LCA REPORT

ZENIT ITALY

FRAMES AND MOUNTING GRIDS OF THE ZENIT ITALY WIRING ACCESORY RANGE

Contents

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Compliant with ISO 14025:2010 Type III environmental declarations

The PCR review was conducted by an expert panel chaired by Philippe Osset (SOLINNEN)

The content of this PEP cannot be compared with content based on another program.

Independent verification of the declaration and data, according to ISO 14025:2010:

1. Definition of objectives and scope

1.1. Objectives of the study

The aim of this study is to obtain the environmental product declaration through the PEP Ecopassport program of some of the components of the products in the ZENIT ITALY range, frames and mounting grids. During the realization of this declaration, this product range is not on the market yet, so some of the information is taken from the ZENIT range, which the main difference is the change in material of the mounting grid from iron to polycarbonate, and that it is marketed in Spain instead of Italy.

The reason for declaring only these two components is that they are used in several products, changing only the mechanism.

1.2. Target audience

This study is destined at an external level and verified by the PEP Ecopassport program.

For the gathering of most of the necessary data, the stakeholders have played an important role. They have been asked for information that was not available in ABB Niessen.

1.3. The company and its products

Niessen, a company which is part of the ABB group, provides solutions to many technological needs regarding the household area, giving greater energy efficiency through automation solutions. They bring comfort to our homes, as well as security and quality with their innovative designs. Out of all the products designed in 2019, five of them were eco-designed and added in the annex of the AENOR audit certificate of March 2020.

1.4. Critical review

In order to make sure that ISO 14040:2006 and 14044:2006 standards are fulfilled in the realization of the analysis and the data veracity; a verification audit will make a critical review of the whole analysis when complete. This audit will validate that the methodology and the data estimations coincide with the objectives.

1.5. Scope

1.5.1. Description of the product

The products that are being studied are the frames and the mounting grids with 2, 3, 4 and 7 modules.

In general, mounting grids and frames are parts of the wiring accessory catalogue.
They are part of the final wiring accessory products, for mounting socket outlets, switches and additional functions such as USB chargers or multimedia connectors.
These frames and the mounting grids are representative products of the new ZEN-IT wiring accessory range of ABB Niessen. This new range is an extension of the existing modular ZENIT range, for the Italian market.

This general scheme shows a general assembly example of the Zenit range, with the frame, the mounting grid (metallic, not plastic, in the Zenit range) and a socket outlet/switch in this example.

All the products in ZENIT ITALY are produced with the same raw materials, the same manufacturing and distribution processes and same end of life treatments.

Some of the data has been taken from the ZENIT range, such as electricity data.

Table 1. Products included in the PEP

Number of modules	Frames				Mounting grids					TOTAL	
	Ref.	Frame's weight	Packaging's weight	TOTAL (inc. packaging)	Ref.	Grid's weight	Screws	Packaging's weight	TOTAL (inc. packaging)	Excluding packaging	Including packaging
2	Z2271.1	16.07g	7.80g	23.87g	Z2271.9	9.46g	1.69g	10.35g	21.50g	27.22g	45.37g
3	Z2373.1	20.32g	7.80g	28.12g	Z2373.9	14.48g	1.69g	12.43g	28.60g	36.49g	56.71g
4	Z2474.1	22.75g	15.60g	38.35g	Z2474.9	17.45g	1.69g	17.75g	36.89g	41.89g	75.24g
7	Z2777.1	30.38g	31.19g	61.57g	Z2777.9	23.54g	3.38g	24.85g	51.77g	57.30g	113.34g

1.5.1.1. Reference product

As a reference product for this study, the frame and the mounting grid with 3 modules have been taken, considering that all of them are manufactured with the same raw material, the same manufacturing and distribution processes and treated the same way in the end of life stage. The results of the reference product are extrapolated to the rest of the range, with the corresponding extrapolation rules explained in 1.5.1.4.

The reference product is: Z2373.1 for the frame and Z2373.9 for the mounting grid.

1.5.1.2. Functional unit

The functional unit is the reference in which all the raw material, manufacturing processes, use and end of life treatments data regarding the reference product is collected.

The applicable PCR is the one for *electrical switchgear and control gear solutions*, and as the PSR indicates, the frame and the mounting grid are part of the category *unequipped enclosures and cabinets* and the functional unit for this category is:

Protect persons during 20 years against direct contact with live parts and allow control devices in a single enclosure having the following dimensions for the frame 86 x 118 x 4mm, and for the mounting grid 70 x 102 x 19 mm.

The reference lifetime is estimated to be 20 years, and it is represented in the functional unit.

