1.76E-02	9.69E-03	1.91E-02	2.71E-03	8.58E-03	8.98E-03	2.42E-02
Acidification	kg SO2 eq.	7.74E-02	1.51E-01	5.66E-02	1.35E-01	2.08E-02	6.72E-02	4.44E-02	1.35E-01
Eutrophication	kg PO4- eq.	1.21E-02	2.11E-02	1.10E-02	2.39E-02	4.40E-03	1.19E-02	9.15E-03	2.39E-02
Human toxicity	kg 1,4- DB eq.	9.89E+00	1.82E+01	4.18E+00	1.80E+01	1.71E+00	1.36E+01	4.01E+00	2.06E+01
Fresh water aquatic ecotox.	Kg 1,4- DB eq.	2.16E-01	4.23E-01	2.00E-01	4.51E-01	7.64E-02	2.02E-01	1.95E-01	5.31E-01
Marine aquatic ecotoxicity	kg 1,4- DB eq.	6.02E+02	1.13E+03	5.41E+02	1.15E+03	2.47E+02	6.94E+02	4.79E+02	1.41E+03
Terrestrial ecotoxicity	kg 1,4- DB eq.	2.21E-01	1.95E-01	9.59E-02	2.47E-01	4.91E-02	1.59E-01	9.14E-02	2.75E-01
Total renewable energy	MJ	2.96E+02	6.85E+02	3.31E+02	6.36E+02	7.25E+01	1.44E+02	3.24E+02	6.43E+02
Total non renewable energy	MJ	2.32E+02	5.51E+02	2.69E+02	6.34E+02	1.57E+02	3.95E+02	2.89E+02	8.40E+02
Total Energy	MJ	5.34E+02	1.25E+03	6.06E+02	1.28E+03	2.34E+02	5.50E+02	6.21E+02	1.50E+03
Water, fresh water use	m^3	6.35E+01	1.12E+02	2.00E+01	1.07E+02	1.45E+01	9.52E+01	1.99E+01	1.20E+02
Waste, non hazardous	kg	1.47E-05	3.86E-01	-3.35E-04	3.78E-01	1.93E-05	3.76E-01	1.98E-05	3.83E-01
Waste, hazardous	kg	2.61E-04	2.41E-01	-6.91E-04	2.35E-01	3.41E-04	2.35E-01	3.49E-04	2.39E-01
Including glazing		No	No	No	No	No	No	No	No
Original dimensions [m]		3.3 x 1.5	1.4 x 1.8	3.3 x 1.5	1.4 x 1.8	3.3 x 1.5	1.4 x 1.8	3.3 x 1.5	1.4 x 1.8
Expected life span [years]		75	75	75	75	25	25	75	75

Table 4B. Shadow costs of 1m^2 wooden windows.

Impact category	Unit	Meranti		African hardwood		European softwood		South American hardwood	
		Fixed frame	Till & turn window	Fixed frame	Till & turn window	Fixed frame	Till & turn window	Fixed frame	Till & turn window
Abiotic depletion, non fuel	kg Sb eq.	€ 0.00	€ 0.00	€ 0.00	€ 0.00	€ 0.00	€ 0.00	€ 0.00	€ 0,00
Abiotic depletion, fuel	kg Sb eq.	€ 0.01	€ 0.02	€ 0.01	€ 0.02	€ 0.00	€ 0.01	€ 0.01	€ 0,04
Global warming (GWP100)	kg CO2 eq.	€ 0.49	€ 1.13	€ 0.54	€ 1.20	€ 0.23	€ 0.73	€ 0.52	€ 1,52
Ozone layer depl. (ODP)	kg CFK-11 eq.	€ 0.00	€ 0.00	€ 0.00	€ 0.00	€ 0.00	€ 0.00	€ 0.00	€ 0,00
Photochemical oxidation	kg ethylene eq.	€ 0.02	€ 0.04	€ 0.02	€ 0.04	€ 0.01	€ 0.02	€ 0.02	€ 0,05
Acidification	kg SO2 eq.	€ 0.31	€ 0.60	€ 0.23	€ 0.54	€ 0.08	€ 0.27	€ 0.18	€ 0,54
Eutrophication	kg PO4- eq.	€ 0.11	€ 0.19	€ 0.10	€ 0.21	€ 0.04	€ 0.11	€ 0.08	€ 0,22
Human toxicity	kg 1,4- DB eq.	€ 0.89	€ 1.64	€ 0.38	€ 1.62	€ 0.15	€ 1.22	€ 0.36	€ 1,86
Fresh water aquatic ecotox.	Kg 1,4- DB eq.	€ 0.01	€ 0.01	€ 0.01	€ 0.01	€ 0.00	€ 0.01	€ 0.01	€ 0,02
Marine aquatic ecotoxicity	kg 1,4- DB eq.	€ 0.06	€ 0.11	€ 0.05	€ 0.11	€ 0.02	€ 0.07	€ 0.05	€ 0,14
Terrestrial ecotoxicity	kg 1,4- DB eq.	€ 0.01	€ 0.01	€ 0.01	€ 0.01	€ 0.00	€ 0.01	€ 0.01	€ 0,02
Total of 7 impact categories		**€ 0,94**	**€ 1.98**	**€ 0.90**	**€ 2.01**	**€ 0.36**	**€ 1.14**	**€ 0.81**	**€ 2.36**
Total all 11 impact categories		€ 1,91	€ 3.75	€ 1.34	€ 3.78	€ 0.55	€ 2.45	€ 1.23	€ 4.39
Total 7 categories for a life span of 75 years		€ 0,94	€ 1.98	€ 0.90	€ 2.01	€ 1.09	€ 3.42	€ 0.81	€ 2.36
Including glazing		No	No	No	No	No	No	No	No
Original dimensions [m]		3.3 x 1.5	1.4 x 1.8	3.3 x 1.5	1.4 x 1.8	3.3 x 1.5	1.4 x 1.8	3.3 x 1.5	1.4 x 1.8
Expected life span [years]		75	75	75	75	25	25	75	75

3 Category 2 and 3 data in the NMD

The EPD of the different wooden window frames are not available yet but will be uploaded in the NMD (Dutch National Environmental Database) soon as category 2 data (general data for the branch). As far as possible, the effect of the new data in the database has been evaluated.

3.1 Available information

At present the NMD database is mainly filled with unverified category 3 data. Little is known how these data are compiled. Table 5 gives 2 screen prints of the information available in the NMD. Screen print 5.1 of the (window) frames, screen print 5.2 of the windows. In Dutch there is a difference between frame (= kozijn) and window (= raam). The later being the turning part in a window frame combination. The products in red are public data and more information should be available. Table 6 shows an example of the available information given.
No underlying data can be excessed and the database looks like an black box. The additional obstacle is the difference in the basis of the data. The description is not always clear what components are included and what not. Is glazing is included? Are locks and hinges included? Is a window included in a frame? Or when looking in the code 31.03 products, windows, are the frames included or not?

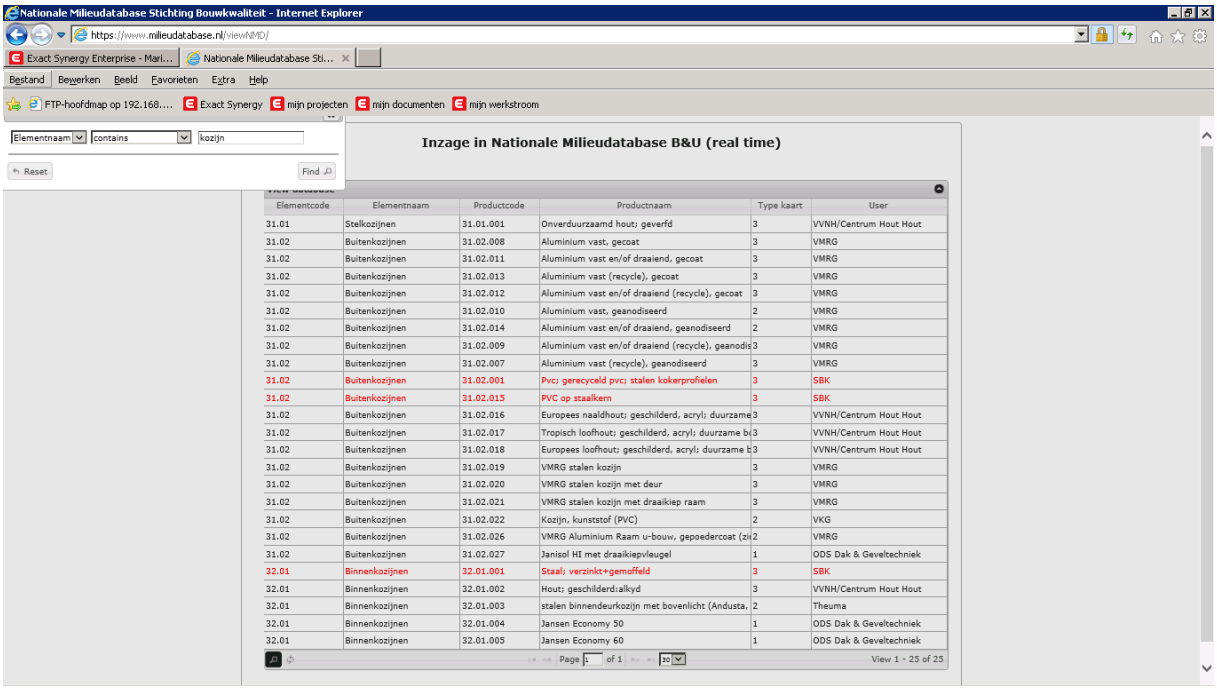
The data in the NMD are mainly meant to use in the calculation tools to calculate the environmental impact of a total building. For the comparison described here, the mrpi-mpg tool is used (www.mrpi-mpg.nl/). In the tools the same product and materials can be accessed as available in the NMD. Although a little more data appears to be available in the tool, the same questions arise as in the NMD: what is included in the data and what not? Do users of the tool realise that products might be incomparable or that one product needs additional materials like glazing or hinges? Are these additional materials available in the NMD and thereby in the tool?
Annex 3 gives the information (in Dutch) available in mrpi-mpg tool and table 8 summarizes the data.

