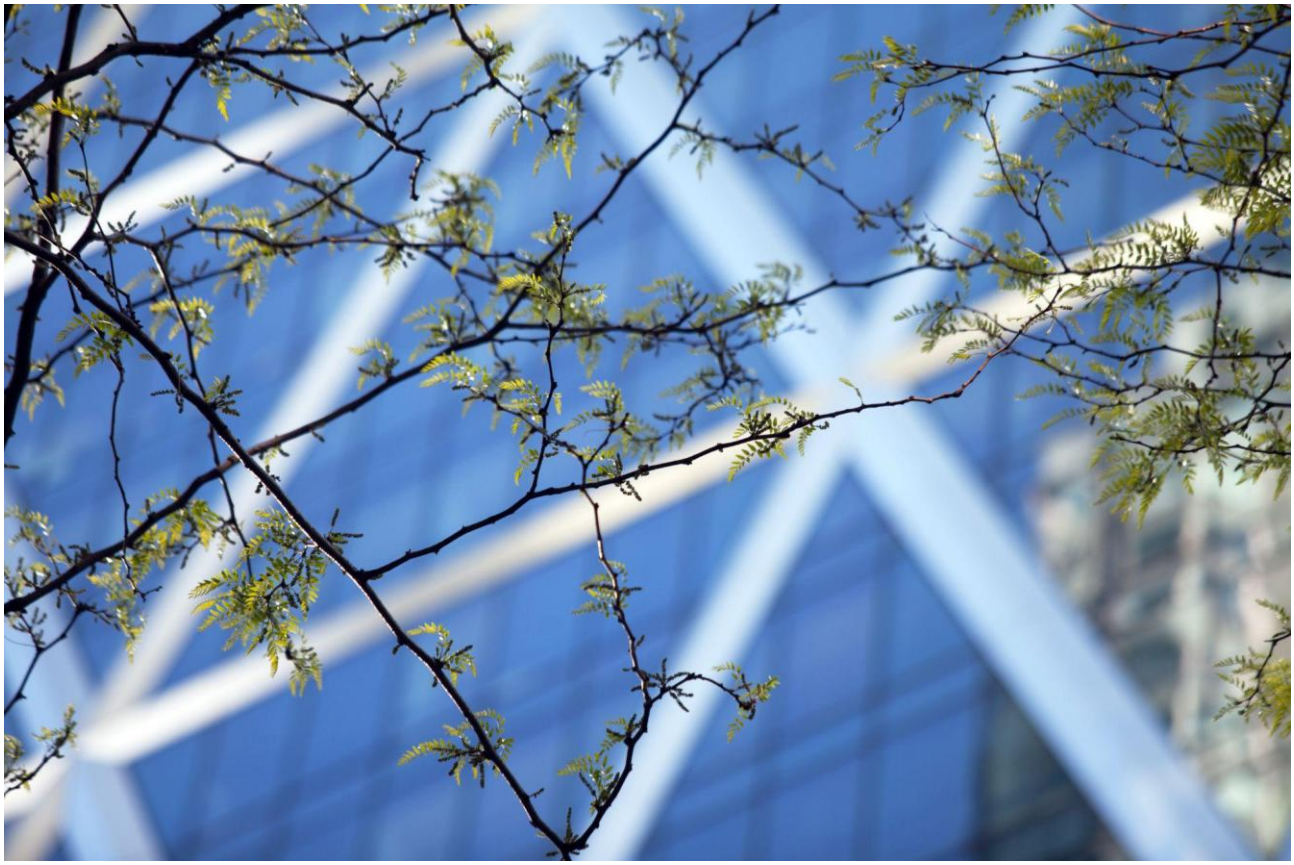
PERMASTEELISA GROUP

CO_2 PERFORMANCE LADDER



Sustainability at Permasteelisa Group ▪

CO2 Performance Ladder ▪

Value Chain Analysis

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Revisions

Rev. #.	Chapter:	Revision:
00		First issue

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01 Introduction

The construction industry has realised that we have to act now and start improving the human impact on the environment, if we want future generations to enjoy our planet the same way as previous generations did. Sustainability has finally become a key performance criterion in facade design, which allows us to create solutions and make decisions which were not viable before.

Our mission
Permasteelisa strives to be a front runner in the facade industry with our sustainability approach

To achieve this, we need to:

- Understand our environmental impact
- Develop knowledge and tools
- Deliver what we promise on the projects
- Show it to the world

01.1 CO2 Performance Ladder

The CO2 Performance Ladder is an initiative for companies in the construction sector that want to be pro-active and set ambitious targets to reduce their carbon footprint as a company. The initiative is chosen by Permasteelisa Group, because it provides a structured framework to manage our sustainability developments. It is aligned with current and expected European legislation and helps us to stay ahead of what is strictly mandatory.

On 19th October 2023 the initial audit took place for the organisational boundary of the Dutch entity Scheldebouw B.V. We have been awarded the level 4 certification on the CO2 Performance Ladder Handbook 3.1 and this has been maintained for three consecutive years. For this year the certification perimeter has been extended to include all European entities of Permasteelisa Group and the system has been updated to comply with Handbook 4.0. The aim is to achieve level 2 in the new three level structure, which is comparable to the previously achieved level for the Scheldebouw perimeter.

This report discusses the value chain analysis that serves as input for the climate transition plan.

02 Business activities and product portfolio

02.1 About Permasteelisa Group

Permasteelisa Group has a long history and a proven good reputation in performing complex international bespoke curtain wall projects in the top segment of the construction industry by integrating design, fabrication, procurement & supply chain, and installation on site. The European entities are active in their core markets in Italy, France, Germany, Switzerland, Austria, the BeNeLux, Scandinavia, Central/East Europe and the United Kingdom. Through an integrated intercompany collaboration with the other entities of the Permasteelisa Group they have also access to the United States, Middle East, Asia, Australia and other parts of the world.

By integrating highly qualified engineering knowledge with sophisticated production plants, Permasteelisa Group is able to deliver fully integrated cutting-edge technology to façade projects, whether they are active or interactive façades, with or without natural ventilation, mfree-CCF closed cavity façades, sun-shading systems or structural/decorative composite solutions. Material that can be incorporated into the projects is almost unlimited and can comprise materials like glass, aluminum, steel, stainless steel, titanium, architectural copper and bronze, natural stones, prefab concrete, ceramic materials, synthetic/composite materials, timber, and the like. The quality of the architectural envelops we use to create high-performance buildings and advanced technologies centered on sustainable solutions.

02.2 Characterisation of product portfolio

Permasteelisa is not a manufacturer of standard products, but makes custom design solutions for every unique project. The starting point is an architectural design intent and a performance specification. To meet these requirements a new design is made for every project, followed by the selection of suppliers for the specific materials and performance testing of the façade design. The result is a product portfolio with a huge diversity in colours, shapes and materials. Developing a strategy to improve the environmental impact of our products is therefore not as straightforward. On the other hand it is possible to give a characterisation of what a “typical” unitised curtain wall element by Permasteelisa looks like, which covers the biggest part of our projects.

Impression of a “typical” unitised curtain wall element by Permasteelisa

02.2.1 Frame

Most Permasteelisa facades are made of rectangular elements with a frame of aluminium profiles (mullions and transoms) that are either anodised or powder coated. For thermal insulation purposes these profiles can be split into an inner and an outer shell, which are connected by polyamide insulator parts. A façade element may contain intermediate mullions or transoms to facilitate the use of different types of infills.

02.2.2 Glazing infills

Vision panels have an infill of glazing units that are usually built up out of two or three glazing panes, separated by spacer bars with an argon filled cavity and one or more coatings on the glass panes. The glass may be laminated and/or heat treated. It is also possible to have coloured frits on the glass.

Single glass panes are used as the outer layer of an opaque infill panel or can be added to create a double skin façade.

02.2.3 Opaque infills

The non-vision part of a façade element is usually made of a rockwool insulated spandrel panel, containing a pre-galvanised steel sheet at the back. When the steel sheet is visible from the inside, it is usually powdercoated. The outer layer of the spandrel panel can be made of an almost infinite list of materials. The most common are:

- Anodised or powdercoated aluminium sheetwork, either flat, corrugated or in any other shape
- Single or double glazing
- Terracotta
- Glass Fibre Reinforced Concrete (GFRC)
- Natural stone
- or a combination of materials

02.2.4 Architectural features

Additional components can be attached to the façade elements to give texture or to provide functions like shading or access to the outside. Also here the list of possible materials is almost infinite. Most common are the following:

- Projecting horizontal or vertical fins of aluminium extrusions, anodised or powdercoated
- Anodised or powdercoated aluminium sheetwork, cut and bended into various shapes
- Fins in other materials like wood, terracotta and GFRC
- Balconies
- Louvres / brise soleils

The distinction between what is an architectural feature and what belongs to the frame of an element or what is the outer layer of an opaque infill, is sometimes a bit arbitrary. This category is mainly used when it provides additional insight for analysis purposes. It is more important to keep the distinction consistent within the same project, than to come up with a general definition that should always be followed.