1.5.1.3. Reference flow

The reference product system formed by the 3-module frame and mounting grid weights 3.48E-2kg which, if the screws, the primary, secondary and tertiary packaging are added, the final weight would be 56.71E-3kg.

In the manufacturing stage there is an electricity consumption, as well as a water and compressed air consumption, and auxiliary materials that produce manufacturing waste.

The frame's packaging includes:

- A primary container that weights 99.8g that includes 20 units of frames in it.
- A macro container that weights 730g that includes 13 primary containers in it (260 frames)
- The 25kg pallet in which 24 macro containers are stacked (6240 frames).

The mounting grid's packaging includes:

- A semi-macro container that weights 212g that includes 20 units of mounting grids in it.
- A macro container that weights 730g that includes 20 semi macro containers in it (400 mounting grids).
- The 25kg pallet in which 24 macro containers are stacked (9600 mounting grids).

In the installation stage, two stainless steel screws that weight 8.43E-4kg, are used for the reference product system, the 3-module frame and mounting grid, that produce a waste in the installation stage. They are included in the mounting grid's packaging and it is estimated that no electrical screwdriver is used.

1.5.1.4. Extrapolation rules

Extrapolation rules are necessary so that a lifecycle assessment of a family-product can be made. Thus, an environmental weighting factor is applied to all the capacities covered by the same product range, ZENIT ITALY. These weighting factors of extrapolation rules are given at the scale of the functional unit.

To extrapolate the product under consideration and calculate the value of each impact-category for each lifecycle stage, the value of the impact category of the reference product must be multiplied by its extrapolation coefficient.

Table 2. Extrapolation rules

STAGE	Manufacturing	Distribution	Installation	Use	End of life
Reference product	1	1	1	-	1
Extrapolation rule	$Coef_{mass(product+screws)}$	$Coef_{mass(product+screws+packaging)}$	$Coef_{mass(packaging)}$	-	$Coef_{mass(product+screws)}$

$$Coef_{mass(n)}=\frac{m_i}{m_{ref}}$$

Where “m” means mass and “i” the nominal current value. The “ref” corresponds to the reference product.

The “n” refers to either the mass of the product and the corresponding screws, the mass of the packaging, or the addition of both.

The extrapolation coefficients calculated for each product in the range are the following:

Table 3. Extrapolation coefficients

Model	**$Coef_{mass(product)}$**	$Coef_{mass(product+packaging)}$	$Coef_{mass(packaging)}$
2M system	0.75	0.80	0.90
3M system	1.00	1.00	1.00
4M system	1.15	1.33	1.65
7M system	1.57	2.00	2.77

It is considered the different coefficient values, one taking the mass of only the product and the screws (the screws only have an impact in the mounting grid) for the manufacturing and end of life stage; another one adding the mass of the product, the screws and the corresponding packaging weight for the distribution stage; and for the installation stage only considering the packaging weight.

1.5.2. Description of raw materials used in the product

As for the reference product, for the frame’s manufacturing, just polycarbonate is used (20.32g), a thermoplastic that presents a high stiffness and a good thermal insulation.

For the mounting grid, the polycarbonate has been reinforced with a 10% of glass fiber, so it has a greater resistance, as the component is exposed to electrical charges. (14.48g)

The 3-module system weights 34.8g, with a 58.4% of polycarbonate and 41.6% reinforced polycarbonate.

Adding the screws and the primary, secondary and tertiary packaging, the weight of the analyzed system would be 56.71g.

Table 4. Percentage of materials in the reference product

Material	**Quantity**	**Unit**	**%**
Cardboard	20.22	g	35.7%
PC	20.32	g	35.8%
PC+GF	14.48	g	25.5%
Steel	1.69	g	3.0%

The attachment points vary with the number of modules, and for the 3-module system 2 steel screws are needed. The number of screws only affect the mounting grid, as it is the one that is attached to the wall. The frame and the mounting grid are joined without the need of additional objects.