3.2 Comparison of data

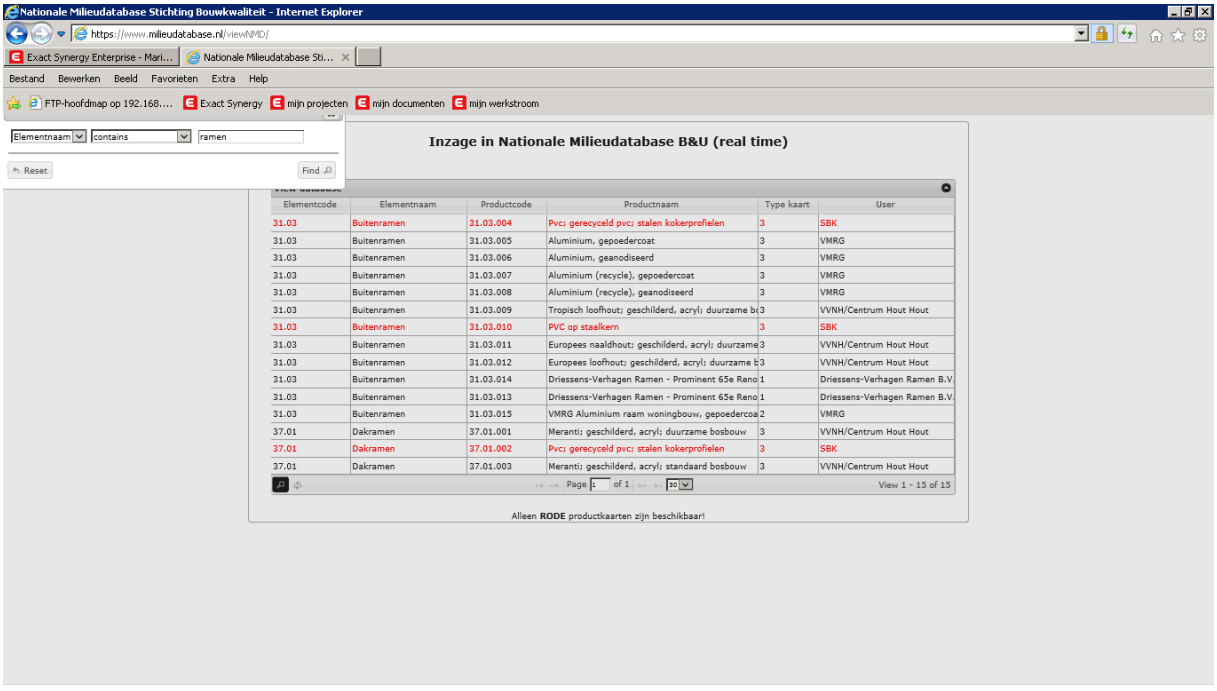
Comparison of the category 2 and 3 data is difficult. Without access to the underlying data the only possibility is to use the calculation tool and compare the costs when choosing one window or another window or frame. In Appendix 3 in column 3 and 4 and in Table 8 the costs of the different windows and frames are given when a 1 m^2 window is place in an imaginary building with floor area of 1 m^2. In column 3 of appendix 3 the costs are given for 1 year. In column 4 the costs are given for 75 years.

The later data, costs in 75 years calculated by the NMD-tool, should be comparable to the data calculated in chapter 2 based on the data in the EPD's. In all type of materials a significant difference is found, between the calculations based on the EPD-data and the calculations based on the NMD calculation tool. Nevertheless, in both systems, the PVC windows have the highest environmental impact and the wooden windows the lowest. The aluminium and steel windows are somewhere in the middle when the environmental impact is concerned.

Table 5. Exterior windows (code 31.03) and exterior frames (code 31.02) available in the NMD



5.1 Screen print of the NMD for frames (31.02)



5.2.Screen print of the NMD for windows (31.03)

Table 6. Screen print of an example of the information of a public product available in the NMD.

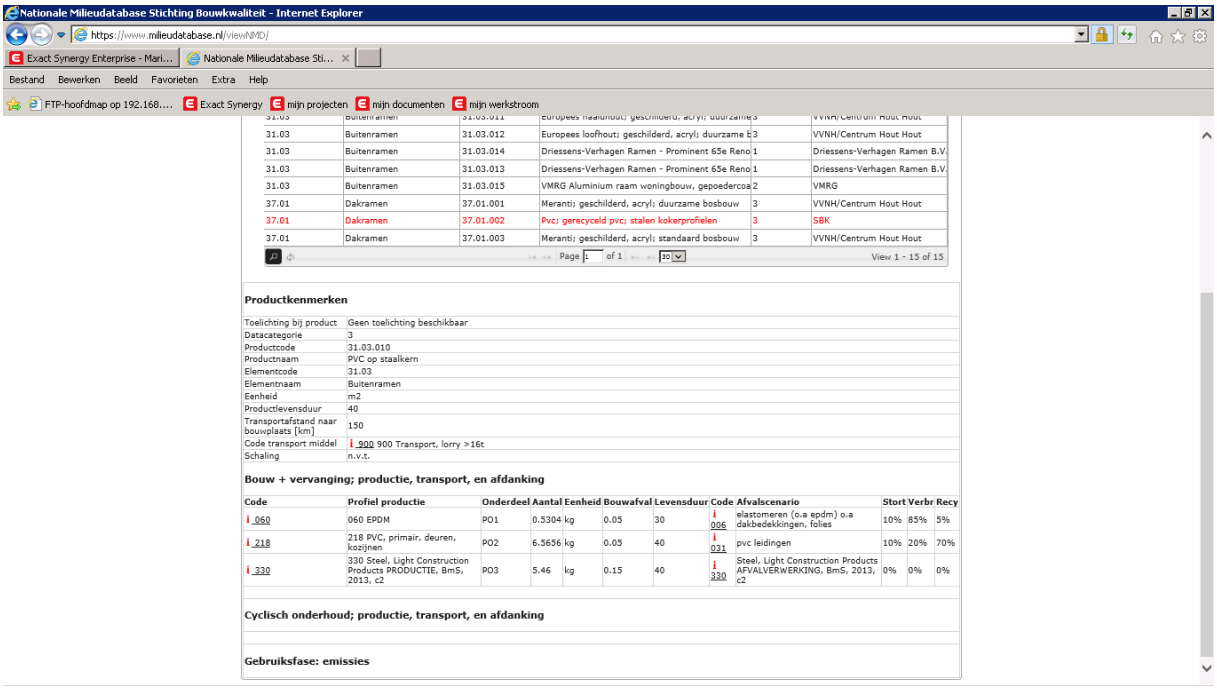


Table 7. Summary of the shadow costs of the verified EPD's

Description	glazing	Locks & hinges	Costs 75 years	Cat.
NBvT, Meranti, fixed frame	No	No	€ 0.94	2
NBvT, Meranti, till and turn window	No	Yes	€ 1.98	2
NBvT, African hardwood, fixed frame	No	No	€ 0.90	2
NBvT, African hardwood, till and turn window	No	Yes	€ 2.01	2
NBvT European softwood, fixed frame	No	No	€ 1.09	2
NBvT European softwood , till and turn window	No	Yes	€ 3.42	2
NBvT South America hardwood, fixed frame	No	No	€ 0.81	2
NBvT South America hardwood, till and turn window	No	Yes	€ 2.36	2
PVC, till and turn window	Yes	Yes	€ 60.14	1
Steel, till and turn window	Yes	Yes	€ 51.63	1
Aluminium, till and turn window	Yes	Yes	€ 58.33	1
Preservative treated wood no aluminium, till and turn window	Yes	Yes	€ 24.72	1
Preservative treated wood with alum., till and turn window	Yes	Yes	€ 19.24	1

Table 8. Summary of information available in the NMD including shadow costs over 75 years.

Description	Glazing*	Locks & hinges*	Cost [€] 75 years	Cat.
Verified data; Frame, code 31.02				
Aluminium vast, geanodiseerd (fixed frame)	?	No	€ 4.21	2
Janisol HI met draaikiepvleugel (partly till and turn)	?	?	€ 4.56	1
Kozijn, kunststof (PVC)	?	?	€ 12.09	2
VMRG Aluminium Raam u-bouw, gepoedercoat (zirkonium voorbehandeling)	No	No	€ 4.65	2
Unverified data ; frames code 31.02				
Aluminium vast (recycle), geanodiseerd (fixed)	?	No	€ 2.42	3
Aluminium vast (recycle), gecoat (fixed frame)	?	No	€ 3.46	3
Aluminium vast en/of draaiend (recycle), geanodiseerd (fixed)	?	No	€ 3.90	3
Aluminium vast en/of draaiend (recycle), gecoat (fixed)	?	No	€ 5.60	3
Aluminium vast en/of draaiend, gecoat (partly till and turn)	?	Yes	€ 7.51	3
Aluminium vast, gecoat (fixed)	?	No	€ 4.52	3
Europees loofhout; geschilderd, acryl; duurzame bosbouw	?	?	€ 0.49	3
Europees naaldhout; geschilderd, acryl; duurzame bosbouw	?	?	€ 0.61	3
PVC op staalkern			€ 7.96	3
Pvc; gerecyceld pvc; stalen kokerprofielen			€ 2.61	3
Tropisch loofhout; geschilderd, acryl; duurzame bosbouw	?	?	€ 1.94	3
VMRG stalen kozijn			€ 1.58	3
VMRG stalen kozijn met deur			€ 5.14	3
VMRG stalen kozijn met draaikiep raam			€ 3.15	3
Verified data; windows code 31.03				
Driessens-Verhagen Ramen - Prominent 65e Renova, inclusief draaiend deel	?	?	€ 4.16	1
Driessens-Verhagen Ramen - Prominent 65e Renova, vast (alu. , gepoedercoat)	?	?	€ 4.32	1
VMRG Aluminium raam woningbouw, gepoedercoat (zirkonium voorbehandeling)	No	No	€ 3.15	2
Unverified data; Windows code 31.03				
Aluminium (recycle), geanodiseerd			€ 2.75	3
Aluminium (recycle), gepoedercoat			€ 7.90	3
Aluminium, geanodiseerd			€ 8.05	3
Aluminium, gepoedercoat			€ 10.23	3
Europees loofhout; geschilderd, acryl; duurzame bosbouw	?	?	€ 0.41	3
Europees naaldhout; geschilderd, acryl; duurzame bosbouw	?	?	€ 1.12	3
PVC op staalkern			€ 11.89	3
Pvc; gerecyceld pvc; stalen kokerprofielen			€ 10.82	3
Tropisch loofhout; geschilderd, acryl; duurzame bosbouw			€ 2.43	3

*) ? means unclear if glazing or locks & hinges are included; no entry means no information is given at all.

4 Conclusion

The NBvT commissioned SHR to compare the Environmental impact calculated for wooden window frames with window frames made of other materials and to evaluate the verified category 2 and unverified category 3 data of the NMD, the Dutch National Environmental Database.

Comparison of the environmental impact based on the new EPD's and the existing EPD's of other materials is difficult as the functional unit is not the same. The EPD's of the wooden frames do not include glazing. The dimensions of the Dutch till and turn windows are slightly larger than the European till and turn windows.
Based on the data available and considering the difference in functional unit, the environmental impact is lowest for windows made of tropical hardwoods. Second best is European softwood than preservative treated softwood, aluminium and steel. PVC has the highest impact. It has to be stated that this order is based on EPD's using 7 impact categories only and that, except for the preservative treated wooden window, the other wooden windows do not include glazing and are based on slightly larger dimensions.

Although the method of determining the environmental impact for the NMD EPD's is more standardized, the comparison of the verified and unverified data from the NMD is even more difficult then that of EPD's made on the basis on the EN 155804 only. Main cause is that there is often too little unity in the functional units. Furthermore the underlying data are not available. Calculated with the available calculation tools, the environmental impact is lowest for windows made of European softwood. Second best are windows of tropical hardwoods, than windows of aluminium and steel. Again PVC has the highest environmental impact.

Literature

Agrodome; 2016; Concept levenscyclus Analyse rapportage Afrikaans loofhout kozijnen: vast, met draaiend raam en met draaival raam.

Agrodome; 2016; Concept levenscyclus Analyse rapportage Europees naaldhout kozijnen: vast, met draaiend raam en met draaival raam.