02.2.5 Other materials

To complete the list of materials that are used in unitised curtain wall facades, the following components are also typically present:

- Galvanised steel bracket to fix the façade units to the concrete structure
- Rockwool insulation and optionally steel sheets to close the gap between the concrete floor and the façade unit
- EPDM gaskets
- Fasteners (bolts, nuts, screws, rivets, etc.) usually stainless steel
- Silicone sealant

03 Life Cycle Analysis – pilot study

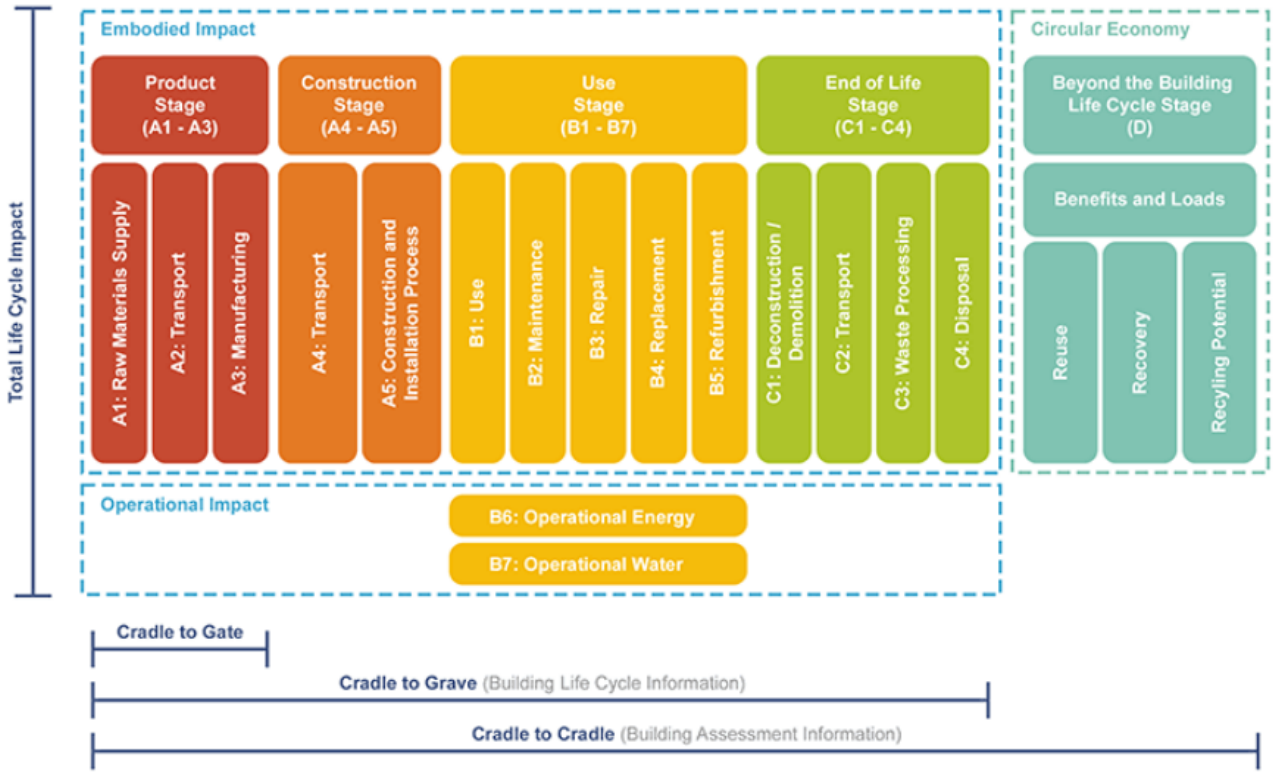
Before starting to apply for the CO2 Performance Ladder initiative the environmental analyses in our organisation focused mainly on the production process of our facades. Using the LCA (Life Cycle Analysis) method, we went through the entire life cycle of our facades and mapped out the environmental impact per phase. In this chapter the pilot LCA study is described. Since this initial study a total of 14 EPDs for Permasteelisa Europe have been published officially through MRPI and EcoPlatform.

03.1 Calculation method

To assess the embodied carbon of our façades a Life Cycle Analysis (LCA) was conducted for the pilot project “n2” in London, using the software application R<THINK by NIBE, which is based on the LCA method EN 15804:2019+A2. This standard also serves as the core PCR, in compliance with ISO 14040:2006 and ISO 14044:2006.

The R<THINK software assesses and reports all life cycle stages A to D and the whole list of environmental impact categories. From the list of environmental impact indicators in EN 15804 the total Global Warming Potential (GWP-total) is taken to express the impact on climate change, often briefly called “carbon”.

The finished LCA calculations were sent to a third party for review. Once approved, an Environmental Product Declaration (EPD) was drawn up and published on ECO platform through MRPI.

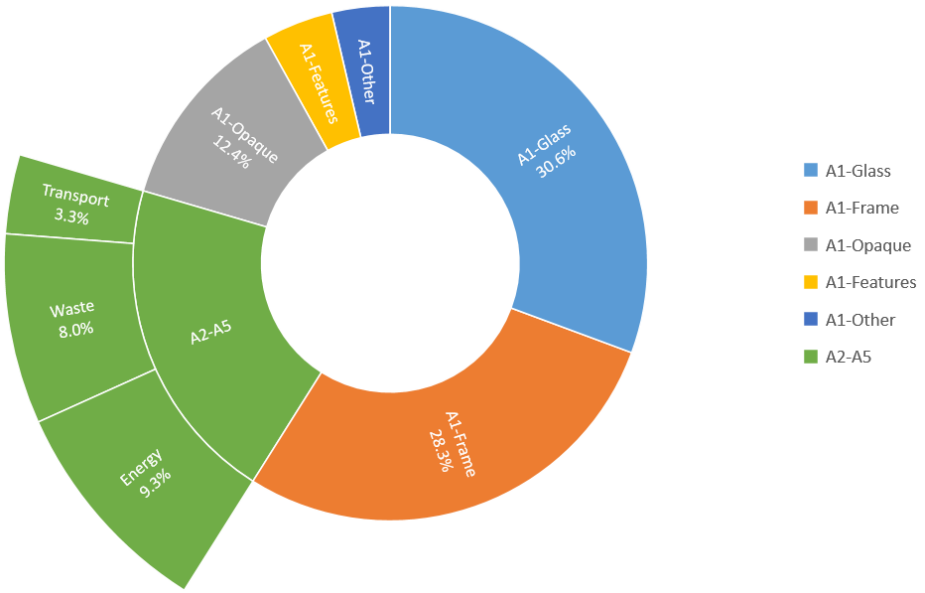


Life cycle stages of a Life Cycle Analysis (LCA)

03.2 Results

03.2.1 FT01A

Based on the assumptions described in the previous paragraph an LCA was executed for one façade element of type FT01A. The results for the embodied carbon in stages A1-A5 are shown in the figures below.



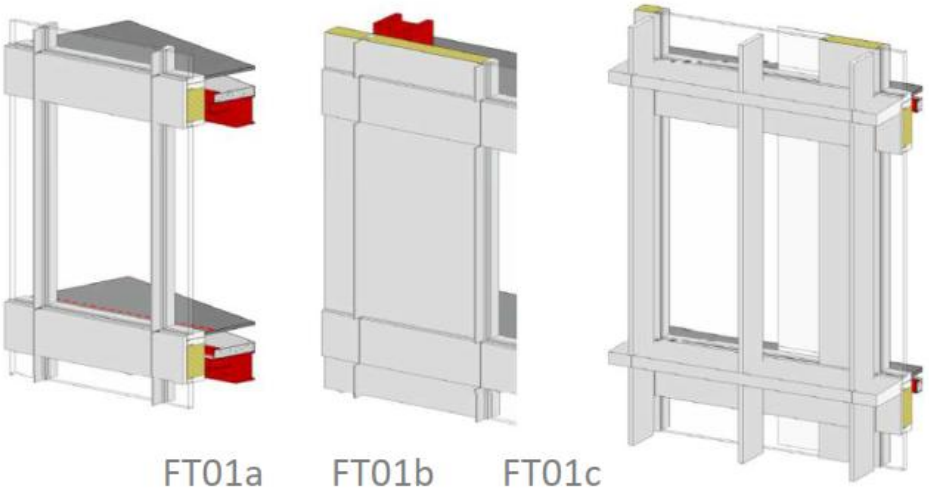
GWP-total [kgCO2e] for one element of 1.5 x 3.55 m²

Stage	kgCO2e	%
A1 - Glass	442.8	30.6%
A1 - Frame	409.2	28.3%
A1 - Opaque infills	179.1	12.4%
A1 - External Features	63.7	4.4%
A1 - Other materials	52.9	3.7%
Subtotal A1	1147.7	79.4%
Transport (A2 & A4)	47.9	3.3%
Waste (A3 & A5)	115.0	8.0%
Energy (A3 & A5)	134.4	9.3%
Total A1-A5	**1445.0**	
	271.4 kgCO2e/m2 façade	

The biggest impact (79.4%) is in stage A1, the materials that are purchased from our supply chain. Of these materials the biggest portion is taken up by the glazing (30.6%) and the aluminium frame (28.3%). The other purchased materials take up 20.5% and the remaining 20.6% is for the life cycle stages A2-A5.

03.2.2 Impact of design variations

Based on the same assumptions as for façade type FT01A, also two other façade types of the same project have been analysed.



FT01B

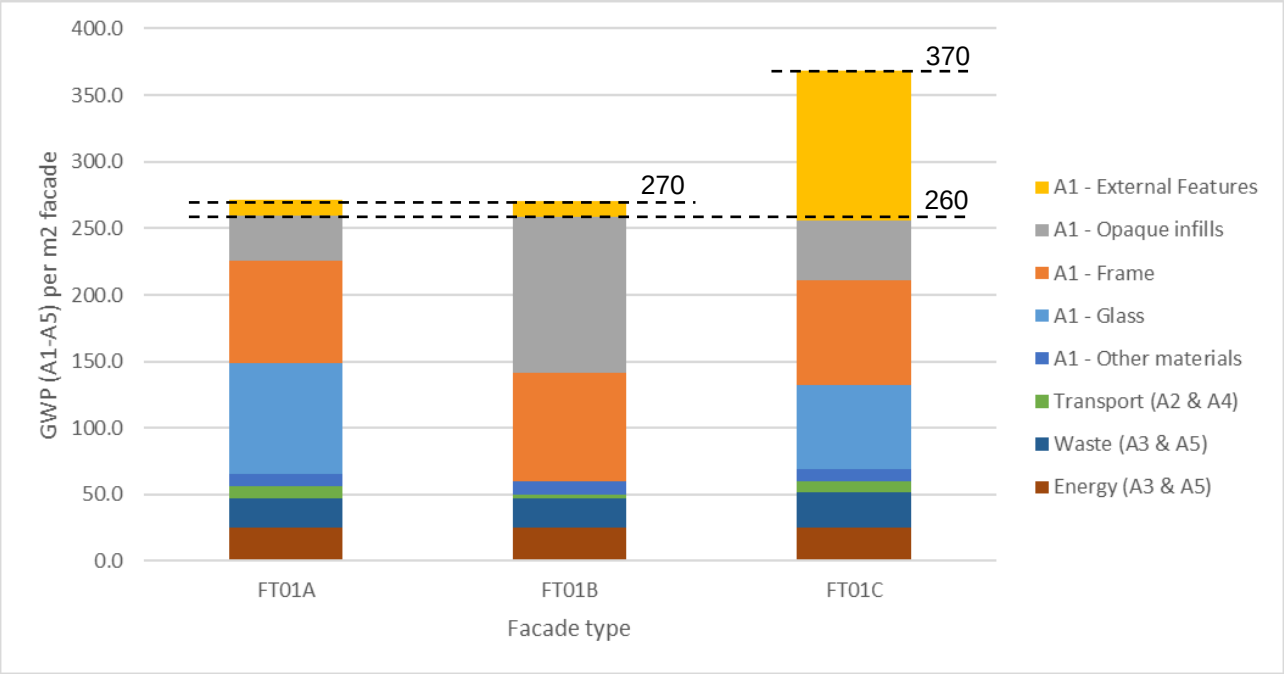
FT01B consists of elements of the same size as FT01A (1.5 x 3.55 m2). The framing members and the materials to attach the façade panels to the main structure are all the same. The only difference is the infill. The glazing of the vision panels is replaced by an opaque panel with an aluminium sheet on the outside.