1.5.3. Stages of the product

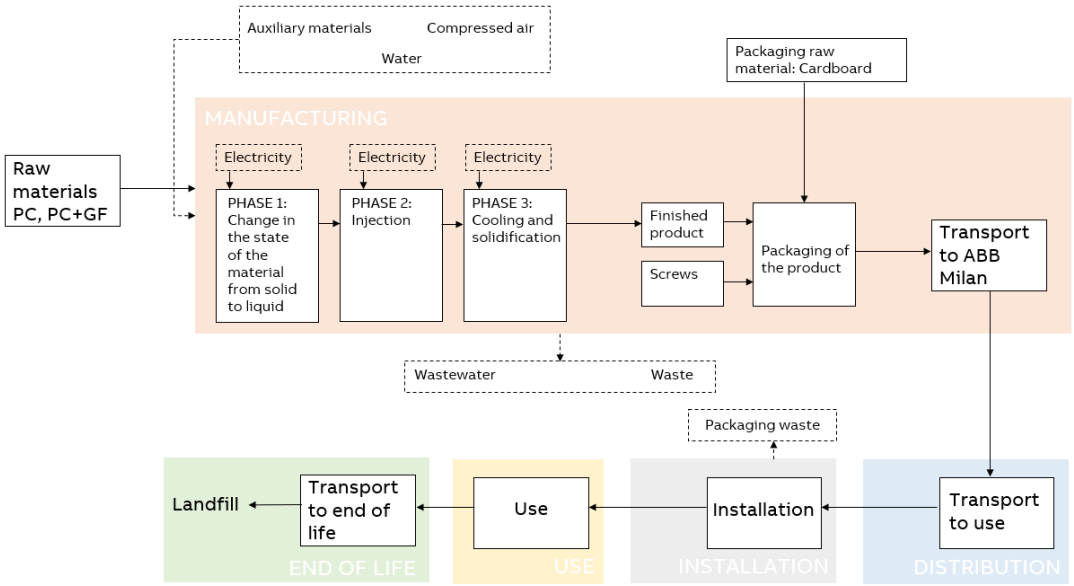

Figure 1. Flowchart representing every lifecycle stage

1.5.4. System limits

The system limits determine the processes included in the study, and the ones that are out of the analysis.

In this case, those processes included in the lifecycle “from gate to grave” are considered:

-Manufacturing stage. The extraction of natural resources to product and packaging manufacturing and their delivery to the manufacturer’s last logistic platform.

-Distribution stage. Transportation from the last manufacturer’s logistics platform to the arrival of the product at the place of use.

-Installation stage. Installation of the product in the place of use.

-Use stage. Use of the product and its maintenance necessary to ensure the ability for use. In the case of this PEP, the use stage has been considered to have no impact.

-End-of-life stage. Removal dismantle and transportation of the end-of-life product to a treatment center or landfill site, and the end-of-life treatment.

As the PCR indicates, these processes are excluded:

-Lighting, heating, sanitary facilities and infrastructure cleaning.

-Employee transport.

-Manufacture and maintenance of the manufacturing facility and machines if they are not proportional to the reference flow.

-Construction and maintenance of the infrastructure if they are not proportional to the reference flow.

-Transport systems and infrastructures if they are not proportional to the reference flow.

-Administrative, management and R&D department flows.

-Marketing activity related to the product.

-Staff catering facilities.

-The packaging of raw material or the packaging of components used to manufacture the product.

The following processes are also excluded:

-Clipping.

-Screwing.

-Parts fitting.

In the transportation, the following are included:

-The transportation of raw materials to the manufacturing site.

-The transportation from the last manufacturing site in Oyarzun, Spain to ABB in Milan.

-The transportation from ABB in Milan to the rest of Italy.

-The transportation to the end of life.

1.5.5. Data quality (primary, secondary and tertiary data)

According to the PCR and the ISO 14044, the data quality shall address the following:

-Time-related coverage. Degree to which the data set reflects the true population of interest regarding time or age of the data, including the background data sets, if any. The data used in the manufacturing processes were obtained in the year 2019, so they represent the system analyzed.

-Geographical coverage. Degree to which the data set reflects the true population of interest regarding geography, including the background data sets, if any.
Every energy, water or auxiliary material consumption have been taken from annual records of the Niessen factory in Oyarzun, so they represent geographically the system analyzed. For the consumption of compressed air, secondary data has been taken, with European coverage.

-Technology coverage. Degree to which the data set reflects the true population of interest regarding technology, including the background data sets, if any. The weight of each component has been taken from the 3D modelling software, Creo Parametric, which indicates the density and the exact quantity of the material used. The number of units per hour and the manufacturing processes obey to the technologies used in the factory.

-Precision. Measure of the variability of the data values for each data expressed. The analysis complies with the precision requirements.

-Completeness. Share of (elementary) flows that are quantitatively included in the inventory. Note that for product and waste flows need to be judged on a system's level.

-Representativeness. The data and indicators used are representative of the activity.

-Consistency. The applied LCI methods and methodological choices are in line with the goal and scope of the data set, especially its intended applications and decision mounting grid context. The methods also have been consistently applied across all data including for included processes, if any. The data that was not available, have been assigned or estimated by the PCR.