Agrodome; 2016; Concept levenscyclus Analyse rapportage Meranti kozijnen: vast, met draaiend raam en met draaival raam.

Agrodome; 2016; Concept levenscyclus Analyse rapportage Zuid Amerikaans loofhout kozijnen: vast, met draaiend raam en met draaival raam.

IFT Rosenheim; 2011; EPD Aluminiumfenster; Eduard Hueck GmbH & Co. KG.

IFT Rosenheim; 2012; EPD steel/stainless steel windows; Janssen AG.

IFT Rosenheim;2012; EPD Flach, Einscheibensicherheits-und Verbundsicherheitsglas, Frerichs Glas., UniGlas.

Institut Bauen und Umwelt eV.; 2014; EPD PVC-U plastic windows.

Saint-Gobain Glass; 2012; Auszug aus der Umweltproduktdeklaration SGG Climaplus 4-16-4 mm.

The Norwegian EPD Foundation; 2014; EPD NorDan NTech Inward opening tilt & turn window 105/80.

Appendix 1. Summary of the bases of the EPD's

Meranti window frames

Name	NBvT Meranti window frame, fixed
Description	Meranti window, fixed (no turning elements) produces according to the Dutch KVT of 500 kg/m^3 Meranti out of sustainable managed forests.
Dimensions	3.30 x 1.50 m
Glazing	no glazing.
Window depth	114 x 67 mm.
Surface treatment	Painted. Acrylic or alkyd emulsion, waterborne exterior coating
Technical life	75 years
Open area	4.33 m^2.
Calculated area	1 m^2
Seals	
Fittings	
Weight	8.5 kg
Publisher	Agrodome
Standards	ISO 14040, ISO 14044, EN15804, SBK bepalingsmethode

Name	NBvT Meranti window frame, till and turn window
Description	Meranti window, till and turn window produces according to the Dutch KVT of 500 kg/m^3 Meranti out of sustainable managed forests.
Dimensions	1.40 x 1.80 m
Glazing	no glazing.
Window depth	114 x 67 mm.
Surface treatment	Painted. Acrylic or alkyd emulsion, waterborne exterior coating
Technical life	75 years
Open area	2.11 m^2.
Calculated area	1 m^2
Seals	TPE/EPDM
Fittings	Steel, stainless steel, anodized, Zamak
Weight	20.4 kg
Publisher	Agrodome
Standards	ISO 14040, ISO 14044, EN15804, SBK bepalingsmethode

South American hardwood window frames

Name	NBvT South American hardwood window frame, fixed
Description	South American hardwood window, fixed (no turning elements) produces according to the Dutch KVT. Example of wood species: Sucupira vermelho, Angelim pedra, Louro out of sustainable managed forests. (754 kg/m^3)
Dimensions	3.30 x 1.50 m
Glazing	no glazing.
Window depth	114 x 67 mm.
Surface treatment	Painted. Acrylic or alkyd emulsion, waterborne exterior coating
Technical life	75 years
Open area	4.33 m^2.
Calculated area	1 m^2
Seals	
Fittings	
Weight	12.6 kg
Publisher	Agrodome
Standards	ISO 14040, ISO 14044, EN15804, SBK bepalingsmethode

Name	NBvT South American hardwood till and turn window
Description	South American hardwood, till and turn window produces according to the Dutch KVT Example of wood species: Sucupira vermelho, Angelim pedra, Louro out of sustainable managed forests. (754 kg/m^3)
Dimensions	1.40 x 1.80 m
Glazing	no glazing.
Window depth	114 x 67 mm.
Surface treatment	Painted. Acrylic or alkyd emulsion, waterborne exterior coating
Technical life	75 years
Open area	2.11 m^2.
Calculated area	1 m^2
Seals	TPE/EPDM
Fittings	Steel, stainless steel, anodized, Zamak
Weight	29,2 kg
Publisher	Agrodome
Standards	ISO 14040, ISO 14044, EN15804, SBK bepalingsmethode

African hardwood window frames

Name	NBvT African hardwood window frame, fixed
Description	African hardwood window, fixed (no turning elements) produces according to the Dutch KVT. Example of wood species: Sapeli and Iroko out of sustainable managed forests.. (670 kg/m^3).
Dimensions	3.30 x 1.50 m
Glazing	no glazing.
Window depth	114 x 67 mm.
Surface treatment	Painted. Acrylic or alkyd emulsion, waterborne exterior coating
Technical life	75 years
Open area	4.33 m^2.
Calculated area	1 m^2
Seals	
Fittings	
Weight	11.2 kg
Publisher	Agrodome
Standards	ISO 14040, ISO 14044, EN15804, SBK bepalingsmethode

Name	NBvT African hardwood till and turn window
Description	African hardwood, till and turn window produces according to the Dutch KVT Example of wood species: Sapeli and Iroko out of sustainable managed forests.. (670 kg/m^3).
Dimensions	1.40 x 1.80 m
Glazing	no glazing.
Window depth	114 x 67 mm.
Surface treatment	Painted. Acrylic or alkyd emulsion, waterborne exterior coating
Technical life	75 years
Open area	2.11 m^2.
Calculated area	1 m^2
Seals	TPE/EPDM
Fittings	Steel, stainless steel, anodized, Zamak
Weight	26.3 kg
Publisher	Agrodome
Standards	ISO 14040, ISO 14044, EN15804, SBK bepalingsmethode

European softwood window frames

Name	NBvT European softwood window frame, fixed
Description	**European softwood** window, fixed (no turning elements) produces according to the Dutch KVT. Example of wood species: Pine, Spruce, Larch out of sustainable managed forests.. (496 kg/m^3).
Dimensions	3.30 x 1.50 m
Glazing	no glazing.
Window depth	114 x 67 mm.
Surface treatment	Painted. Acrylic or alkyd emulsion, waterborne exterior coating
Technical life	25 years
Open area	4.33 m^2.
Calculated area	1 m^2
Seals	
Fittings	
Weight	8.4 kg
Publisher	Agrodome
Standards	ISO 14040, ISO 14044, EN15804, SBK bepalingsmethode

Name	NBvT European softwood window frame, till and turn window
Description	**European softwood** , till and turn window produces according to the Dutch KVT. Example of wood species: Pine, Spruce, Larch out of sustainable managed forests.. (496 kg/m^3).
Dimensions	1.40 x 1.80 m
Glazing	no glazing.
Window depth	114 x 67 mm.
Surface treatment	Painted. Acrylic or alkyd emulsion, waterborne exterior coating
Technical life	25 years
Open area	2.11 m^2.
Calculated area	1 m^2
Seals	TPE/EPDM
Fittings	Steel, stainless steel, anodized, Zamak
Weight	20.3 kg
Publisher	Agrodome
Standards	ISO 14040, ISO 14044, EN15804, SBK bepalingsmethode

Window frames of various materials

Name	EPD Aluminiumfenster. Aluminium Window
Description	Aluminium till & turn window conform EN 14351-1.
Dimensions	1.23 x 1.48 m
Glazing	Double or triple glazing.
Window depth	Window depth 60 – 75 mm.
Surface treatment	Powder coated or anodized.
Technical life	50 years
Open area	
Calculated area	1 m^2
Seals	EPDM/TPE/TPV seals.
Fittings	Acc. EPD 'Fensterbeschläge'
Weight	35.2 kg
Publisher	IFT Rosenheim
Standards	EN 15084 and ISO 14025

Name	EPD steel/stainless steel windows
Description	Steel/stainless steel till & turn window conform EN 14351-1
Dimensions	1.23 x 1.48 m
Glazing	Double or triple glazing.
Window depth	50 - 120 mm
Surface treatment	Powder coated, wet paint, mechanical surface treatment or anodized
Technical life	50 years
Open area	
Calculated area	1 m^2
Seals	EPDM/CR/TPE/TPV seals.
Fittings	
Weight	51.8 kg
Publisher	IFT Rosenheim
Standards	EN 15084 and ISO 14025

Name	PVC-U plastic windows
Description	Single-sach till & turn window consisting of a PVC frame profile
Dimensions	1.23 x 1.48 m
Glazing	Insulating double glazing
Window depth	70 mm
Surface treatment	laminated with PVC film, coated with PMMA (polymethyl-methacrylate) or painted. This produces white or coated, structured of smooth surfaces.
Technical life	50 years
Open area	
Calculated area	1 m^2
Seals	soft PVC, EPDM (ethylene propylene diene monomers) or TPE (thermoplastic elastomers),
Fittings	steel
Weight	56,85 kg = 31.2 kg/m^2
Publisher	Institut Bauen und Umwelt e.V
Standards	EN 15084 and ISO 14025

Window frames of preservative treated softwood

Name	NorDan NTech Inward opening tilt & turn window 105/80
Description	Window with inward opening sash for use in exterior walls of domestic and commercial buildings. Preservative treated pine
Dimensions	1.23 x 1.48 m
Glazing	Triple glazing
Window depth	105 x 80mm
Surface treatment	Paint
Technical life	40 years
Open area	
Calculated area	1 m^2
Seals	Plastic
Fittings	Aluminium, steel
Weight	64.45 kg = 35.7 kg/m^3
Publisher	The Norwegian EPD foundation
Standards	EN 15084, ISO 21930 and ISO 14025

Name	NorDan NTech Inward opening tilt & turn window 105/80 Alu clad
Description	Window with inward opening sash for use in exterior walls of domestic and commercial buildings. Preservative treated pine
Dimensions	1.23 x 1.48 m
Glazing	Triple glazing
Window depth	105 x 80mm
Surface treatment	aluminium cladding Alu clad
Technical life	60 years
Open area	
Calculated area	1 m^2
Seals	Plastic
Fittings	Aluminium, steel
Weight	65.67 kg = 36.1 kg/m^2
Publisher	The Norwegian EPD foundation
Standards	EN 15084, ISO 21930 and ISO 14025

Glazing

Name	SGG Climaplus 4-16-4, 2-Scheiben-Isolierglas (DGU) mit niedrig emissiven Beschichtung
Description	Double glazing. Consisting o two 4mm panes of glass. Separated from each other with aluminium or plastic composite
Dimensions	1 m^2
Technical life	30 years
Calculated area	1 m^2
Weight	20.12 kg
Publisher	Saint-Gobain
Standards	NF P 01-010

Name	Flach-, Einscheibensicherheits- und Verbundsicherheitsglas
Description	Float glass, single glass, safety glass 1 mm thickness
Dimensions	1 m^2
Technical life	
Calculated area	1 m^2
Weight	
Publisher	IFT Rosenheim
Standards	EN 15084, and ISO 14025