FT01C

FT01C consists of elements that are double the size of FT01A (3.0 x 3.55 m2). They are a combination of FT01A and FT01B in the sense that they are partially vision panels and that the other part has an opaque infill. In addition to that, this façade type has much bigger external features.

In the figure below the embodied carbon (A1-A5) per m^2 façade is compared for the three façade types.

The embodied carbon of both FT01A and FT01B is approx. 270 $kgCO_2e$ / m^2. When omitting the external features the embodied carbon of all three façade types is approx. 260 $kgCO_2e$ / m^2. Including the external features for FT01C the embodied carbon is approx. 370 $kgCO_2e$ / m^2, so the impact of these features is that they add approx. 100 kg CO_2e / m^2 to the façade embodied carbon, when comparing FT01C to FT01A and FT01B.



03.2.3 Analysis

An easy conclusion from this analysis would be to remove the external features from the design, because they have a huge impact on the embodied carbon of the product. This is, however, a decision that Permasteelisa cannot make on its own. The architectural features are part of the client's design intent and are there for a reason. This might be aesthetics, but they might also have a specific function, like solar shading. By keeping the solar heat out of the building and thus reducing the cooling loads, they have an impact on the operational energy use of the building. These are also carbon savings, but they occur on a different location and within a different timeframe. Operational carbon savings for the end user are our organisation's most important category of "Other Influenceable Emissions" (see chapter 05.3.1).

03.3 Conclusions

A pilot LCA study was conducted for the project "n2", part of the Nova development in Victoria, London. Three façade types were analysed and the resulting calculations were sent to a third party verifier for review. The official EPD document has been published by MRPI.

Our expectation was confirmed that life cycle stage A1 mainly determines the CO_2 footprint of our product. These are the materials purchased from our supply chain and involves the specific design of a project, together with the choice of our suppliers and the further agreements with them. The other stages (A2-A5), which include transportation, waste and the activities in our own assembly facilities and on the building site, have a much lower impact.

04 Value chain analysis

The organisation must identify and analyse the relevant parts of its value chain associated with the most important activities following from the Impact and Influence analysis. These activities are:

- Purchased aluminium extrusions
- Purchased glazing
- Purchased aluminium sheetwork
- Subcontracted site installation activities
- Purchased steel profiles
- Purchased steel sheetwork
- Fuel combustion in own facilities
- Purchased stainless steel sheetwork

The value chain analysis focuses on key emission sources, short-term and medium-term reduction opportunities and the volume of CO2 emissions. These emissions can fall into scope 1, 2 and 3.

04.1 Direct relationships

04.1.1 Direct upstream relationships

A supplier analysis has already been made to determine the organisational boundary (see the “background report”). There are no other parties receiving money from the organisation, so this overview can also be used to analysis the upstream value chain relationships.

The top 80% suppliers for FY26 are a total of 72 companies and can be grouped as follows:

Supplier type (no. suppliers)	Amount [mln. €]	share of total [%]
Subcontractor for site installation (20)	51.32	41%
Special materials* (20)	14.17	11%
Logistics, transport and storage (5)	9.58	8%
Glass (6)	8.73	7%
Metal sheetwork (8)	6.09	5%
Aluminium extrusions (3)	5.66	5%
GRC, terracotta et al. (4)	2.21	2%
Building rent (3)	1.20	1%
Design services (1)	0.64	1%
Car leasing (1)	0.56	0%
IT (1)	0.30	0%

* Relationship with category above analysed in paragraph 04.2.3

The highlighted groups in the table above together amount to 58% of our total expenditure on suppliers in FY26 and are aligned with our organisation’s most important activities following from the Impact and Influence analysis. Therefore, these are selected as our most important direct upstream relationships.

04.1.2 Direct downstream relationships

To determine the downstream relationships an overview has been generated of the awarded projects during the past 5 years together with their total contract sum and the contract partner.

The top 80% clients are as follows:

Contract partner	Amount [mln. €]	share of total [%]
Multiplex	184.6	28%
Mace	128.8	19%
Bovis (former Lendlease)	60.1	9%
John Sisk	53.3	8%
Laing O'Rourke	44.6	7%
Hent	41.3	6%
Bouygues	34.5	5%

The highlighted relationships in the table above together amount to 63% of our total awarded contract sum in the past 5 years. These are all main contractors and they are responsible for the management of the building sites on which we install our facades. Site installation was identified as one of our most important activities, therefore these are selected as our key direct downstream relationships.

04.2 Value chain description and mapping

04.2.1 End users, investors and contract partners

Permasteelisa works in the construction industry. Construction projects have a relatively long span between the first talks about new opportunities and the practical completion of the building, which can stretch to 5 years or even longer with intermediate pauses. The party who takes the initiative for a building project usually is a developer or real estate investment company. Their incentives are to realise a profitable building that they can either sell immediately or keep in their portfolio and lease to another company as end user. In both cases the initiating party for the project is not intending to occupy the building themselves and more interested in profitability than in the exact use of the building. Sometimes the end user is a big company like Google, Apple or Booking.com and they will develop the project themselves for their own use, which gives a completely different focus in the process.

The most common contract forms for Permasteelisa are either a subcontract with the main contractor or a direct contract with the joint venture that is established specifically for one project. The top 3 of our contract partners in the past 5 years are all main contractors. As described, these are generally not the parties that take the initiative for a project. Apart from developers, investors and own developments by big companies, there are more influencing parties in the process that we need to take on board if we want to reduce the project's carbon emissions, like cost consultants, technical consultants and architects. Our sales and tender team identified the most important relationships to manage in this field.

04.2.2 Main facade materials

As explained in chapter 02.2 our product portfolio is not a static catalogue, but customised to the clients' requirements for every project. This means that also the supply chain is not static and consists of a wide variety in materials and companies. The most important components following the Impact & Influence analysis are:

- Aluminium extrusions
- Glazing
- Metal sheetwork

Aluminium extrusions

The process to obtain aluminium profiles as components for our facades consists of the following steps:

- Aluminium extrusion ingot / billet production
- Extrusion process
- Rolling in of thermal breaks
- Surface treatment: anodisation or powder coating
- Cutting to size, machining and further processing

The last step is usually done in our own assembly facility and our direct supplier takes care of the preceding steps. The three suppliers for aluminium extrusions included in our top 80% are:

- Pandolfo
- Gartner Extrusions
- Metra

The extrusion billets have by far the largest impact on the total carbon emissions of the production of aluminium extrusions. These three suppliers all produce their own billets and are working on internal carbon reduction developments, which are a combination of energy reduction, renewable energy sources and increased recycled content as raw material. As an alternative option they can also work with billets produced by the company Hydro, who has a specific product on the market produced by hydro-electricity, called "Hydro Reduxa".

Glazing

The process to make insulation glazing consists of the following steps:

- Float glass production
- Application of heat treatment or ceramic frit (optional)
- Sputtering of reflective coating on the glass pane
- Cutting to size
- Lamination of glass pane by applying PVB interlayer (optional)
- Applying spacer bar and gas filling to create insulation glazing

On average the float glass production makes up half of the total carbon emissions of an insulation glazing assembly and all the other processes together the other half. The ratio varies based on the exact requirements and treatment needed. Also the thickness of the float glass is important for the ratio, because it is the only variable related to the mass of the material, the other processes are related to the surface area.

Our direct suppliers are the companies that assemble insulation glazing compositions from separate glazing panes. There are a total of 6 glazing suppliers in our top 80%. Which of the processes from the list above they execute in-house varies. Some companies also produce float glass themselves, but most of them buy these from one of the following companies: AGC (also on our list of direct suppliers), Guardian and Saint Gobain.

All three have comparable low-carbon options in their product range by now, which is being achieved by a combination of energy reduction, renewable energy sources and increased recycled content. Because of the heavy restrictions for contaminations in the raw materials, the recycled content is mainly pre-consumer cullet from their own production processes and consists to a much lower extent of post-consumer recycled material.

Although the other processes to make an insulation glazing composition together also make up a substantial portion, we currently focus our efforts to keep our information up to date on the developments to reduce the carbon emissions for the production of float glass, because this has the biggest impact.

Metal sheetwork

Sheetworks are a much more diverse group than the two material categories described before. The base material may be aluminium, steel, stainless steel and other metals. And they are both used as part of a typical facade panel, as well as on the building site to achieve special connection and closure details. In general the process steps are as follows:

- Metal ingot production
- Hot rolling and sheet rolling of the base material into coils
- Surface treatment: anodisation / galvanisation, powder coating or other
- Cutting to size, machining, bending and further processing

Our direct supplier usually takes care of the last two steps, buying coils from their suppliers one step further up the value chain. Sometimes these coils already have the surface treatment on them. Another option happens in our production facility in Italy, which has a division that does the last process step in-house and buys coils or flat sheets with surface treatment and not the finished product in the final shape.

In FY26 we had a total of 8 companies in the sheetwork category in our top 80% suppliers. To complicate the analysis even more, these suppliers are often also suppliers of steel profiles, a different category in our emission inventory with a different function in our facades.

From the described process steps to obtain metal sheetwork the metal ingot production takes up the biggest portion of the carbon emissions. Unlike aluminium extrusions and glazing, there are at least two intermediate suppliers in the value chain before we reach that step, so it’s much more difficult to influence the process. We are also a much smaller customer compared to the others, which gives us less leverage. Together with the high demands on other aspects, like visual appearance, durability and high-specialty forming techniques, makes this a difficult category to achieve significant carbon reductions.

In theory it should be possible to achieve similar reductions on the aluminium sheetwork as we can achieve on the aluminium extrusions, because the base material is not that different. The issue is a more fragmented supply chain, which makes it more difficult to influence. We assess per individual project what the impact of the sheetwork is on the total emissions and where our focus should be. Interaction with the supply chain for these materials is mainly within the project execution context.