In addition to the Program requirements mentioned above, secondary data has been selected from one of the sources below, in descending order of priority:
1. LCI datasets that have been checked by independent experts attesting to their conformity with this PCR
2. LCI datasets that have been checked by the PEP developer attesting to their conformity with the PCR
3. LCI datasets based on LCA studies compliant with ISO 14040 and 14044 standards or any other reference document referring to these standards and independently verified.
4. LCI datasets that have been pre-checked by the data supplier attesting to their conformity with this PCR
5. LCI datasets with no proof of verification. In this case, the LCA report shall justify the selection of this dataset.

Following a method that consists on listing every data gathered during the realization of the PEP and quantifying them with numbers from 1 to 5, being 1 very good and 5 very bad, considering the time-related coverage, the geographical coverage, the technology coverage, the precision, the completeness and the representativeness. Then, doing the average of every data, the result is a quantitative quality data, which in this case is 2.7, which is a good result.

Data quality	**Method**
Time-related coverage	The indicators used in SimaPro 9.1 are representative of previous years, so the points given are between 2 and 3.
Geographical coverage	The indicators used in SimaPro 9.1 that are representative of the factory in Oyarzun have been given 1 point, the ones representative of Spain (ES) 2 points, Europe (RER) 3 points and the world (RoW) 4 or 5 points.
Technology coverage	The indicators used in SimaPro 9.1 are from the Ecoinvent 3.6 library. Moreover, the indicator used for the transportations by lorry cover the EURO 0,1,2,3 and 4.
Precision	The data assigned or estimated have been given more points.
Completeness	All the data have been given 1 or 2 points, as they all are included in the lifecycle analysis.
Representativeness	The data estimated and the transport indicators are not as representative, so they have been given 3 or 4 points.

The secondary data (primary data that has been assigned to the functional unit) are:
- The electricity consumed in the factory, which has been obtained knowing the power of the machines used and the corresponding units per hour. This information has been assigned to the functional unit.
- The manufacturing waste, assigned for each unit.
- The auxiliary materials, assigned for each unit.

The tertiary data, estimated or taken from another indicator are:
- The transportations which distance is unknown, have been estimated with what the PCR states, 1000km for local transports by lorry.
- End of life unknown treatment indicators that have been used are the ones that the PCR states, the ones from the ELCD library.

- Electricity used in the extraction of river water have been taken from an existing indicator in the Ecoinvent 3.6 library.
- The electricity used in the air compressor, taken from an existing indicator in the Ecoinvent 3.6 library.

1.5.6. Cut-off criteria

As mentioned in the PCR, the cut-off criteria applied by default for each stage is:

-The mass of intermediate flows not taken into account shall be less than or equal to 5% of the mass (less than or equal to 2.94g)

-The energy flows not taken into account shall be less than or equal to 5% of the total use of primary energy during the lifecycle of the reference product corresponding to the functional unit, the 3-module system.

For this lifecycle analysis the flows that have been excluded are:

- the ink of the plastic used for the frames, as the information was not available because the plastic comes painted from the supplier, and its weight is less than 2.94g. Moreover, these paintings are water-based paints, which means that no toxic element is being excluded.
- the labels, as the weight is less than the 5% of the total mass, a 3% in the case of the mounting grid and a 2% in the case of the frame.
- the process of logistics, which is a robot that has a consumption that for each reference product system is less than the 5% of the total electrical consumption. (8kWh/1973 references sold= 0.004kWh/unit)
- the prize of the screws (0.0043€), which is negligible compared with the total prize of the system (0.8€)
- the cleaning processes and products used during its useful life.
- Manufacture and maintenance of the machinery used.

1.5.7. Estimations

The estimations made during the realization of the lifecycle assessment have been on the data that was not available or reliable. In that case, it was either considered what the PCR indicates, or information taken from existing Ecoinvent 3.6 indicators.

The estimated data have been:

-The transportation to the place of use, from ABB in Milan to the rest of Italy.

-The transportation to end-of-life of the product and the packaging.

-The end-of-life treatment of the final product and packaging.

-The transportation of the screws from the supplier’s warehouse to ABB Niessen.

-The transportation of auxiliary materials to ABB Niessen in Oyarzun.

-The extraction of river water.

-Electricity consumption of the air compressor.

The distribution data has been calculated with Google Maps, knowing the exact origin, destination and transport method, the 32T lorry. The unknown distances have been considered 1000km by lorry, being a local transport, as estimated by the PCR.

The end-of-life treatment is not available either so as the PCR states, is considered a 1000km drive by lorry to the plastic landfill for the frame and mounting grid, inert waste landfill for the packaging and metal landfill for the screws.