Appendix 2. Environmental impact of different window frames and glazing

Environmental impact of Meranti window frames without glazing

		product and construction stage		use stage	end of life stage and benefint byond systme bounderies			total
impact category	units	materialen	transport		transport	waste treatement		
		A1,A2,A3+A5	A4	B1(2)	C2	C1,C3,C4+D		
		NBvT Meranti fixed frame						
Abiotic depletion, non fuel	kg Sb eq.	3,04E-04	4,67E-07	1,44E-05	4,84E-07	3,37E-07		3,20E-04
Abiotic depletion, fuel	kg Sb eq.	7,26E-02	1,15E-03	2,53E-02	1,21E-03	-4,08E-02		5,94E-02
Global warming (GWP100)	kg CO2 eq.	1,00E+01	1,61E-01	3,98E+00	1,67E-01	-4,44E+00		9,90E+00
Ozone layer depl. (ODP)	kg CFK-11 eq.	6,70E-07	2,57E-08	4,79E-07	2,68E-08	-3,06E-07		8,95E-07
Photochemical oxidation	kg ethylene eq.	5,31E-03	1,18E-04	2,47E-03	1,22E-04	-2,97E-04		7,72E-03
Acidification	kg SO2 eq.	6,92E-02	8,67E-04	1,06E-02	9,05E-04	-4,20E-03		7,74E-02
Eutrophication	kg PO4- eq.	1,07E-02	2,00E-04	1,85E-03	2,08E-04	-9,05E-04		1,21E-02
Human toxicity	kg 1,4- DB eq.	9,14E+00	4,51E-02	1,10E+00	4,69E-02	-4,38E-01		9,89E+00
Fresh water aquatic ecotox.	Kg 1,4- DB eq.	1,31E-01	1,98E-03	8,34E-02	2,06E-03	-3,00E-03		2,16E-01
Marine aquatic ecotoxicity	kg 1,4- DB eq.	6,76E+02	8,12E+00	1,82E+02	8,44E+00	-2,72E+02		6,02E+02
Terrestrial ecotoxicity	kg 1,4- DB eq.	1,97E-01	5,22E-04	2,40E-02	5,43E-04	-1,49E-03		2,21E-01
Total renewable energy	MJ	3,89E+02	3,34E-02	2,08E+00	3,48E-02	-9,58E+01		2,96E+02
Total non renewable energy	MJ	1,62E+02	2,69E+00	5,99E+01	2,79E+00	4,82E+00		2,32E+02
Total Energy	MJ	5,52E+02	2,72E+00	6,20E+01	2,83E+00	-8,54E+01		5,34E+02
Water, fresh water use	m3	5,70E+01	1,94E-01	7,86E+00	2,02E-01	-1,79E+00		6,35E+01
Waste, non hazardous	kg	1,47E-05	0,00E+00	0,00E+00	0,00E+00	0,00E+00		1,47E-05
Waste, hazardous	kg	2,61E-04	0,00E+00	0,00E+00	0,00E+00	0,00E+00		2,61E-04
		NBvT Meranti turning window						
Abiotic depletion, non fuel	kg Sb eq.	2,29E-05	1,43E-06	3,11E-05	1,67E-07	1,28E-06		5,69E-05
Abiotic depletion, fuel	kg Sb eq.	2,03E-01	3,55E-03	8,27E-02	4,16E-04	-1,27E-01		1,63E-01
Global warming (GWP100)	kg CO2 eq.	2,78E+01	4,93E-01	1,34E+01	5,77E-02	-1,41E+01		2,76E+01
Ozone layer depl. (ODP)	kg CFK-11 eq.	1,91E-06	7,91E-08	1,58E-06	9,24E-09	-9,27E-07		2,65E-06
Photochemical oxidation	kg ethylene eq.	1,24E-02	3,63E-04	1,38E-02	4,24E-05	-8,20E-04		2,58E-02
Acidification	kg SO2 eq.	1,56E-01	2,66E-03	3,57E-02	3,11E-04	-1,25E-02		1,82E-01
Eutrophication	kg PO4- eq.	2,22E-02	6,13E-04	6,41E-03	7,17E-05	-2,71E-03		2,65E-02
Human toxicity	kg 1,4- DB eq.	9,32E+00	1,39E-01	3,65E+00	1,62E-02	-1,33E+00		1,18E+01
Fresh water aquatic ecotox.	Kg 1,4- DB eq.	2,58E-01	6,08E-03	2,88E-01	7,12E-04	-8,35E-03		5,45E-01
Marine aquatic ecotoxicity	kg 1,4- DB eq.	1,62E+03	2,49E+01	6,18E+02	2,91E+00	-8,48E+02		1,41E+03
Terrestrial ecotoxicity	kg 1,4- DB eq.	1,21E-01	1,60E-03	8,45E-02	1,88E-04	-3,68E-03		2,04E-01
Total renewable energy	MJ	1,29E+03	1,03E-01	7,07E+00	1,20E-02	-3,01E+02		1,00E+03
Total non renewable energy	MJ	4,57E+02	8,25E+00	1,95E+02	9,65E-01	1,79E+01		6,79E+02
Total Energy	MJ	1,75E+03	8,35E+00	2,02E+02	9,78E-01	-2,66E+02		1,70E+03
Water, fresh water use	m3	4,31E+01	5,97E-01	2,66E+01	7,00E-02	-5,39E+00		6,50E+01
Waste, non hazardous	kg	5,87E-05	0,00E+00	0,00E+00	0,00E+00	0,00E+00		5,87E-05
Waste, hazardous	kg	1,04E-03	0,00E+00	0,00E+00	0,00E+00	0,00E+00		1,04E-03
		NBvT Meranti till and turn window						
Abiotic depletion, non fuel	kg Sb eq.	1,33E-04	1,10E-06	3,61E-05	1,16E-06	7,98E-07		1,72E-04
Abiotic depletion, fuel	kg Sb eq.	1,72E-01	2,73E-03	6,32E-02	2,90E-03	-1,01E-01		1,40E-01
Global warming (GWP100)	kg CO2 eq.	2,43E+01	3,80E-01	9,95E+00	4,01E-01	-1,25E+01		2,25E+01
Ozone layer depl. (ODP)	kg CFK-11 eq.	1,54E-06	6,09E-08	1,19E-06	6,44E-08	-8,61E-07		2,00E-06
Photochemical oxidation	kg ethylene eq.	1,17E-02	2,79E-04	6,70E-03	2,94E-04	-1,40E-03		1,76E-02
Acidification	kg SO2 eq.	1,34E-01	2,05E-03	2,67E-02	2,16E-03	-1,38E-02		1,51E-01
Eutrophication	kg PO4- eq.	1,84E-02	4,72E-04	4,62E-03	5,00E-04	-2,92E-03		2,11E-02
Human toxicity	kg 1,4- DB eq.	1,68E+01	1,07E-01	2,75E+00	1,13E-01	-1,59E+00		1,82E+01
Fresh water aquatic ecotox.	Kg 1,4- DB eq.	2,25E-01	4,68E-03	2,07E-01	4,95E-03	-1,89E-02		4,23E-01
Marine aquatic ecotoxicity	kg 1,4- DB eq.	1,33E+03	1,92E+01	4,53E+02	2,03E+01	-6,91E+02		1,13E+03
Terrestrial ecotoxicity	kg 1,4- DB eq.	1,42E-01	1,24E-03	6,00E-02	1,31E-03	-9,80E-03		1,95E-01
Total renewable energy	MJ	9,05E+02	7,91E-02	5,21E+00	8,35E-02	-2,25E+02		6,85E+02
Total non renewable energy	MJ	3,88E+02	6,36E+00	1,50E+02	6,72E+00	2,85E-01		5,51E+02
Total Energy	MJ	1,30E+03	6,44E+00	1,55E+02	6,80E+00	-2,12E+02		1,25E+03
Water, fresh water use	m3	9,74E+01	4,60E-01	1,96E+01	4,87E-01	-5,56E+00		1,12E+02
Waste, non hazardous	kg	3,86E-01	0,00E+00	0,00E+00	0,00E+00	0,00E+00		3,86E-01
Waste, hazardous	kg	2,41E-01	0,00E+00	0,00E+00	0,00E+00	0,00E+00		2,41E-01