04.2.3 Site installation activities and materials

FY26 was not a typical year for our organisation. No new projects started in production and we only continued or finished production and site installation activities for older projects. This means that the amount of materials coming in for the typical facade units was relatively low. Compared to that, relatively more special materials for use on site were received, together with the purchase of subcontracted work on site. There also was more focus on service and maintenance work, which is grouped in our books together with the site activities for new-built projects and not separated out.

The table in paragraph 04.1.1 groups the suppliers in categories. The first group of “subcontractors for site installation” provides both materials for use on building sites and the services to install them with an average ratio of approx. 70% materials and 30% services. In our emission inventory these materials are grouped together with the second category of “special materials”, which is not part of our organisation’s most important activities following from the Impact and Influence analysis.

The emissions following from the remaining 30% installation activities on the building site are partially included in our inventory as energy consumption for site equipment (mobile scope 1 & 2). Measures have already been taken to introduce more renewable fuels, like green electricity and HVO. The other part of the energy consumption on site is the electricity used from and by the main contractors, which are also often our contract partner for the project. It is difficult to obtain reliable data from them, because there are no separate meters for the different subcontractors and trades.

04.3 Analysis and conclusions

Looking at the value chain of our organisation and the projects we work on, the most important mechanisms to reduce carbon emissions are:

- Purchasing materials with lower carbon emissions during production
- Influencing design decisions with the aim to use less or alternative materials

For the first mechanism we need to stay informed about developments in the market. We must understand what the technical, aesthetic and commercial implications are if we purchase a specific low-carbon alternative. The focus is currently on aluminium extrusion billets and float glass production. The following companies are our main focus.

Aluminium extrusion billets:

- Pandolfo
- Gartner Extrusions
- Metra
- Hydro

Float glass production:

- AGC
- Guardian
- Saint Gobain

Regarding metal sheetwork it is more difficult to influence the supply chain, because it is more fragmented. The communication here is more on a project-by-project basis depending on the importance of the material for the specific design and circumstances of the project.

To influence design decisions we need to work with a wider group of companies than just our contract partners. The decision making process is a balance of aesthetic, technical and commercial aspects and influenced by architects, technical and cost consultants, next to the real estate investor or developer who is behind our direct contract partner (usually the main contractor). We have to stay in close contact with all of these parties, partially on a project-by-project basis when project opportunities come up and partially on a business-to-business level. Main contractors are especially important, though, because they also have an impact on our potential to reduce emissions of our site installation activities.

Main contractors:

- Multiplex
- Mace
- Bovis

Based on the percentages of the total emissions in FY22-26 of each activity, the total potential carbon savings are estimated and presented in the table below:

	Percentage of total emissions FY22-FY26	**Potential relative emission reduction**	**Potential emission reduction on total**
Aluminium extrusions	15.7%	Reduxa: ± 50% Circal / Futural: ± 75%	7.9% 11.8%
Glazing	8.8%	± 25%	2.2%
Aluminium sheets	8.0%	Similar to extrusions	4.0% 6.0%
Steel sheets	4.1%	Under investigation	
Site activities	7.5%	Under investigation	

05 Other Influenceable Emissions (OIEs)

The organisation must provide a qualitative analysis of its Other Influenceable Emissions (OIEs). These are the emissions that fall outside its scope 1, 2 or 3 per the GHG protocol. The reason is that these are short-cycle or occur outside the organisation's value chain. If the organisation can significantly influence these emissions, they are relevant to contributing to global climate neutrality. A distinction is made between three OIE types: biogenic CO2 emissions, CO2 removals and avoided emissions. CO2 compensation is explicitly not part of OIE.

To support the analysis, Permasteelisa used the tool/questionnaire available on the SKAO website and the results are discussed here.

05.1 Biogenic CO2 emissions

To reduce carbon emissions from the equipment used on building sites a switch has been made from traditional diesel and petrol to HVO. These involve direct biogenic emissions. Other direct biogenic emissions for passenger mobility or in our buildings are not relevant to the organisation. Also indirect biogenic emissions are not relevant for us.

The amount of HVO used on building sites for the installation equipment is very low compared to our other emissions. It has been introduced as a carbon reduction measure, because alternative options, like green electricity, were not suitable for this activity. If better alternatives become available in the market we will re-evaluate this.

05.2 CO2 removals

CO2 removals by Direct Air Capture or by sequestration through mineralisation are not relevant to our organisation. We do, however, have the possibility to build our facades using timber instead of other materials. This is something we have done before in several projects, but it has significant aesthetic impact as well as technical consequences for structural integrity and fire-safety. It needs to be balanced against other aspects that might increase carbon emissions, like structural enhancements to carry the additional weight of wood against aluminium and additional fire protection materials. These considerations are made on a project by project basis.

05.3 Avoided emissions

05.3.1 Targeted avoided emissions: reduction of operational energy use

"Targeted avoided emissions" are our organisation's most important OIEs, because the development of better performing facades has contributed significantly to reduce the operational energy use of buildings. Examples are the addition of thicker thermal insulation material to the opaque parts of the façade and the improvement of the glazing properties. Double skin façade concepts have been developed to reduce the energy consumption further and it is even possible to add solar panels to the façade to generate electricity.

The operational energy use (B6) is not part of the Life Cycle Analysis standard, because it has a different assessment method. The operational energy use of a building is not purely material related, but is a characteristic of the whole building. It cannot be easily attributed to the different components of a building, so there is no easy answer to which part of the total energy use of the building is "caused by" the façade. For

this reason the operational energy use of the building cannot be accounted for in our organisation's Upstream Scope 3 as 3.11 Use of sold products.

05.3.2 Other avoided emissions

Permasteelisa Europe is not involved in the scheduling of road work, dredging activities, management of peatland areas or handling of third-party waste, so "Potential avoided emissions" are not relevant. "Working together on avoided emissions" is relevant for Permasteelisa Europe to the extent that some of the electricity generated by the PV panels or the cogenerator in our production facilities is not used and delivered back to the grid. As a first step we aim to organise our activities in such a way that more of the generated electricity is used directly by ourselves. If there is still a surplus after this optimisation step, we will look further at finding a better purpose for it.

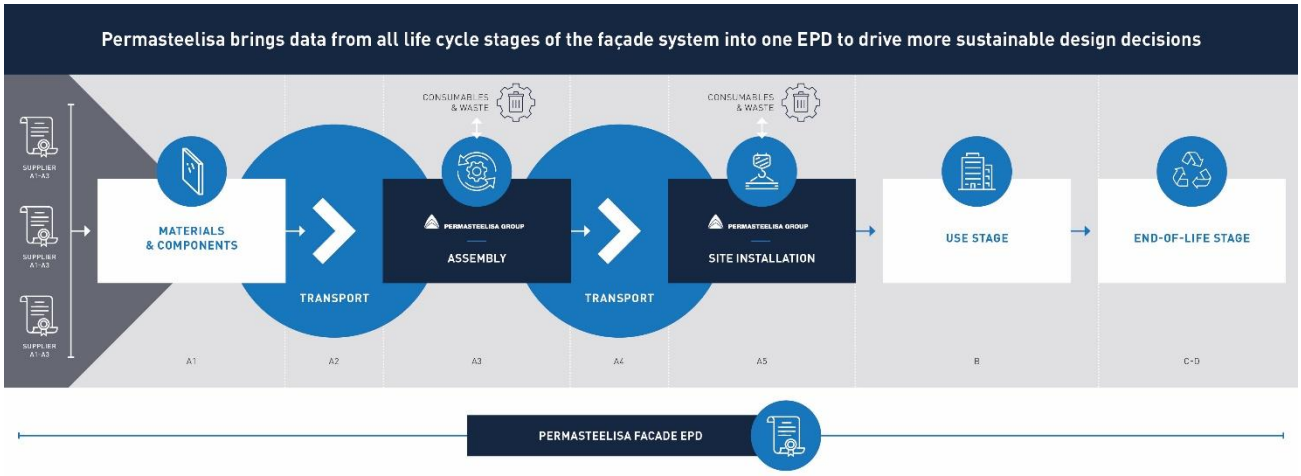
05.4 Conclusion and application during project execution

The emissions that are being avoided by making better performing facades are our organisation's most impactful "Other Influenceable Emissions. Our R&D department developed a tool to advise our clients on the operational performance impact of our facades. It balances the carbon "investments" by applying new materials during a refurbishment or by comparing different design alternatives, against the "savings" in carbon emissions during the use stage. This allows us to calculate the "carbon payback time" in order to assess the effectiveness. An example for the project "New Zealand House" can be found in the portfolio.

06 Application of LCA in project execution

An LCA is now a standard part of our project execution. The analysis in the previous chapter confirms this strategy, which is focused on providing better insight for the project related design, engineering and purchasing decisions we have to make together with our clients. By comparing the environmental impact of different design and material related alternatives, we are able to make better informed decisions. We provide embodied carbon calculations from the early design stages on, update those regularly during the project execution phase and finalise the process by going through a full third party verification to obtain official Environmental Product Declarations (EPDs) for the specific design of that project.

All of this in close collaboration with our client's project team to make sure that we meet their expectations, requirements and architectural design intent. With this approach we try to reduce the embodied carbon of our products in a holistic way instead of focussing on specific solutions.