Environmental impact of African hardwood window frames without glazing

		product and construction stage		use stage	end of life stage and benefint byond systme bounderies		total
impact category	units	materialen	transport		transport	waste treatement	
		A1,A2,A3+A5	A4	B1(2)	C2	C1,C3,C4+D	
		NBvT African hardwood fixed frame					
Abiotic depletion, non fuel	kg Sb eq.	1,11E-05	6,28E-07	1,03E-05	6,02E-07	4,16E-07	2,30E-05
Abiotic depletion, fuel	kg Sb eq.	8,61E-02	1,56E-03	2,75E-02	1,50E-03	-4,78E-02	6,89E-02
Global warming (GWP100)	kg CO2 eq.	1,14E+01	2,16E-01	4,45E+00	2,07E-01	-5,40E+00	1,09E+01
Ozone layer depl. (ODP)	kg CFK-11 eq.	9,85E-07	3,47E-08	5,23E-07	3,33E-08	-3,57E-07	1,22E-06
Photochemical oxidation	kg ethylene eq.	5,04E-03	1,59E-04	4,60E-03	1,52E-04	-2,66E-04	9,69E-03
Acidification	kg SO2 eq.	4,69E-02	1,17E-03	1,19E-02	1,12E-03	-4,51E-03	5,66E-02
Eutrophication	kg PO4- eq.	9,34E-03	2,69E-04	2,13E-03	2,58E-04	-9,48E-04	1,10E-02
Human toxicity	kg 1,4- DB eq.	3,32E+00	6,09E-02	1,21E+00	5,84E-02	-4,73E-01	4,18E+00
Fresh water aquatic ecotox.	Kg 1,4- DB eq.	1,02E-01	2,67E-03	9,59E-02	2,56E-03	-3,03E-03	2,00E-01
Marine aquatic ecotoxicity	kg 1,4- DB eq.	6,35E+02	1,09E+01	2,05E+02	1,05E+01	-3,20E+02	5,41E+02
Terrestrial ecotoxicity	kg 1,4- DB eq.	6,79E-02	7,04E-04	2,81E-02	6,75E-04	-1,51E-03	9,59E-02
Total renewable energy	MJ	4,42E+02	4,51E-02	2,35E+00	4,32E-02	-1,13E+02	3,31E+02
Total non renewable energy	MJ	1,91E+02	3,62E+00	6,49E+01	3,47E+00	6,04E+00	2,69E+02
Total Energy	MJ	6,32E+02	3,67E+00	6,73E+01	3,52E+00	-1,00E+02	6,06E+02
Water, fresh water use	m3	1,28E+01	2,62E-01	8,80E+00	2,51E-01	-2,08E+00	2,00E+01
Waste, non hazardous	kg	-3,35E-04	0,00E+00	0,00E+00	0,00E+00	0,00E+00	-3,35E-04
Waste, hazardous	kg	-6,91E-04	0,00E+00	0,00E+00	0,00E+00	0,00E+00	-6,91E-04
		NBvT African hardwood turning window					
Abiotic depletion, non fuel	kg Sb eq.	8,67E-04	1,70E-06	4,06E-05	1,76E-06	8,12E-07	9,12E-04
Abiotic depletion, fuel	kg Sb eq.	2,52E-01	4,23E-03	7,14E-02	4,36E-03	-1,47E-01	1,85E-01
Global warming (GWP100)	kg CO2 eq.	3,39E+01	5,85E-01	1,13E+01	6,03E-01	-1,65E+01	2,99E+01
Ozone layer depl. (ODP)	kg CFK-11 eq.	2,78E-06	9,40E-08	1,35E-06	9,70E-08	-1,15E-06	3,17E-06
Photochemical oxidation	kg ethylene eq.	1,74E-02	4,30E-04	7,26E-03	4,44E-04	-1,11E-03	2,44E-02
Acidification	kg SO2 eq.	1,83E-01	3,16E-03	3,02E-02	3,26E-03	-1,55E-02	2,04E-01
Eutrophication	kg PO4- eq.	3,54E-02	7,29E-04	5,24E-03	7,52E-04	-3,25E-03	3,89E-02
Human toxicity	kg 1,4- DB eq.	2,64E+01	1,65E-01	3,11E+00	1,70E-01	-1,61E+00	2,82E+01
Fresh water aquatic ecotox.	Kg 1,4- DB eq.	4,13E-01	7,23E-03	2,36E-01	7,46E-03	-1,32E-02	6,50E-01
Marine aquatic ecotoxicity	kg 1,4- DB eq.	2,16E+03	2,96E+01	5,14E+02	3,06E+01	-9,85E+02	1,75E+03
Terrestrial ecotoxicity	kg 1,4- DB eq.	6,28E-01	1,91E-03	6,79E-02	1,97E-03	-6,82E-03	6,93E-01
Total renewable energy	MJ	1,13E+03	1,22E-01	5,89E+00	1,26E-01	-3,41E+02	7,95E+02
Total non renewable energy	MJ	5,57E+02	9,81E+00	1,69E+02	1,01E+01	1,27E+01	7,59E+02
Total Energy	MJ	1,69E+03	9,93E+00	1,75E+02	1,02E+01	-3,09E+02	1,58E+03
Water, fresh water use	m3	1,58E+02	7,10E-01	2,22E+01	7,33E-01	-6,85E+00	1,75E+02
Waste, non hazardous	kg	-8,56E-04	0,00E+00	0,00E+00	0,00E+00	0,00E+00	-8,56E-04
Waste, hazardous	kg	-1,91E-03	0,00E+00	0,00E+00	0,00E+00	0,00E+00	-1,91E-03
		NBvT African hardwood till and turn window					
Abiotic depletion, non fuel	kg Sb eq.	1,37E-04	1,39E-06	3,56E-05	1,46E-06	1,39E-05	1,89E-04
Abiotic depletion, fuel	kg Sb eq.	2,07E-01	3,46E-03	6,20E-02	3,62E-03	-1,22E-01	1,54E-01
Global warming (GWP100)	kg CO2 eq.	2,84E+01	4,79E-01	9,76E+00	5,00E-01	-1,52E+01	2,39E+01
Ozone layer depl. (ODP)	kg CFK-11 eq.	2,23E-06	7,70E-08	1,17E-06	8,04E-08	-1,03E-06	2,53E-06
Photochemical oxidation	kg ethylene eq.	1,34E-02	3,52E-04	6,57E-03	3,68E-04	-1,63E-03	1,91E-02
Acidification	kg SO2 eq.	1,21E-01	2,59E-03	2,61E-02	2,71E-03	-1,77E-02	1,35E-01
Eutrophication	kg PO4- eq.	2,21E-02	5,97E-04	4,54E-03	6,24E-04	-3,98E-03	2,39E-02
Human toxicity	kg 1,4- DB eq.	1,69E+01	1,35E-01	2,70E+00	1,41E-01	-1,86E+00	1,80E+01
Fresh water aquatic ecotox.	Kg 1,4- DB eq.	2,55E-01	5,93E-03	2,04E-01	6,19E-03	-2,04E-02	4,51E-01
Marine aquatic ecotoxicity	kg 1,4- DB eq.	1,50E+03	2,43E+01	4,45E+02	2,54E+01	-8,49E+02	1,15E+03
Terrestrial ecotoxicity	kg 1,4- DB eq.	1,95E-01	1,56E-03	5,89E-02	1,63E-03	-1,04E-02	2,47E-01
Total renewable energy	MJ	9,12E+02	1,00E-01	5,11E+00	1,04E-01	-2,81E+02	6,36E+02
Total non renewable energy	MJ	4,61E+02	8,04E+00	1,47E+02	8,39E+00	9,75E+00	6,34E+02
Total Energy	MJ	1,37E+03	8,14E+00	1,52E+02	8,50E+00	-2,55E+02	1,28E+03
Water, fresh water use	m3	9,24E+01	5,82E-01	1,92E+01	6,08E-01	-6,21E+00	1,07E+02
Waste, non hazardous	kg	3,78E-01	0,00E+00	0,00E+00	0,00E+00	0,00E+00	3,78E-01
Waste, hazardous	kg	2,35E-01	0,00E+00	0,00E+00	0,00E+00	0,00E+00	2,35E-01

Environmental impact of European softwood window frames without glazing

		product and construction stage		use stage	end of life stage and benefint byond systme bounderies		total
impact category	units	materialen	transport		transport	waste treatement	
		A1,A2,A3+A5	A4	B1(2)	C2	C1,C3,C4+D	
		NBvT European softwood fixed frame					
Abiotic depletion, non fuel	kg Sb eq.	7,07E-06	4,71E-07	7,38E-07	4,50E-07	4,51E-07	9,18E-06
Abiotic depletion, fuel	kg Sb eq.	6,33E-02	1,17E-03	1,93E-03	1,12E-03	-3,77E-02	2,98E-02
Global warming (GWP100)	kg CO2 eq.	8,16E+00	1,62E-01	3,13E-01	1,55E-01	-4,16E+00	4,63E+00
Ozone layer depl. (ODP)	kg CFK-11 eq.	5,22E-07	2,60E-08	3,65E-08	2,49E-08	-2,69E-07	3,41E-07
Photochemical oxidation	kg ethylene eq.	2,57E-03	1,19E-04	1,10E-04	1,14E-04	-2,05E-04	2,71E-03
Acidification	kg SO2 eq.	2,18E-02	8,74E-04	8,48E-04	8,37E-04	-3,49E-03	2,08E-02
Eutrophication	kg PO4- eq.	4,61E-03	2,02E-04	1,50E-04	1,93E-04	-7,58E-04	4,40E-03
Human toxicity	kg 1,4- DB eq.	1,91E+00	4,57E-02	8,65E-02	4,37E-02	-3,71E-01	1,71E+00
Fresh water aquatic ecotox.	Kg 1,4- DB eq.	6,75E-02	2,00E-03	6,84E-03	1,92E-03	-1,81E-03	7,64E-02
Marine aquatic ecotoxicity	kg 1,4- DB eq.	4,68E+02	8,21E+00	1,46E+01	7,85E+00	-2,52E+02	2,47E+02
Terrestrial ecotoxicity	kg 1,4- DB eq.	4,69E-02	5,28E-04	1,99E-03	5,05E-04	-7,72E-04	4,91E-02
Total renewable energy	MJ	1,62E+02	3,38E-02	1,68E-01	3,23E-02	-8,99E+01	7,25E+01
Total non renewable energy	MJ	1,41E+02	2,71E+00	4,57E+00	2,60E+00	6,18E+00	1,57E+02
Total Energy	MJ	3,03E+02	2,75E+00	4,74E+00	2,63E+00	-7,89E+01	2,34E+02
Water, fresh water use	m3	1,50E+01	1,97E-01	6,30E-01	1,88E-01	-1,54E+00	1,45E+01
Waste, non hazardous	kg	1,93E-05	0,00E+00	0,00E+00	0,00E+00	0,00E+00	1,93E-05
Waste, hazardous	kg	3,41E-04	0,00E+00	0,00E+00	0,00E+00	0,00E+00	3,41E-04
		NBvT European softwood turning window					
Abiotic depletion, non fuel	kg Sb eq.	8,44E-04	1,28E-06	1,70E-06	1,22E-06	1,02E-06	8,49E-04
Abiotic depletion, fuel	kg Sb eq.	2,19E-01	3,17E-03	4,42E-03	3,03E-03	-9,93E-02	1,30E-01
Global warming (GWP100)	kg CO2 eq.	3,00E+01	4,42E-01	7,17E-01	4,17E-01	-1,06E+01	2,10E+01
Ozone layer depl. (ODP)	kg CFK-11 eq.	1,94E-06	7,08E-08	8,47E-08	6,71E-08	-7,27E-07	1,44E-06
Photochemical oxidation	kg ethylene eq.	1,49E-02	3,25E-04	2,54E-04	3,07E-04	-6,08E-04	1,52E-02
Acidification	kg SO2 eq.	1,94E-01	2,38E-03	1,95E-03	2,26E-03	-9,56E-03	1,91E-01
Eutrophication	kg PO4- eq.	3,05E-02	5,49E-04	3,46E-04	5,20E-04	-2,05E-03	2,99E-02
Human toxicity	kg 1,4- DB eq.	2,56E+01	1,24E-01	1,99E-01	1,18E-01	-9,93E-01	2,51E+01
Fresh water aquatic ecotox.	Kg 1,4- DB eq.	3,71E-01	5,44E-03	1,58E-02	5,17E-03	-5,25E-03	3,92E-01
Marine aquatic ecotoxicity	kg 1,4- DB eq.	2,03E+03	2,23E+01	3,32E+01	2,12E+01	-6,61E+02	1,44E+03
Terrestrial ecotoxicity	kg 1,4- DB eq.	5,73E-01	1,44E-03	4,49E-03	1,36E-03	-2,71E-03	5,78E-01
Total renewable energy	MJ	1,07E+03	9,20E-02	3,83E-01	8,71E-02	-2,35E+02	8,36E+02
Total non renewable energy	MJ	4,86E+02	7,39E+00	1,05E+01	7,00E+00	1,41E+01	5,25E+02
Total Energy	MJ	1,56E+03	7,49E+00	1,08E+01	7,10E+00	-2,08E+02	1,37E+03
Water, fresh water use	m3	1,59E+02	5,34E-01	1,46E+00	5,08E-01	-4,17E+00	1,57E+02
Waste, non hazardous	kg	4,29E-05	0,00E+00	0,00E+00	0,00E+00	0,00E+00	4,29E-05
Waste, hazardous	kg	7,61E-04	0,00E+00	0,00E+00	0,00E+00	0,00E+00	7,61E-04
		NBvT European softwood till and turn window					
Abiotic depletion, non fuel	kg Sb eq.	1,28E-04	1,07E-06	1,56E-06	1,00E-06	8,53E-07	1,33E-04
Abiotic depletion, fuel	kg Sb eq.	1,61E-01	2,64E-03	4,32E-03	2,50E-03	-8,16E-02	8,88E-02
Global warming (GWP100)	kg CO2 eq.	2,19E+01	3,67E-01	6,88E-01	3,45E-01	-8,67E+00	1,47E+01
Ozone layer depl. (ODP)	kg CFK-11 eq.	1,28E-06	5,89E-08	7,61E-08	5,54E-08	-5,97E-07	8,79E-07
Photochemical oxidation	kg ethylene eq.	8,32E-03	2,70E-04	2,29E-04	2,54E-04	-4,95E-04	8,58E-03
Acidification	kg SO2 eq.	6,94E-02	1,98E-03	1,79E-03	1,87E-03	-7,84E-03	6,72E-02
Eutrophication	kg PO4- eq.	1,24E-02	4,57E-04	3,23E-04	4,30E-04	-1,69E-03	1,19E-02
Human toxicity	kg 1,4- DB eq.	1,40E+01	1,03E-01	1,87E-01	9,74E-02	-8,14E-01	1,36E+01
Fresh water aquatic ecotox.	Kg 1,4- DB eq.	1,83E-01	4,53E-03	1,40E-02	4,26E-03	-4,18E-03	2,02E-01
Marine aquatic ecotoxicity	kg 1,4- DB eq.	1,17E+03	1,86E+01	3,31E+01	1,75E+01	-5,42E+02	6,94E+02
Terrestrial ecotoxicity	kg 1,4- DB eq.	1,54E-01	1,20E-03	4,71E-03	1,12E-03	-2,17E-03	1,59E-01
Total renewable energy	MJ	3,37E+02	7,65E-02	3,78E-01	7,21E-02	-1,94E+02	1,44E+02
Total non renewable energy	MJ	3,61E+02	6,15E+00	1,01E+01	5,79E+00	1,18E+01	3,95E+02
Total Energy	MJ	6,98E+02	6,23E+00	1,05E+01	5,87E+00	-1,71E+02	5,50E+02
Water, fresh water use	m3	9,64E+01	4,45E-01	1,29E+00	4,20E-01	-3,43E+00	9,52E+01
Waste, non hazardous	kg	3,76E-01	0,00E+00	0,00E+00	0,00E+00	0,00E+00	3,76E-01
Waste, hazardous	kg	2,35E-01	0,00E+00	0,00E+00	0,00E+00	0,00E+00	2,35E-01