The design options we provide to the client usually focus on a combination of the following aspects to achieve the biggest impact:

- Optimising the design to reduce the quantities of the different materials
- Assessing the impact of using an alternative material, e.g. aluminium sheets vs. terracotta
- Looking for alternative suppliers and/or production methods, e.g. low-carbon aluminium billets

The following aspects are also part of the embodied carbon assessment of our products, but currently have a much more limited impact:

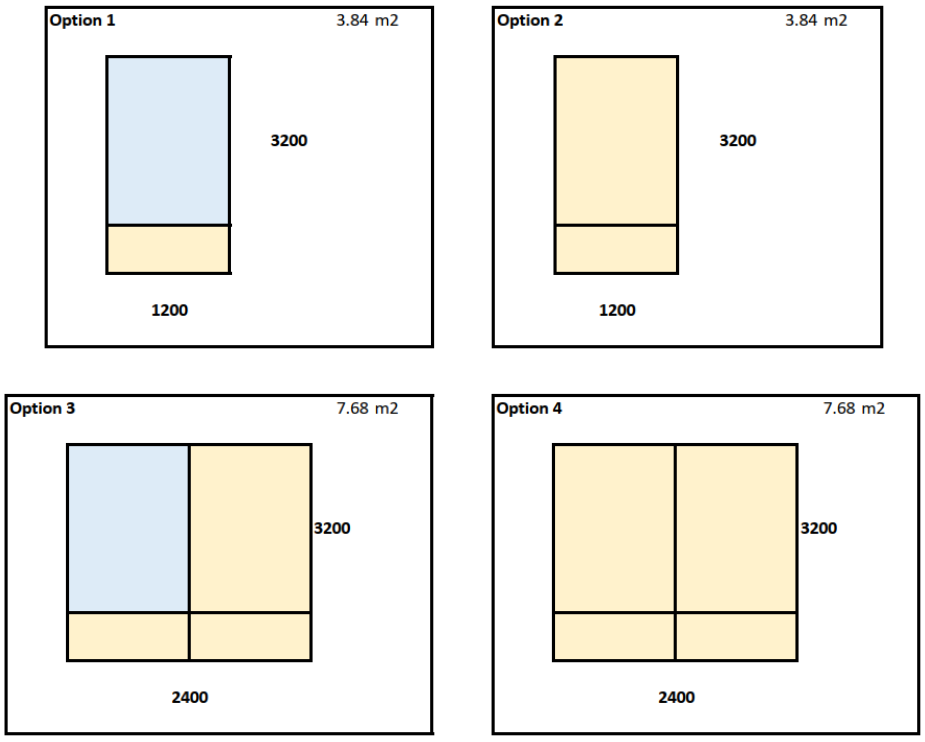
- Transportation distances
- Façade assembly activities in our own production facility
- Façade installation on the building site

In the next paragraphs we describe two effective strategies to reduce the embodied carbon of our products in the early design stages.

06.1 Strategy 1: Design optimisation

The starting point of a project for Permasteelisa Europe is an architectural design intent and a performance specification. To meet these requirements a new design is made for every project, followed by the selection of suppliers for the specific materials. In the early project stages this approach makes it possible to balance all the technical, planning and cost aspects with the environmental aspects resulting in an optimal solution for the specific project.

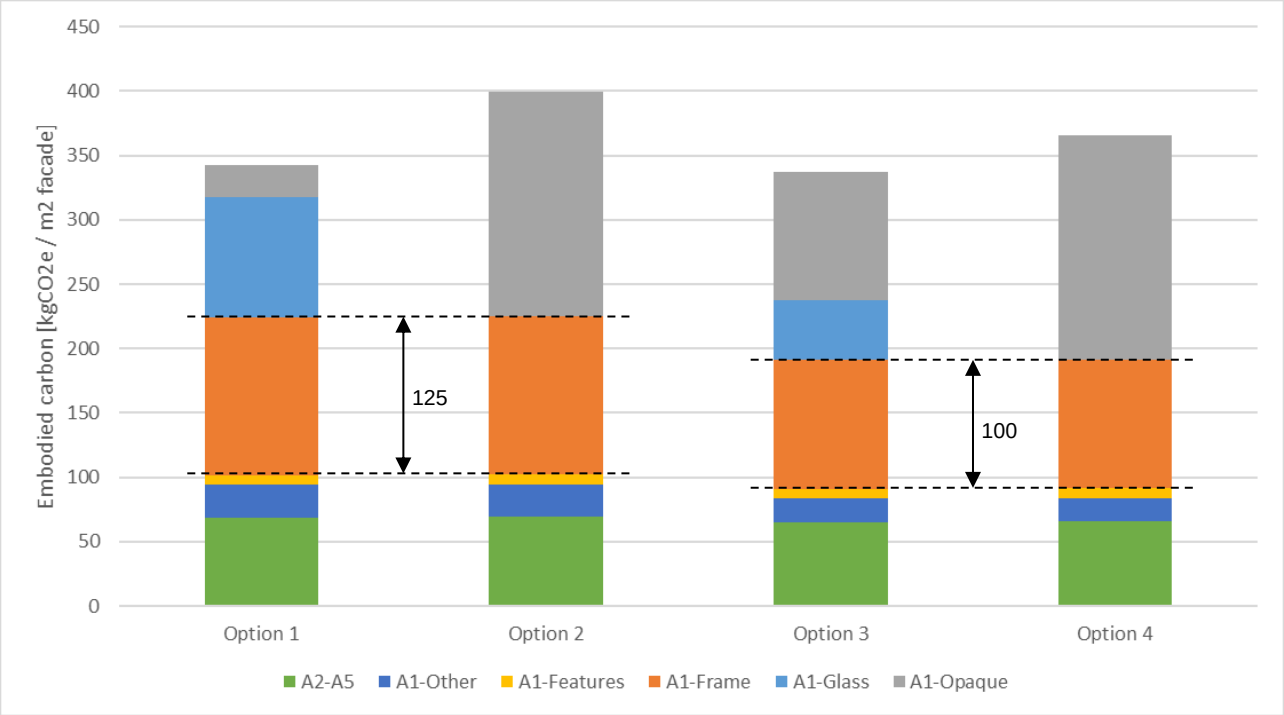
An example from a recent tender project is shown here. Four design options are being compared and the decision is about façade panels that are 1200 mm wide or 2400 mm wide. Option 1 and 2 are 1200 mm wide, one vision panel and one opaque panel. Option 3 and 4 are 2400 mm wide, one panel with a combination of vision and opaque, the other panel fully opaque.



For the same visual effect, Option 3 is a combination of Option 1 and Option 2, and Option 4 is a combination of two panels of Option 2. The difference is the split in the middle. When we look at the embodied carbon of the frame (in orange), it becomes apparent that combining two panels of 1200 mm wide into one panel of 2400 mm wide, saves 25 kg CO2e / m^2 façade just for the frame. In stages A2-A5 and in “A1-other materials” there are some additional savings, because we need to transport less weight and because we omit one joint, so we need less gaskets.

Another conclusion we can draw from this overview is that the opaque infill is more carbon intensive than the glazing infill. This is caused by the specific design of this project, which has a corrugation to the outside of the opaque panel that uses a lot of additional material.

After providing an overview like this to our clients, the conclusions are combined with the analysis of the other technical aspects of the façade and their implications for the costs and planning of the project. In this way it is possible to make an informed decision for the execution of the next project stages.

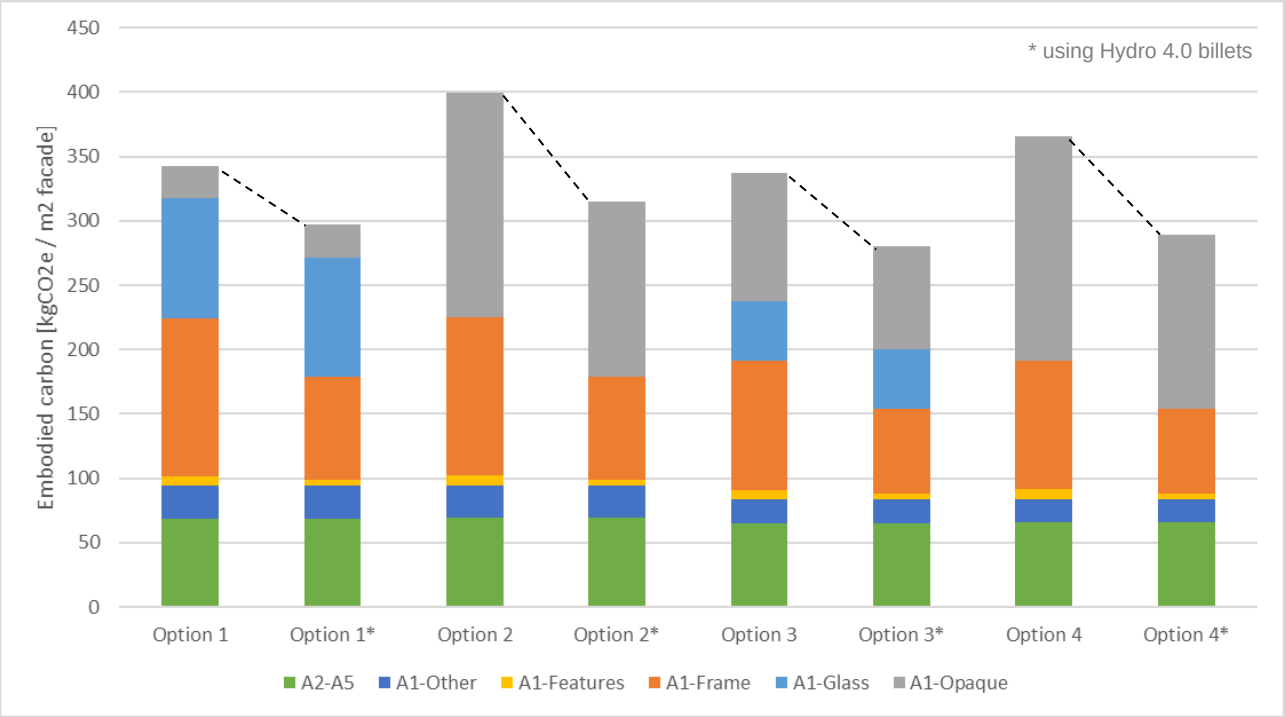


06.2 Strategy 2: Low-carbon material options

Like explained in the previous paragraph, the design of each project is completely tailored to the client's wishes and needs. Also the suppliers of the materials Permasteelisa use in their facades are chosen for each project individually. This means that after the design optimisation, the next strategy that can have a lot of impact on the carbon intensity of our facades is to look for suppliers with improved production processes that have lower carbon emissions. An example are the so called "low-carbon" aluminium billets.

In the table below the assumptions and figures are provided that we use as an industry average of our European supply chain for the extrusion profiles.

	anodising	**powder coating**
1 kg of billets [kg CO2e]	7.17	7.17
1 kg extrusion process [kg CO2e]	0.80	0.80
0.18 m^2 of surface treatment [kg CO2e]	0.62	0.54
Total [kg CO2e]	**8.59**	**8.51**



The supplier Hydro now provides billets that are produced by using hydro-electric power, which have an embodied carbon of 4.0 kg CO2e / kg aluminium. Comparing that number to the table above, the carbon saving is 3.17 kg CO2e per kg of aluminium (7.17 – 4.0). The impact of this choice for the frame of the façade panels can be seen in the graph.

The supplier Hydro also provides aluminium billets with an embodied carbon of 2.3 kg CO2e / kg aluminium. These are produced by using a much higher percentage of recycled content. The consequence is that they have more impurities, which makes them not suitable at the moment to use anodisation as a surface treatment. Also the availability of these billets is limited and Hydro decided not to provide them for custom extrusions, like Permasteelisa uses on their projects. It means that in practise we cannot use these billets at the moment.

For every project we look again at the options available from our suppliers, because the developments go very quickly. Recently another supplier of aluminium billets Pandolfo, entered the market with a low-carbon product, which has already been used in a few Permasteelisa projects.

07 Summary

Following from the value chain analysis, the most important mechanisms to reduce carbon emissions for our organisation are:

- Purchasing materials with lower carbon emissions during production
- Influencing design decisions with the aim to use less or alternative materials

For the first mechanism we need to stay informed about developments in the market. We must understand what the technical, aesthetic and commercial implications are if we purchase a specific low-carbon alternative. The focus is currently on aluminium extrusion billets and float glass production.

To influence design decisions we need to work with a wider group of companies than just our contract partners. The decision making process is a balance of aesthetic, technical and commercial aspects and influenced by architects, technical and cost consultants, next to the real estate investor or developer who is behind our direct contract partner (usually the main contractor). We have to maintain close contact with all of these parties, but main contractors are especially important because they also have an impact on our potential to reduce emissions of our site installation activities.

Annex: Published EPD of “n2”

Environmental Product Declaration

according to ISO 14025 and EN 15804

This declaration is for:

Curtain wall FT01a of "n2" London

Provided by:

Scheldebouw b.v.

- Permasteelisa Group

program operator

Stichting MRPI®

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MRPI® REGISTRATION

1.1.00325.2022

DATE OF ISSUE

22-09-2022

EXPIRY DATE

22-09-2027

PRODUCT

Curtain wall FT01a of "n2" London

DECLARED UNIT/FUNCTIONAL UNIT

1 piece

DESCRIPTION OF PRODUCT

One typical curtain wall facade element FT01A of the project "n2", London, including fixings and closures. Size: 1.5 x 3.55 = 5.325 m².

VISUAL PRODUCT

MORE INFORMATION

https://scheldebouw.permasteelisagroup.com

SCOPE OF DECLARATION

This MRPI®-EPD certificate is verified by **U. Hofstra, SGS INTRON b.v..**
The LCA study has been done by **G.J. van Beijnum, Nibe b.v..**
The certificate is based on an LCA-dossier according to ISO14025 and EN15804+A2. It is verified according to the 'MRPI®-EPD verification protocol November 2020.v4.0'. EPDs of construction products may not be comparable if they do not comply with EN15804+A2. Declaration of SVHC that are listed on the 'Candidate List of Substances of Very High Concern for authorisation' when content exceeds the limits for registration with ECHA.

PROGRAM OPERATOR

Stichting MRPI®
Kingsfordweg 151
1043GR
Amsterdam

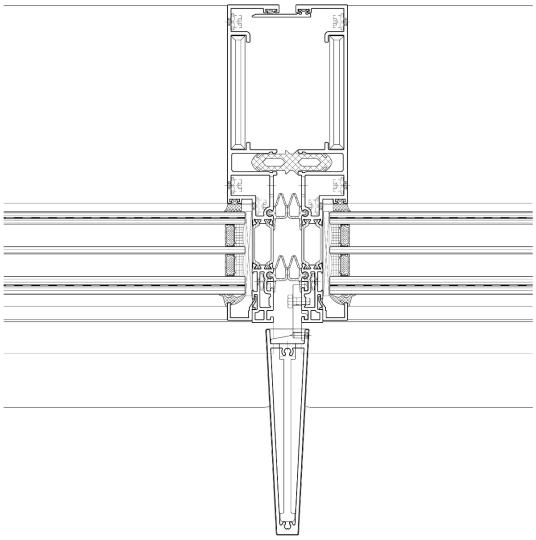
ir. J-P den Hollander, Managing director MRPI®

DEMONSTRATION OF VERIFICATION
CEN standard EN15804 serves as the core PCR[a]
Independent verification of the declaration and data, according to EN ISO 14025:2010: internal: external: X
Third party verifier: U. Hofstra, SGS INTRON b.v.
[a] PCR = Product Category Rules

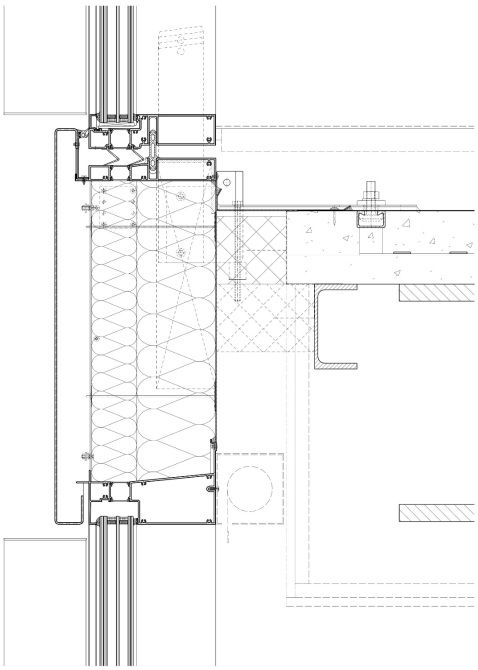
DETAILED PRODUCT DESCRIPTION

One typical curtain wall facade element FT01A of the project "n2", London, including fixings and closures.
Size: 1.5 x 3.55 = 5.325 m².
Weight: 357.23 kg.
Performance in accordance with DoP and CE-marking nr. 2021-91211.

Consisting of the following parts:
Glazing: 55.2-16-5-18-44.2
Spandrel: 3 mm aluminium sheet, air cavity, 220 mm rockwool, 1.5 mm steel sheet
Aluminium profiles: 225 mm deep with 145 mm deep fins
Firestop at floor edge: 125 x 120 mm Lamatherm (stone wool) with 1.5 mm steel sheet on top



FT01A - Typical mullion



FT01A - Typical floor edge detail

RSL Product
The curtain wall facade has a reference service life of 60 years.

RSL parts
The facade consists of various parts with different service lifetimes. During the reference service life (RSL) of the facade (60 years), several parts like glazing, sealants and gaskets need to be replaced. The replacement of these parts has been accounted for in life cycle stage B3.
The reference service life of the product parts in this report is based on the estimated service life, as defined in BS ISO 15686-1, which Scheldebouw provides to the client in their general guarantees and warranties schedule.

Product part	RSL
Laminated triple glazing	25 years
EPDM gaskets	30 years
Sealant	25 years
All other parts	60 years

COMPONENT >1% of total mass	[kg / %]
Laminated triple glazing	243.14 kg
Anodised aluminium extrusions	21.16 kg
Powder coated aluminium extrusions	31.68 kg
Thermal breaks	2.46 kg *
Anodised aluminium sheets	15.90 kg
Mineral wool insulation	10.43 kg
Pre-galvanised steel sheets	17.72 kg
Galvanised steel bracket plate	6.30 kg
EPDM gaskets	6.68 kg
Chromium steel parts e.g. fasteners	1.15 kg *
Sealant	0.61 kg *

(*) < 1% of total mass, but included for completeness of the assessment

SCOPE AND TYPE

The input data are representative for facade type FT01A of the project “n2” in London, a product produced by Scheldebouw B.V. in Middelburg, The Netherlands. The data are representative for building site London and production location Middelburg with suppliers located in Europe. In absence of predefined waste / end-of-life scenarios for the United Kingdom, the Dutch scenarios are used, because they are deemed representative.

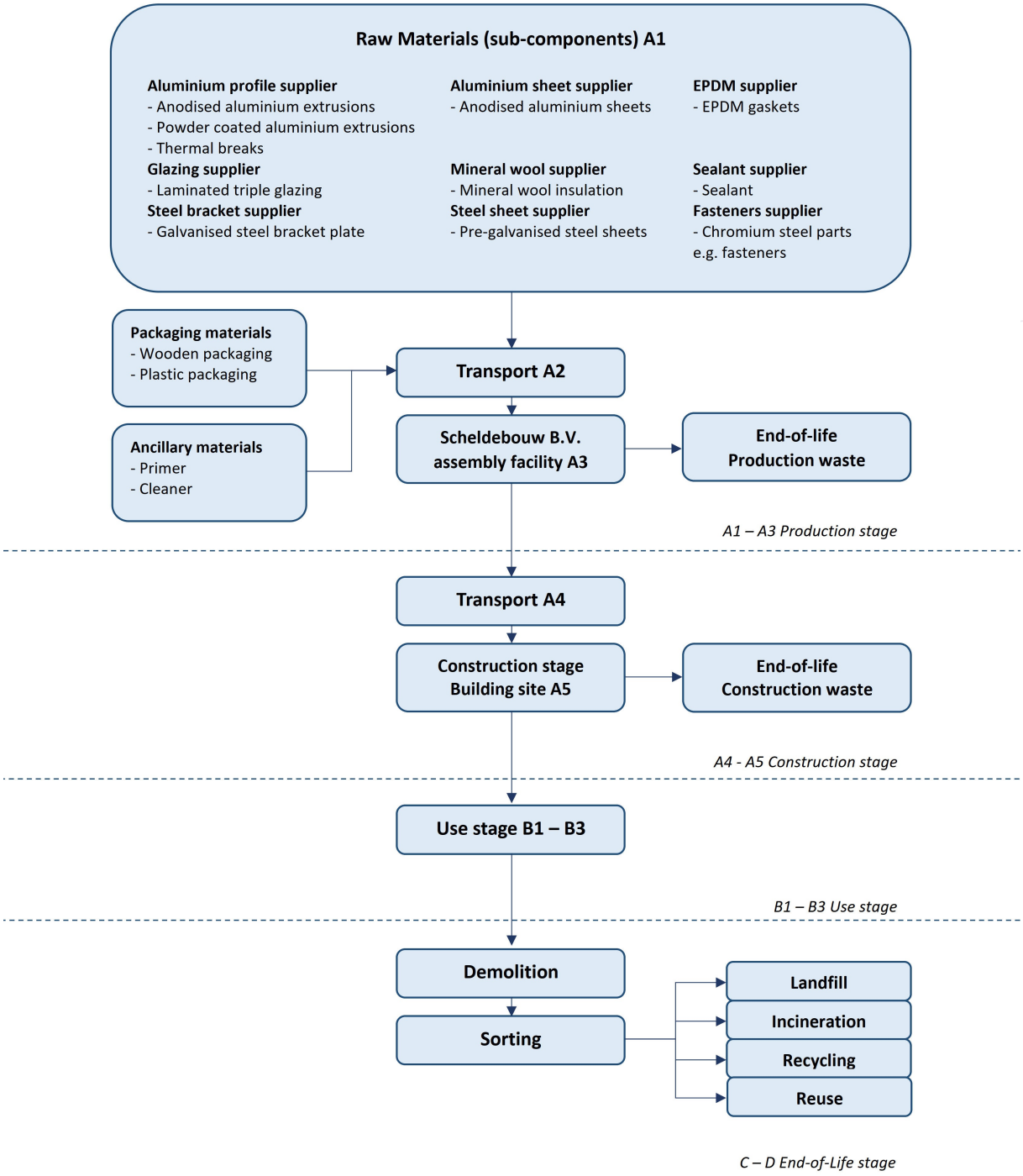
Scheldebouw works with a variety of suppliers, which are not known at the start of a project. The aim of this LCA is to define a baseline performance which Scheldebouw can always deliver regardless of project specific agreements with suppliers. The material quantities are based on the specific facade configuration of FT01A of the project "n2".