Environmental impact of South American hardwood window frames without glazing

		product and construction stage		use stage	end of life stage and benefint byond systme bounderies		total
impact category	units	materialen	transport		transport	waste treatement	
		A1,A2,A3+A5	A4	B1(2)	C2	C1,C3,C4+D	
		NBvT South American hardwood fixed frame					
Abiotic depletion, non fuel	kg Sb eq.	1,54E-05	7,07E-07	1,04E-05	7,81E-07	2,63E-07	2,75E-05
Abiotic depletion, fuel	kg Sb eq.	9,54E-02	1,75E-03	2,76E-02	4,10E-03	-6,01E-02	6,87E-02
Global warming (GWP100)	kg CO2 eq.	1,21E+01	2,43E-01	4,47E+00	1,08E+00	-7,48E+00	1,04E+01
Ozone layer depl. (ODP)	kg CFK-11 eq.	1,08E-06	3,91E-08	5,25E-07	1,07E-07	-5,14E-07	1,24E-06
Photochemical oxidation	kg ethylene eq.	4,45E-03	1,79E-04	4,56E-03	6,35E-04	-8,40E-04	8,98E-03
Acidification	kg SO2 eq.	3,57E-02	1,31E-03	1,20E-02	3,74E-03	-8,27E-03	4,44E-02
Eutrophication	kg PO4- eq.	7,61E-03	3,02E-04	2,14E-03	8,30E-04	-1,74E-03	9,15E-03
Human toxicity	kg 1,4- DB eq.	3,26E+00	6,85E-02	1,22E+00	4,08E-01	-9,48E-01	4,01E+00
Fresh water aquatic ecotox.	Kg 1,4- DB eq.	9,79E-02	3,00E-03	9,63E-02	9,49E-03	-1,14E-02	1,95E-01
Marine aquatic ecotoxicity	kg 1,4- DB eq.	6,35E+02	1,23E+01	2,07E+02	3,65E+01	-4,12E+02	4,79E+02
Terrestrial ecotoxicity	kg 1,4- DB eq.	6,40E-02	7,91E-04	2,82E-02	4,22E-03	-5,86E-03	9,14E-02
Total renewable energy	MJ	4,56E+02	5,07E-02	2,36E+00	1,64E-01	-1,35E+02	3,24E+02
Total non renewable energy	MJ	2,10E+02	4,07E+00	6,53E+01	9,51E+00	7,52E-02	2,89E+02
Total Energy	MJ	6,67E+02	4,12E+00	6,75E+01	9,68E+00	-1,27E+02	6,21E+02
Water, fresh water use	m3	1,31E+01	2,95E-01	8,85E+00	9,65E-01	-3,33E+00	1,99E+01
Waste, non hazardous	kg	1,98E-05	0,00E+00	0,00E+00	0,00E+00	0,00E+00	1,98E-05
Waste, hazardous	kg	3,49E-04	0,00E+00	0,00E+00	0,00E+00	0,00E+00	3,49E-04
		NBvT South American hardwood turning window					
Abiotic depletion, non fuel	kg Sb eq.	8,78E-04	1,89E-06	4,07E-05	1,95E-06	7,36E-07	9,23E-04
Abiotic depletion, fuel	kg Sb eq.	2,75E-01	4,71E-03	7,15E-02	4,85E-03	-1,64E-01	1,92E-01
Global warming (GWP100)	kg CO2 eq.	3,54E+01	6,51E-01	1,13E+01	6,69E-01	-1,86E+01	2,94E+01
Ozone layer depl. (ODP)	kg CFK-11 eq.	3,01E-06	1,05E-07	1,36E-06	1,08E-07	-1,30E-06	3,28E-06
Photochemical oxidation	kg ethylene eq.	1,58E-02	4,78E-04	7,04E-03	4,92E-04	-1,26E-03	2,25E-02
Acidification	kg SO2 eq.	1,54E-01	3,52E-03	3,02E-02	3,61E-03	-1,75E-02	1,74E-01
Eutrophication	kg PO4- eq.	3,09E-02	8,11E-04	5,24E-03	8,32E-04	-3,65E-03	3,42E-02
Human toxicity	kg 1,4- DB eq.	2,61E+01	1,84E-01	3,12E+00	1,89E-01	-1,81E+00	2,77E+01
Fresh water aquatic ecotox.	Kg 1,4- DB eq.	4,00E-01	8,04E-03	2,36E-01	8,28E-03	-1,58E-02	6,37E-01
Marine aquatic ecotoxicity	kg 1,4- DB eq.	2,15E+03	3,30E+01	5,13E+02	3,39E+01	-1,10E+03	1,63E+03
Terrestrial ecotoxicity	kg 1,4- DB eq.	6,12E-01	2,12E-03	6,80E-02	2,18E-03	-8,25E-03	6,76E-01
Total renewable energy	MJ	1,16E+03	1,36E-01	5,91E+00	1,39E-01	-3,79E+02	7,89E+02
Total non renewable energy	MJ	6,05E+02	1,09E+01	1,70E+02	1,12E+01	1,22E+01	8,09E+02
Total Energy	MJ	1,77E+03	1,10E+01	1,76E+02	1,14E+01	-3,45E+02	1,62E+03
Water, fresh water use	m3	1,58E+02	7,89E-01	2,23E+01	8,14E-01	-7,79E+00	1,74E+02
Waste, non hazardous	kg	4,25E-05	0,00E+00	0,00E+00	0,00E+00	0,00E+00	4,25E-05
Waste, hazardous	kg	7,50E-04	0,00E+00	0,00E+00	0,00E+00	0,00E+00	7,50E-04
		NBvT South American hardwood till and turn window					
Abiotic depletion, non fuel	kg Sb eq.	1,47E-04	1,57E-06	1,69E-04	1,62E-06	6,10E-07	3,19E-04
Abiotic depletion, fuel	kg Sb eq.	2,27E-01	3,88E-03	1,30E-01	4,03E-03	-1,35E-01	2,30E-01
Global warming (GWP100)	kg CO2 eq.	3,01E+01	5,37E-01	1,45E+01	5,58E-01	-1,53E+01	3,04E+01
Ozone layer depl. (ODP)	kg CFK-11 eq.	2,45E-06	8,64E-08	2,32E-06	8,96E-08	-1,07E-06	3,88E-06
Photochemical oxidation	kg ethylene eq.	1,23E-02	3,94E-04	1,21E-02	4,09E-04	-1,04E-03	2,42E-02
Acidification	kg SO2 eq.	9,87E-02	2,91E-03	4,53E-02	3,01E-03	-1,44E-02	1,35E-01
Eutrophication	kg PO4- eq.	1,87E-02	6,69E-04	6,92E-03	6,95E-04	-3,01E-03	2,39E-02
Human toxicity	kg 1,4- DB eq.	1,70E+01	1,52E-01	4,85E+00	1,57E-01	-1,49E+00	2,06E+01
Fresh water aquatic ecotox.	Kg 1,4- DB eq.	2,48E-01	6,66E-03	2,83E-01	6,89E-03	-1,29E-02	5,31E-01
Marine aquatic ecotoxicity	kg 1,4- DB eq.	1,51E+03	2,72E+01	7,48E+02	2,83E+01	-9,05E+02	1,41E+03
Terrestrial ecotoxicity	kg 1,4- DB eq.	1,89E-01	1,75E-03	8,91E-02	1,82E-03	-6,75E-03	2,75E-01
Total renewable energy	MJ	9,46E+02	1,12E-01	8,79E+00	1,17E-01	-3,12E+02	6,43E+02
Total non renewable energy	MJ	5,05E+02	9,02E+00	3,07E+02	9,34E+00	1,01E+01	8,40E+02
Total Energy	MJ	1,45E+03	9,14E+00	3,15E+02	9,46E+00	-2,84E+02	1,50E+03
Water, fresh water use	m3	9,40E+01	6,54E-01	3,12E+01	6,77E-01	-6,39E+00	1,20E+02
Waste, non hazardous	kg	3,83E-01	0,00E+00	0,00E+00	0,00E+00	0,00E+00	3,83E-01
Waste, hazardous	kg	2,39E-01	0,00E+00	0,00E+00	0,00E+00	0,00E+00	2,39E-01

Environmental impact of window frames of various materials including glazing

		product and construction stage		use stage	end of life stage and benefint byond systme bounderies		total
impact category	units	materialen	transport		transport	waste treatement	
		A1,A2,A3+A5	A4	B1(2)	C2	C1,C3,C4+D	
		Steel and stainless steel till and turn window					
Abiotic depletion, non fuel	kg Sb eq.	4,15E-03	1,33E-07	1,45E-03	2,46E-08	-9,67E-05	5,50E-03
Abiotic depletion, fuel	kg Sb eq.						
Global warming (GWP100)	kg CO2 eq.	1,11E+02	4,11E+00	5,12E+02	6,60E-01	-4,47E+01	5,83E+02
Ozone layer depl. (ODP)	kg CFK-11 eq.	1,04E-06	-2,39E-10	2,40E-07	1,15E-11	1,35E-09	1,28E-06
Photochemical oxidation	kg ethylene eq.	4,00E-02	-4,70E-03	9,07E-02	-9,15E-04	-2,96E-02	9,55E-02
Acidification	kg SO2 eq.	6,10E-01	1,00E-02	7,08E-01	2,85E-03	-3,22E-01	1,01E+00
Eutrophication	kg PO4- eq.	5,00E-02	3,29E-03	8,13E-02	6,53E-04	-1,97E-02	1,16E-01
Human toxicity	kg 1,4- DB eq.						
Fresh water aquatic ecotox.	Kg 1,4- DB eq.						
Marine aquatic ecotoxicity	kg 1,4- DB eq.						
Terrestrial ecotoxicity	kg 1,4- DB eq.						
Total renewable energy	MJ	1,68E+02	6,50E-01	7,37E+01	3,60E-01	1,14E+00	2,44E+02
Total non renewable energy	MJ	1,89E+03	3,97E+01	7,27E+02	9,15E+00	-6,36E+02	2,03E+03
Total Energy	MJ	2,06E+03	4,04E+01	8,01E+02	9,51E+00	-6,35E+02	2,27E+03
Water, fresh water use	m3	2,14E+02	-1,65E+00	8,92E+01	4,00E-02	3,99E+00	3,06E+02
Waste, non hazardous	kg	3,29E+02	1,24E+00	1,68E+02	3,00E-02	-2,50E+02	2,48E+02
Waste, hazardous	kg	5,00E-02	0,00E+00	7,00E-02	0,00E+00	0,00E+00	1,20E-01
		PVC till and turn window					
Abiotic depletion, non fuel	kg Sb eq.	3,94E-03	1,08E-05	3,14E-03	3,27E-05	-1,76E-03	5,37E-03
Abiotic depletion, fuel	kg Sb eq.	5,30E+03	6,47E+02	1,67E+04	2,05E+03	-1,88E+03	2,28E+04
Global warming (GWP100)	kg CO2 eq.	1,23E+02	8,55E-01	9,61E+02	2,83E+00	-3,70E+01	1,05E+03
Ozone layer depl. (ODP)	kg CFK-11 eq.	5,41E-06	1,40E-07	1,24E-04	4,47E-07	-1,12E-06	1,29E-04
Photochemical oxidation	kg ethylene eq.	1,20E+00	2,67E-03	1,50E+00	8,53E-03	-1,56E-01	2,56E+00
Acidification	kg SO2 eq.	1,38E-01	7,17E-04	2,44E-01	2,25E-03	-7,45E-02	3,11E-01
Eutrophication	kg PO4- eq.	3,69E-02	1,10E-04	1,15E-01	3,44E-04	-1,34E-02	1,39E-01
Human toxicity	kg 1,4- DB eq.						
Fresh water aquatic ecotox.	Kg 1,4- DB eq.						
Marine aquatic ecotoxicity	kg 1,4- DB eq.						
Terrestrial ecotoxicity	kg 1,4- DB eq.						
Total renewable energy	MJ	8,30E+01	1,84E-01	8,49E+01	5,98E-01	-2,34E+01	1,45E+02
Total non renewable energy	MJ	2,31E+03	1,45E+01	1,53E+04	4,66E+01	-7,76E+02	1,69E+04
Total Energy	MJ	2,39E+03	1,47E+01	1,54E+04	4,72E+01	-8,00E+02	1,70E+04
Water, fresh water use	m3	3,60E+01	3,68E-03	3,64E+01	1,06E-02	-2,56E-01	7,21E+01
Waste, non hazardous	kg	1,47E+02	1,09E-01	1,03E+03	2,73E-01	4,34E+01	1,22E+03
Waste, hazardous	kg	1,61E-01	1,46E-05	1,81E-01	4,36E-05	-6,16E-02	2,80E-01
		Aluminium tull and turn window					
Abiotic depletion, non fuel	kg Sb eq.	2,86E-02	0,00E+00	2,59E-03	0,00E+00	-4,14E-03	2,71E-02
Abiotic depletion, fuel	kg Sb eq.	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
Global warming (GWP100)	kg CO2 eq.	2,05E+02	1,00E+00	5,90E+02	1,00E+00	-1,07E+02	6,90E+02
Ozone layer depl. (ODP)	kg CFK-11 eq.	1,67E-05	1,90E-09	3,59E-06	8,90E-10	-9,48E-06	1,08E-05
Photochemical oxidation	kg ethylene eq.	0,00E+00	5,00E-04	7,94E-02	0,00E+00	0,00E+00	7,99E-02
Acidification	kg SO2 eq.	7,20E-01	5,50E-03	6,33E-01	1,60E-03	-5,60E-01	8,00E-01
Eutrophication	kg PO4- eq.	5,45E-02	1,30E-03	9,33E-02	3,00E-04	-3,57E-02	1,14E-01
Human toxicity	kg 1,4- DB eq.						
Fresh water aquatic ecotox.	Kg 1,4- DB eq.						
Marine aquatic ecotoxicity	kg 1,4- DB eq.						
Terrestrial ecotoxicity	kg 1,4- DB eq.						
Total renewable energy	MJ	3,97E+02	0,00E+00	3,70E+01	0,00E+00	-3,55E+02	7,90E+01
Total non renewable energy	MJ	2,24E+03	1,50E+01	9,80E+03	7,00E+00	-1,48E+03	1,06E+04
Total Energy	MJ	2,63E+03	1,50E+01	9,83E+03	7,00E+00	-1,83E+03	1,07E+04
Water, fresh water use	m3	3,13E+02	0,00E+00	6,67E+02	0,00E+00	-1,74E+02	8,06E+02
Waste, non hazardous	kg						
Waste, hazardous	kg						

Environmental impact of preservative treated European softwood window frames including glazing

		product and construction stage		use stage	end of life stage and benefint byond systme bounderies			total
impact category	units	materialen	transport		transport	waste treatement		
		A1,A2,A3+A5	A4	B1(2)	C2	C1,C3,C4+D		
		Preservative treated wooden till and turn window without aluminium						
Abiotic depletion, non fuel	kg Sb eq.	4,33E-04	1,28E-05	2,59E-05	1,47E-06	-1,32E-06		4,72E-04
Abiotic depletion, fuel	kg Sb eq.	1,78E+03	5,33E+01	1,83E+02	9,23E+00	-8,90E-01		2,02E+03
Global warming (GWP100)	kg CO2 eq.	1,03E+02	3,58E+00	7,18E+00	6,21E-01	3,67E+01		1,51E+02
Ozone layer depl. (ODP)	kg CFK-11 eq.	1,22E-05	5,68E-07	6,87E-07	1,01E-07	2,73E-08		1,36E-05
Photochemical oxidation	kg ethylene eq.	3,77E-02	4,63E-04	2,24E-03	1,19E-04	2,15E-04		4,07E-02
Acidification	kg SO2 eq.	7,80E-01	1,36E-02	3,24E-02	3,41E-03	6,17E-03		8,36E-01
Eutrophication	kg PO4- eq.	2,20E-01	3,75E-03	1,21E-02	8,89E-04	6,78E-03		2,44E-01
Human toxicity	kg 1,4- DB eq.							
Fresh water aquatic ecotox.	Kg 1,4- DB eq.							
Marine aquatic ecotoxicity	kg 1,4- DB eq.							
Terrestrial ecotoxicity	kg 1,4- DB eq.							
Total renewable energy	MJ	1,17E+03	9,63E-01	6,13E+00	1,21E-01	-4,00E+00		1,17E+03
Total non renewable energy	MJ	2,05E+03	6,06E+01	2,07E+02	1,03E+01	-4,00E+00		2,33E+03
Total Energy	MJ	3,22E+03	6,15E+01	2,13E+02	1,05E+01	-8,00E+00		3,50E+03
Water, fresh water use	m3	1,43E+00	1,54E-02	1,88E-01	2,40E-03	3,71E-02		1,67E+00
Waste, non hazardous	kg	5,24E+01	3,99E-01	7,71E-01	9,74E-02	3,31E+01		8,67E+01
Waste, hazardous	kg	5,81E-01	1,60E-03	2,37E-03	2,02E-04	1,16E+01		1,22E+01
		Preservative treated wooden till and turn window with aluminium						
Abiotic depletion, non fuel	kg Sb eq.	4,79E-04	1,28E-05	3,37E-05	1,53E-06	-1,18E-06		5,26E-04
Abiotic depletion, fuel	kg Sb eq.	2,08E+03	5,33E+01	2,41E+02	9,59E+00	7,00E-01		2,38E+03
Global warming (GWP100)	kg CO2 eq.	1,28E+02	3,58E+00	9,23E+00	6,45E-01	3,68E+01		1,78E+02
Ozone layer depl. (ODP)	kg CFK-11 eq.	1,38E-05	5,56E-07	7,48E-07	1,05E-07	6,20E-08		1,52E-05
Photochemical oxidation	kg ethylene eq.	4,63E-02	4,63E-04	2,90E-03	1,24E-04	2,48E-04		5,00E-02
Acidification	kg SO2 eq.	8,90E-01	1,36E-02	3,90E-02	3,54E-04	6,98E-03		9,50E-01
Eutrophication	kg PO4- eq.	2,66E-01	3,75E-05	1,45E-02	9,23E-06	7,00E-03		2,88E-01
Human toxicity	kg 1,4- DB eq.							
Fresh water aquatic ecotox.	Kg 1,4- DB eq.							
Marine aquatic ecotoxicity	kg 1,4- DB eq.							
Terrestrial ecotoxicity	kg 1,4- DB eq.							
Total renewable energy	MJ	1,23E+03	9,63E-01	6,72E+00	1,25E-01	-8,20E+01		1,15E+03
Total non renewable energy	MJ	2,39E+03	6,06E+01	2,71E+02	1,07E+01	-2,21E+00		2,73E+03
Total Energy	MJ	3,62E+03	6,15E+01	2,78E+02	1,09E+01	-8,42E+01		3,89E+03
Water, fresh water use	m3	1,54E+00	1,54E-02	2,68E-01	2,50E-03	4,06E-02		1,87E+00
Waste, non hazardous	kg	5,58E+01	3,99E-01	9,05E-01	7,00E-02	3,31E+01		9,03E+01
Waste, hazardous	kg	6,17E-01	1,60E-03	3,30E-03	2,10E-04	1,53E+01		1,60E+01

Environmental impact glazing, float glass and double glazing

		product and construction stage		use stage	end of life stage and benefint byond systme bounderies			total
impact category	units	materialen	transport		transport	waste treatement		
		A1,A2,A3+A5	A4	B1(2)	C2	C1,C3,C4+D		
		Float glass 1m2, 1mm thickness						
Abiotic depletion, non fuel	kg Sb eq.	1,33E-05	0,00E+00			-1,23E-05		1,00E-06
Abiotic depletion, fuel	kg Sb eq.							
Global warming (GWP100)	kg CO2 eq.	8,60E-01	1,80E+00			-1,39E+00		1,27E+00
Ozone layer depl. (ODP)	kg CFK-11 eq.	1,54E-08	2,97E-09			-3,65E-09		1,48E-08
Photochemical oxidation	kg ethylene eq.	2,87E-04	1,08E-03			0,00E+00		1,37E-03
Acidification	kg SO2 eq.	4,08E-03	1,93E-02			-1,40E-02		9,38E-03
Eutrophication	kg PO4- eq.	6,91E-04	1,83E-03			-1,00E-03		1,52E-03
Human toxicity	kg 1,4- DB eq.							
Fresh water aquatic ecotox.	Kg 1,4- DB eq.							
Marine aquatic ecotoxicity	kg 1,4- DB eq.							
Terrestrial ecotoxicity	kg 1,4- DB eq.							
Total renewable energy	MJ							
Total non renewable energy	MJ							
Total Energy	MJ							
Water, fresh water use	m3							
Waste, non hazardous	kg	3,49E+00				-2,90E+00		5,90E-01
Waste, hazardous	kg							0,00E+00
		SGG double glazing 4-16-4						
Abiotic depletion, non fuel	kg Sb eq.							6,34E-03
Abiotic depletion, fuel	kg Sb eq.							
Global warming (GWP100)	kg CO2 eq.							1,05E+00
Ozone layer depl. (ODP)	kg CFK-11 eq.							1,13E-11
Photochemical oxidation	kg ethylene eq.							3,50E-03
Acidification	kg SO2 eq.							6,77E-03
Eutrophication	kg PO4- eq.							4,71E-01
Human toxicity	kg 1,4- DB eq.							
Fresh water aquatic ecotox.	Kg 1,4- DB eq.							
Marine aquatic ecotoxicity	kg 1,4- DB eq.							
Terrestrial ecotoxicity	kg 1,4- DB eq.							
Total renewable energy	MJ							6,91E-01
Total non renewable energy	MJ							1,54E+01
Total Energy	MJ							
Water, fresh water use	m3							8,15E-03
Waste, non hazardous	kg							
Waste, hazardous	kg							

Appendix 3. Information available in the mrpi-mpg calculation tool

When cells in column 2 are blank, no information is given.
In column 3 the costs are calculated by the mrpi-mpg tool calculated for 1 m^2 window in a building with floor area of 1 m^2. In column 4 the data given over a period of 75 years.