LCA Method: EN15804+A2:2019
LCA Software: Simapro 9.1.1
Characterisation method: EN 15804 +A2 Method v1.0
LCA database profiles: EcoInvent version 3.6
Version database: v3.09 (2022-05-10)

PRODUCT STAGE			CONSTRUCTION PROCESS STAGE		USE STAGE							END OF LIFE STAGE				BENEFITS AND LOADS BEYOND THE SYSTEM BOUNDARIES
Raw material supply	Transport	Manufacturing	Transport gate to 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	x	ND	ND	ND	ND	x	x	x	x	x

X = Modules Assessed

ND = Not Declared



LCA process diagram according to EN 15804 (7.2.1)

REPRESENTATIVENESS

The input data are representative for facade type FT01A of the project “n2” in London, a product produced by Scheldebouw B.V. in Middelburg, The Netherlands. The data are representative for building site London and production location Middelburg with suppliers located in Europe.

ENVIRONMENTAL IMPACT per functional unit or declared unit (core indicators A2)

	UNIT	A1	A2	A3	A1-A3	A4	A5	B1	B2	B3	C1	C2	C3	C4	D
GWP-total	kg CO2 eq.	1.15 E+3	4.14 E+1	1.81 E+2	1.37 E+3	6.51 E+0	6.81 E+1	0.00	0.00	7.68 E+2	7.61 E-1	3.14 E+0	4.81 E+1	6.17 E-1	-6.47 E+2
GWP-fossil	kg CO2 eq.	1.13 E+3	4.14 E+1	2.01 E+2	1.38 E+3	6.51 E+0	5.42 E+1	0.00	0.00	7.62 E+2	7.60 E-1	3.14 E+0	4.64 E+1	6.14 E-1	-6.37 E+2
GWP-biogenic	kg CO2 eq.	3.79 E+0	1.91 E-2	-2.04 E+1	-1.66 E+1	2.35 E-3	1.37 E+1	0.00	0.00	5.84 E+0	5.47 E-4	1.45 E-3	1.76 E+0	2.76 E-3	-1.77 E+0
GWP-luluc	kg CO2 eq.	8.94 E+0	1.52 E-2	3.80 E-1	9.33 E+0	2.72 E-3	3.10 E-1	0.00	0.00	7.96 E-1	9.91 E-4	1.15 E-3	1.14 E-2	1.60 E-4	-7.81 E+0
ODP	kg CFC11 eq.	1.01 E-4	9.13 E-6	1.37 E-5	1.24 E-4	1.42 E-6	4.33 E-6	0.00	0.00	7.94 E-5	7.73 E-8	6.93 E-7	1.75 E-6	1.88 E-7	-4.53 E-5
AP	mol H+ eq.	8.55 E+0	2.40 E-1	6.94 E-1	9.48 E+0	5.37 E-2	3.11 E-1	0.00	0.00	6.05 E+0	2.93 E-3	1.82 E-2	9.66 E-2	4.24 E-3	-4.13 E+0
EP-freshwater	kg PO4 eq.	4.94 E-2	4.17 E-4	9.47 E-3	5.93 E-2	6.20 E-5	1.92 E-3	0.00	0.00	2.44 E-2	2.12 E-5	3.17 E-5	6.14 E-4	6.06 E-6	-2.55 E-2
EP-marine	kg N eq.	1.22 E+0	8.46 E-2	1.32 E-1	1.44 E+0	1.64 E-2	4.89 E-2	0.00	0.00	1.03 E+0	5.33 E-4	6.41 E-3	1.88 E-2	1.53 E-3	-5.10 E-1
EP-terrestrial	mol N eq.	1.41 E+1	9.32 E-1	1.53 E+0	1.66 E+1	1.81 E-1	5.63 E-1	0.00	0.00	1.21 E+1	6.32 E-3	7.07 E-2	2.12 E-1	1.65 E-2	-6.56 E+0
POCP	kg NMVOC eq.	4.18 E+0	2.66 E-1	4.41 E-1	4.88 E+0	5.07 E-2	1.65 E-1	0.00	0.00	3.16 E+0	1.61 E-3	2.02 E-2	5.93 E-2	4.78 E-3	-1.92 E+0
ADP-minerals & metals	kg Sb eq.	1.07 E-1	1.05 E-3	3.66 E-2	1.45 E-1	1.54 E-4	3.44 E-3	0.00	0.00	2.49 E-2	5.56 E-6	7.95 E-5	4.14 E-4	4.05 E-6	2.42 E-1
ADP-fossil	MJ, net calorific value	1.48 E+4	6.24 E+2	2.87 E+3	1.82 E+4	9.65 E+1	6.04 E+2	0.00	0.00	9.47 E+3	1.85 E+1	4.73 E+1	1.70 E+2	1.31 E+1	-7.28 E+3
WDP	m3 world eq. deprived	3.84 E+2	2.23 E+0	5.10 E+1	4.37 E+2	3.30 E-1	1.39 E+1	0.00	0.00	1.70 E+2	3.32 E-2	1.69 E-1	2.70 E+0	1.33 E-1	-1.26 E+2

GWP-total = Global Warming Potential total
GWP-fossil = Global Warming Potential fossil fuels
GWP-biogenic = Global Warming Potential biogenic
GWP-luluc = Global Warming Potential land use and land use change
ODP = Depletion potential of the stratospheric ozone layer
AP = Acidification Potential, Accumulated Exceedence
EP-freshwater = Eutrophication Potential, fraction of nutrients reaching freshwater end compartment
EP-marine = Eutrophication Potential, fraction of nutrients reaching marine end compartment
EP-terrestrial = Eutrophication Potential, Accumulated Exceedence
POCP = Formation potential of tropospheric ozone photochemical oxidants
ADP-minerals&metals = Abiotic Depletion Potential for non fossil resources [2]
ADP-fossil = Abiotic Depletion for fossil resources potential [2]
WDP = Water (user) deprivation potential, deprivation-weighted water consumption [2]

Disclaimer [2]

- The results of this environmental impact indicator shall be used with care as the uncertainties on these results are high or as there is limited experience with the indicator.

ENVIRONMENTAL IMPACT per functional unit or declared unit (additional indicators A2)

	UNIT	A1	A2	A3	A1-A3	A4	A5	B1	B2	B3	C1	C2	C3	C4	D
PM	Disease incidence	8.08 E-5	3.72 E-6	4.69 E-6	8.92 E-5	5.45 E-7	2.92 E-6	0.00	0.00	5.90 E-5	9.47 E-9	2.82 E-7	1.19 E-6	8.51 E-8	-3.96 E-5
IRP	kBq U235 eq.	5.95 E+1	2.61 E+0	6.84 E+0	6.90 E+1	4.05 E-1	2.53 E+0	0.00	0.00	3.48 E+1	3.06 E-1	1.98 E-1	7.43 E-1	5.56 E-2	-2.59 E+1
ETP-fw	CTUe	3.23 E+4	5.57 E+2	3.66 E+3	3.65 E+4	8.42 E+1	1.33 E+3	0.00	0.00	1.98 E+4	1.17 E+1	4.22 E+1	1.18 E+3	1.29 E+3	-1.53 E+4
HTP-c	CTUh	2.01 E-6	1.81 E-8	1.12 E-7	2.14 E-6	2.99 E-9	7.31 E-8	0.00	0.00	4.31 E-7	2.45 E-10	1.37 E-9	1.92 E-8	2.30 E-10	-1.08 E-6
HTP-nc	CTUh	2.93 E-5	6.09 E-7	2.51 E-6	3.24 E-5	9.05 E-8	1.09 E-6	0.00	0.00	9.57 E-6	8.27 E-9	4.62 E-8	5.54 E-7	7.01 E-9	-9.91 E-6
SQP	---	3.77 E+3	5.41 E+2	2.45 E+3	6.76 E+3	7.73 E+1	2.29 E+2	0.00	0.00	3.66 E+3	1.06 E+1	4.11 E+1	1.61 E+2	2.78 E+1	-1.88 E+3

PM = Potential incidence of disease due to PM emissions
IRP = Potential Human exposure efficiency relative to U235 [1]
ETP-fw = Potential Comparative Toxic Unit for ecosystems [2]
HTP-c = Potential Comparative Toxic Unit for humans [2]
HTP-nc = Potential Comparative Toxic Unit for humans, non-cancer [2]
SQP = Potential soil quality index [2]

Disclaimer [1]

- This impact category deals mainly with the eventual impact of low dose ionizing radiation on human health of the nuclear fuel cycle. It does not consider effects due to possible nuclear accidents, occupational exposure nor due to radioactive waste disposal in underground facilities. Potential ionizing radiation from the soil, from radon and from some construction materials is also not measured by this indicator.

Disclaimer [2]

- The results of this environmental impact indicator shall be used with care as the uncertainties on these results are high or as there is limited experience with the indicator.