Verified data; Frame, code 31.02

Description	Information available in the calculation tool (www.mrpi-mpg.nl/)	Cost [€]		Cat.
		1 year	75 years	
Aluminium vast, geanodiseerd	Representatief vast raam: 3300X1500 mm, terug gerekend naar 1 m2. Het basisprofiel 343 aluminium kozijn woningbouw omvat alle onderdelen van het vaste raam. Men dient het totale oppervlak van de het vaste raam in te voeren.	0,06	4.21	2
Janisol HI met draaikiepvleugel	Stalen raamkozijn met draaikiepraam per m2 geleverd door ODS met een Uf-waarde van 1,40 W/m2K. De afmetingen van de tussenstijl en draaikiepvleugel zijn gekoppeld aan de afmetingen van het kozijn. De afmeting van het raamkozijn is 1500x3300mm conform de functionele eenheid van de NMD. Afwerking, onderhoud en reparaties zijn meegenomen.	0,06	4.56	1
Kozijn, kunststof (PVC)	Kozijn, kunststof (PVC) representatief voor leden VKG	0,16	12.09	2
VMRG Aluminium Raam u-bouw, gepoedercoat (zirkonium voorbehandeling)	Representatief voor: VMRG aluminium kozijnen met het kenmerk A-RT72 HR. Alleen het gevelelement is in beschouwing genomen. Beglazing, stelkozijn, hang- en sluitwerk, aansluitmaterialen, suskast, dorpel en waterkering zijn niet meegenomen. Op de bouwplaats wordt het kozijn handmatig aangebracht in het aanwezige stelkozijn. De materialen die nodig zijn om het kozijn vast te zetten zijn niet meegenomen. Het energieverlies door kozijn tijdens gebruiksfase is ook niet meegenomen.	0,06	4.65	2

Unverified data ; frames code 31.02

Description	Information available in the calculation tool (www.mrpi-mpg.nl/). **	Cost [€]		Cat.
		1 year	75 years	
Aluminium vast (recycle), geanodiseerd	Representatief vast raam van geanodiseerd gerecycled aluminium: 3300X1500 mm, terug gerekend naar 1 m2. Men dient het totale oppervlak van de het vaste raam in te voeren.	0,03	2.42	3
Aluminium vast (recycle), gecoat	Representatief vast raam van gecoat gerecycled aluminium: 3300X1500 mm, terug gerekend naar 1 m2. Men dient het totale oppervlak van de het vaste raam in te voeren.	0,05	3.46	3
Aluminium vast en/of draaiend (recycle), geanodiseerd	Representatief vast raam van geanodiseerd gerecycled aluminium: 3300X1500 mm, terug gerekend naar 1 m2. Men dient het totale oppervlak van de het vaste raam in te voeren.	0,05	3.90	3
Aluminium vast en/of draaiend (recycle), gecoat	Representatief gecoat aluminium raam met 1 draaiend deel: 3300X1500 mm, terug gerekend naar 1 m2. Men dient het oppervlak van het totale vaste raam en/of draaiend deel in te voeren.	0,07	5.60	3
Aluminium vast en/of draaiend, gecoat	Representatief raam met 1 draaiend deel: 3300X1500 mm, terug gerekend naar 1 m2. Men dient het oppervlak van het totale vaste raam en/of draaiend deel in te voeren.	0,10	7.51	3
Aluminium vast, gecoat	Representatief vast raam van gecoat aluminium: 3300X1500 mm, terug gerekend naar 1 m2. Men dient het totale oppervlak van de het vaste raam in te voeren.	0,06	4.52	3
Europees loofhout; geschilderd, acryl; duurzame bosbouw	Watergedragen acrylaat/alkydemulsie verf systeem voor buiten (voldoet aan Verfrichtlijn 2004/42/EC) Ondergronden hout en met verf behandeld hout van woningen, buitensituaties tifa-systemen (concept 3 = volledig afgewerkte systmen) + vervolg met zelfde productypeVerbruik - nieuw syteem 3 lagen = 0,313 kg/m2Onderhoudsfreq. 1 maal per 10 jaarVerbruik per 10 jaar (1 laag) 0,104 kg/m2Verbruik - onderhoud 4 lagen = 0,417 kg/m2Nieuw systeem opbouwen na 50 jaarVerbruik over 50 jaar 3 + 4 lagen = 0,730 kg/m2	0,01	0.49	3

Europees naaldhout; geschilderd, acryl; duurzame bosbouw	Watergedragen acrylaat/alkydemulsie verf systeem voor buiten (voldoet aan Verfrichtlijn 2004/42/EC) Ondergronden hout en met verf behandeld hout van woningen, buitensituaties tifa-systemen (concept 3 = volledig afgewerkte systmen) + vervolg met zelfde productypeVerbruik - nieuw syteem 3 lagen = 0,313 kg/m2Onderhoudsfreq. 1 maal per 10 jaarVerbruik per 10 jaar (1 laag) 0,104 kg/m2Verbruik - onderhoud 4 lagen = 0,417 kg/m2Nieuw systeem opbouwen na 50 jaarVerbruik over 50 jaar 3 + 4 lagen = 0,730 kg/m2	0,01	0.61	3
PVC op staalkern		0,11	7.96	3
Pvc; gerecyceld pvc; stalen kokerprofielen		0,03	2.61	3
Tropisch loofhout; geschilderd, acryl; duurzame bosbouw	Watergedragen acrylaat/alkydemulsie verf systeem voor buiten (voldoet aan Verfrichtlijn 2004/42/EC) Ondergronden hout en met verf behandeld hout van woningen, buitensituaties tifa-systemen (concept 3 = volledig afgewerkte systmen) + vervolg met zelfde productypeVerbruik - nieuw syteem 3 lagen = 0,313 kg/m2Onderhoudsfreq. 1 maal per 10 jaarVerbruik per 10 jaar (1 laag) 0,104 kg/m2Verbruik - onderhoud 4 lagen = 0,417 kg/m2Nieuw systeem opbouwen na 50 jaarVerbruik over 50 jaar 3 + 4 lagen = 0,730 kg/m2	0,03	1.94	3
VMRG stalen kozijn		0,02	1.58	3
VMRG stalen kozijn met deur		0,07	5.14	3
VMRG stalen kozijn met draaikiep raam		0,04	3.15	3

Verified data; windows code 31.03

Description	Information available in the calculation tool (www.mrpi-mpg.nl/). **	Cost [€]		Cat.
		1 year	75 years	
Driessens-Verhagen Ramen - Prominent 65e Renova, inclusief draaiend deel	Driessens-Verhagen Ramen - Prominent 65e Renova, kozijn inclusief draaiend deel (aluminium, gepoedercoat)	0,06	4.16	1
Driessens-Verhagen Ramen - Prominent 65e Renova, vast (alu. , gepoedercoat)	Prominent aluminium kozijnen zijn leverbaar in diverse isolatieklassen waarmee een U-window van U-w = 1,84 tot U-w = 1,02 haalbaar is. Iedere variant is leverbaar in alle verschillende modellen. Slank als staal, de robuuste uitstraling van hout of gewoon vlak.	0,06	4.32	1
VMRG Aluminium raam woningbouw, gepoedercoat (zirkonium voorbehandeling)	Representatief voor: VMRG aluminium kozijnen met het kenmerk B-RT72 HR. Alleen het gevelelement is in beschouwing genomen. Beglazing, stelkozijn, hang- en sluitwerk, aansluitmaterialen, suskast, dorpel en waterkering zijn niet meegenomen. Op de bouwplaats wordt het kozijn handmatig aangebracht in het aanwezige stelkozijn. De materialen die nodig zijn om het kozijn vast te zetten zijn niet meegenomen. Het energieverlies door kozijn tijdens gebruiksfase is ook niet meegenomen.	0,04	3.15	2

Unverified data; Windows code 31.03

Description	Information available in the calculation tool (www.mrpi-mpg.nl/). **	Cost [€]		Cat.
		1 year	75 years	
Aluminium (recycle), geanodiseerd		0,07	2.75	3
Aluminium (recycle), gepoedercoat		0,11	7.90	3
Aluminium, geanodiseerd		0,11	8.05	3
Aluminium, gepoedercoat		0,13	10.23	3
Europees loofhout; geschilderd, acryl; duurzame bosbouw	Watergedragen acrylaat/alkydemulsie verf systeem voor buiten (voldoet aan Verfrichtlijn 2004/42/EC) Ondergronden hout en met verf behandeld hout van woningen, buitensituaties tifa-systemen (concept 3 = volledig afgewerkte systmen) + vervolg met zelfde productypeVerbruik - nieuw syteem 3 lagen = 0,313 kg/m2Onderhoudsfreq. 1 maal per 10 jaarVerbruik per 10 jaar (1 laag) 0,104 kg/m2Verbruik - onderhoud 4 lagen = 0,417 kg/m2Nieuw systeem opbouwen na 50 jaarVerbruik over 50 jaar 3 + 4 lagen = 0,730 kg/m2	0,00	0.41	3
Europees naaldhout; geschilderd, acryl; duurzame bosbouw	Watergedragen acrylaat/alkydemulsie verf systeem voor buiten (voldoet aan Verfrichtlijn 2004/42/EC) Ondergronden hout en met verf behandeld hout van woningen, buitensituaties tifa-systemen (concept 3 = volledig afgewerkte systmen) + vervolg met zelfde productypeVerbruik - nieuw syteem 3 lagen = 0,313 kg/m2Onderhoudsfreq. 1 maal per 10 jaarVerbruik per 10 jaar (1 laag) 0,104 kg/m2Verbruik - onderhoud 4 lagen = 0,417 kg/m2Nieuw systeem opbouwen na 50 jaarVerbruik over 50 jaar 3 + 4 lagen = 0,730 kg/m2	0,01	1.12	3
PVC op staalkern		0,16	11.89	3
Pvc; gerecyceld pvc; stalen kokerprofielen		0,14	10.82	3
Tropisch loofhout; geschilderd, acryl; duurzame bosbouw		0,03	2.43	3