RESOURCE USE per functional unit or declared unit (A1 / A2)

	UNIT	A1	A2	A3	A1-A3	A4	A5	B1	B2	B3	C1	C2	C3	C4	D
PERE	MJ	2.88 E+3	7.81 E+0	5.26 E+2	3.42 E+3	1.17 E+0	1.13 E+2	0.00	0.00	7.29 E+2	3.45 E+0	5.93 E-1	4.30 E+0	2.47 E+0	-1.95 E+3
PERM	MJ	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-7.87 E+0
PERT	MJ	2.88 E+3	7.81 E+0	5.27 E+2	3.42 E+3	1.17 E+0	1.14 E+2	0.00	0.00	7.27 E+2	3.45 E+0	5.93 E-1	1.76 E+1	2.56 E-1	-2.04 E+3
PENRE	MJ	1.55 E+4	6.63 E+2	2.88 E+3	1.90 E+4	1.03 E+2	6.22 E+2	0.00	0.00	9.92 E+3	1.95 E+1	5.03 E+1	4.53 E+1	4.65 E+1	-6.58 E+3
PENRM	MJ	2.74 E+2	0.00	2.02 E+2	4.75 E+2	0.00	1.43 E+1	0.00	0.00	2.51 E+2	0.00	0.00	0.00	0.00	-2.65 E+1
PENRT	MJ	1.57 E+4	6.63 E+2	3.08 E+3	1.95 E+4	1.03 E+2	6.45 E+2	0.00	0.00	1.01 E+4	1.95 E+1	5.03 E+1	1.82 E+2	1.39 E+1	-7.77 E+3
SM	kg	2.36 E+1	0.00	2.64 E+0	2.62 E+1	0.00	7.87 E-1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RSF	MJ	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NRSF	MJ	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FW	m3	2.11 E+1	7.60 E-2	2.24 E+0	2.34 E+1	1.12 E-2	7.63 E-1	0.00	0.00	5.61 E+0	3.60 E-3	5.77 E-3	1.32 E-1	1.49 E-2	-1.15 E+1

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

OUTPUT FLOWS AND WASTE CATEGORIES per functional unit or declared unit (A1 / A2)

	UNIT	A1	A2	A3	A1-A3	A4	A5	B1	B2	B3	C1	C2	C3	C4	D
HWD	kg	2.79 E-1	1.58 E-3	1.43 E-1	4.24 E-1	2.31 E-4	2.36 E-2	0.00	0.00	4.73 E-2	1.37 E-5	1.20 E-4	4.27 E-1	1.51 E-5	5.35 E-1
NHWD	kg	2.26 E+2	3.96 E+1	2.09 E+1	2.87 E+2	5.59 E+0	1.41 E+1	0.00	0.00	2.55 E+2	4.93 E-2	3.00 E+0	1.14 E+1	8.62 E+1	-1.40 E+2
RWD	kg	5.73 E-2	4.10 E-3	6.78 E-3	6.82 E-2	6.37 E-4	2.36 E-3	0.00	0.00	3.80 E-2	1.51 E-4	3.11 E-4	8.28 E-4	8.55 E-5	-2.47 E-2
CRU	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MFR	kg	0.00	0.00	1.39 E+1	1.39 E+1	0.00	8.97 E+0	0.00	0.00	2.53 E+2	0.00	0.00	2.60 E+2	0.00	0.00
MER	kg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
EEE	MJ	0.00	0.00	7.30 E+0	7.30 E+0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.07 E+2
ETE	MJ	0.00	0.00	1.26 E+1	1.26 E+1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.84 E+2

HWD = Hazardous Waste Disposed
NHWD = Non Hazardous Waste Disposed
RWD = Radioactive Waste Disposed
CRU = Components for reuse
MFR = Materials for recycling
MER = Materials for energy recovery
EEE = Exported Electrical Energy
ETE = Exported Thermal Energy

BIOGENIC CARBON CONTENT per functional unit or declared unit (A1 / A2)

	UNIT	A1	A2	A3	A1-A3	A4	A5	B1	B2	B3	C1	C2	C3	C4	D
BCCpr	kg C	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BCCpa	kg C	0.00	0.00	5.46 E+0	5.46 E+0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

BCCpr = Biogenic carbon content in product
BCCpa = Biogenic carbon content in packaging

CALCULATION RULES

CUT-OFF CRITERIA

There is no cut-off applied for the inputs or outputs of any of the processes.

TIME PERIOD DATA COLLECTION

Background data is primarily based on EcoInvent 3.6. Foreground data is <2 years and background data <10 years. The data quality is considered to be good.
material quantities: 2022
suppliers: 2019-2021
factory and building site: 2020
emissions: n/a

ALLOCATION

Allocation is applied for recycling at end-of-life of various materials according to EN 15804 rules.

SCENARIOS AND ADDITIONAL TECHNICAL INFORMATION

Life cycle stages A1-A3 (production)

Scheldebouw B.V. produce the curtain wall panels in their factory in Middelburg. The various parts and materials are sourced from various suppliers as semi-finished products, enter the factory and are assembled into a facade panel. After assembly, the facade elements are packed and made ready for transport to the building site together with the brackets and other materials for fixing and/or closure.
Semi-finished products of the suppliers (cradle to supplier gate) are included in stage A1 of this LCA study. The transport movements between suppliers and Scheldebouw are included in stage A2 and all activities in the Scheldebouw assembly location in Middelburg are included in stage A3.
The production stage consists of the extraction of raw materials, transportation of the raw materials, processing the raw materials into sub-components and the assembly of the sub-components into the end-product. The required energy for production, external treatments, ancillary materials, packaging material and production emissions are included.

Average supplier distances (stage A2)	km
Glazing	1000
Aluminium profiles	877
Aluminium sheets	372
Mineral wool	199
Steel sheets	161
Steel brackets	206
Gaskets	390
Fasteners	156
Sealant, incl. primer and cleaner	104
Wooden packaging	7.4
Plastic packaging	0.75

Ancillary materials and packaging (stage A3)	amount
Plastic packaging	3.674 kg
Wooden packaging	10.93 kg
Primer	0.367 kg
Cleaner	0.080 kg

Life cycle stages A4-A5 (construction)

This stage consists of the transport of the product from production plant to the construction site. It also includes the loss of material during construction. The additional needed production, transport and end-of-life treatment of the lost material during construction is included. The end-of-life of packaging material up to the end-of-waste state or disposal of final residues is also included. The energy use for installation of the product is taken into account.

The facade elements are delivered on the building site including fastening and closure materials (floor brackets and fire stop). The facade elements are lifted up with a crane and installed onto the floors of the building. After that, the floor edge detail is completed by applying the fire stop and steel sheets.

The transport movements between Scheldebouw Middelburg and the building site are included in stage A4 and all activities on the building site are included in stage A5.The use of the tower crane is excluded from this LCA, because it is a capital good.

Transport to the construction site consists of the following:

Transport conveyance (stage A4)	Distance	Weight x distance
Lorry (truck): Middelburg-Rotterdam	85 km	
Transoceanic ship: Rotterdam-Purfleet	282 km	
Lorry (truck): Purfleet-London	31 km	
Total:	398 km	147.99 tkm

Life cycle stages B1-B3 (use stage)
This stage consists of the impacts arising from components of the building and construction works during their use. No specific maintenance actions are necessary during the service life to maintain the product in a state in which it can perform its required functional and technical performance, as well as preserve the aesthetic qualities of the product.

The facade consists of various parts with different service lifetimes. During the reference service life (RSL) of the facade (60 years), several parts like glazing, sealants and gaskets need to be replaced. The replacement of these parts has been accounted for in life cycle stage B3.
Product replacement (B4) and renovation (B5) are not considered. Operational water and energy use (B6-7) are not considered.

Life cycle stages C1-C4 (end of life)
When the end of the life stage of the building is reached, the de-construction/demolition begins. This EPD includes de-construction/demolition (C1), the necessary transport (C2) from the demolition site to the sorting location and distance to final disposal. The end of life stage includes the final disposal to landfill (C4), incineration (C3) and needed recycling processes up to the end-of-waste point (C3). Loads and benefits of recycling, re-use and exported energy are part of module D.
The default end-of-life scenarios of the annex (november 2020) to the NMD Determination method v1.0 have been used for the various materials in the product.

Waste scenario	Not removed [%]	Landfill [%]	Incineration [%]	Recycling [%]	Re-use [%]
finishes (adhered to wood, plastic, metal)	0.0	0.0	100.0	0.0	0.0
polyolefines (i.a. pe,pp) (i.a. pipes, foils)	0.0	10.0	85.0	5.0	0.0
wood 'clean', via residue	0.0	10.0	85.0	5.0	0.0
glass (i.a. flat glass)	0.0	30.0	0.0	70.0	0.0
aluminium, wrought alloy for buildings (i.a. profiles, sheets, pipes)	0.0	3.0	3.0	94.0	0.0
plastics, via residue	0.0	20.0	80.0	0.0	0.0
rockwool (insulation)	0.0	85.0	5.0	10.0	0.0

Transport by "Lorry (Truck), unspecified (default) | market group for (GLO)"	distance [km]
Not removed, stays in work	0.0
Landfill	100.0
Incineration	150.0
Recycling	50.0
Re-use	0.0

Life cycle stage D (benefits and loads beyond the system boundary)
This stage contains the potential loads and benefits of recycling and re-use of raw materials/products. The loads contain the needed recycling processes from end-of-waste-point up to the point-of-equivalence of the substituted primary raw material and a load for secondary material that will be lost at the end-of-life stage. The loads and benefits of recycling and reuse are included in this module. The benefits are calculated based on the primary content and the primary equivalent. In addition, the benefits of energy recovery are granted at this stage. The amount of avoided energy is

based on the Lower Heating Values of the materials and the efficiencies of the incinerators as mentioned in the NMD Determination method v1.0 or EcoInvent 3.6 (2019).

DECLARATION OF SVHC

The product does not contain any substances listed in the “Candidate List of Substances of Very High Concern (SVHC) for authorisation” exceeding 0.1% of the weight of the product.

REFERENCES

ISO 14040
ISO 14040:2006-10, Environmental management - Life cycle assessment - Principles and framework; EN ISO 14040:2006

ISO 14044
ISO 14044:2006-10, Environmental management - Life cycle assessment - Requirements and guidelines; EN ISO 14040:2006

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

EN 15804+A2
EN 15804+A2: 2019: Sustainability of construction works – Environmental Product Declarations – Core rules for the product category of construction products

MRPI verification protocol
MRPI®-EPD verification protocol November 2020.v4.0

REMARKS

This declaration is only valid for the specific design of this project and facade type. It is based on Scheldebouw's average supplier distances and processes.