For the water drawn from the river, it is known the volume of the water and it has been considered as a natural flow, to which an electrical consumption from the Ecoinvent 3.6 indicator "Tap water {Europe without Switzerland}| tap water production, underground water without treatment | Cut-off, U" has been added.

To estimate the consumption of air compressors, knowing that the pressure varies within 6.8 and 7.04 bars, the electricity consumption has been estimated in kWh/m^3 equivalent to the one in the Ecoinvent 3.6 indicator "Compressed air, 700 kPa gauge {RER}| compressed air production, 700 kPa gauge, >30kW, average generation | Cut-off, U". The m^3 have been calculated with the number of units per hour that use the compressor, and the average flow per hour.

For the electricity consumption in the injection molding it has been considered that the consumption is derived from the power of the machinery and the units per hour.

1.5.8. Allocation rules

In those cases that the specific consumptions per unit were not available, like the water consumption or the waste generated in the factory, a monetary or physical assignation rule have been made.

For the monetary assignations made, it has been considered the total price of the reference system, 3-module frame and mounting grid, (0.77€) regarding the total income of the factory in 2019 (27.4M€).

- For the packaging, a physical assignation has been made for both, the primary and secondary packaging, dividing the weight of the container by the units in it.
- For the pallet, is has been considered a 25kg pallet and 25 uses in total. Knowing the boxes stacked in each, it has been physically assigned as well for each unit of frame and mounting grid.
- For the electrical consumption, knowing the power of the machines and the units per hour, the kWh per unit have been calculated.

2. Life cycle inventory

2.1. Manufacturing stage

2.1.1. Raw material

Concept	Quantity	Unit	Reference flow	Comment	Indicators (1) Ecoinvent 3.6 (2) ELCD	Calculation method	Data origin
PC+GF	1.45E-2	kg	1 reference product (3 module frame and mounting grid)	Mounting grid's raw material.	Polycarbonate {RER}| production | Cut-off, S[(1)] Glass fiber {RER}| production | Cut-off, S[(1)]		Weight given by the 3D modelling software, Creo Parametric. 10% of the total weight is glass fibre.
PC	2.03E-2	kg		Frame's raw material. The quantity of material used is reconditioned in order to have less waste.	Polycarbonate {RER}| production | Cut-off, S[(1)]		Weight given by the 3D modelling software, Creo Parametric.
Stainless steel	1.69E-3	kg		2 Screws' raw material. One screw weight 0.8431E-3kg.	Steel, chromium steel 18/8 {GLO}| market for | Cut-off, S[(1)] Forging, steel {RoW}| forging, steel, large open die | Cut-off, S[(1)]	2 screws of 0.8431E-3kg makes 1.69E-3kg of material.	Weight given by the inventory software, SAP.

It refers to the attributable inventory of one functional unit of the reference product, a 3-module frame and mounting grid, that includes the packaging.

2.1.2. Packaging's raw material

Concept	Quantity	Unit	Reference flow	Comment	Indicators (1) Ecoinvent 3.6 (2) ELCD	Calculation method	Data origin
Cardboard	4.99E-3	kg		Frame's primary packaging. 99.8g box which includes 20 frames.	Core board {RER}| production | Cut-off, S[(1)]	99.8g divided into 20 frames	Weight given by the inventory software, SAP.
Cardboard	2.81E-3	kg		Frame's secondary packaging. 730g macro container which includes 13 primary packaging (260 frames).	Corrugated board box {RER}| production | Cut-off, S[(1)]	730g divided into 260 frames	Weight given by the inventory software, SAP.
Pallet	1.60E-4	kg	1 reference product (3 module frame and mounting grid)	25 uses, 25kg. Each pallet includes 24 macro containers of frames (6240 units)	EUR-flat pallet {RER}| production | Cut-off, S[(1)]	The indicator's pallet is 25kg and is estimated to be used 25 times, which makes it 1kg per use. Dividing that value by 6240 units, it is 1.6E-4kg of pallet per unit of frame.	Weight estimated for the common pallet.
Cardboard	10.60E-3	kg		Mounting grid's primary packaging. 212g box which includes 20 mounting grids.	Core board {RER}| production | Cut-off, S[(1)]	212g divided into 20 mounting grids	Weight given by the inventory software, SAP.
Cardboard	1.83E-3	kg		Mounting grid's secondary packaging. 730g macro container that includes 400 mounting grids.	Corrugated board box {RER}| production | Cut-off, S[(1)]	730g divided into 400 mounting grids	Weight given by the inventory software, SAP.

Pallet	1.04E-4	kg	25 uses, 25kg. Each pallet includes 24 macro containers of mounting grids. (9600 units)	EUR-flat pallet {RER}| production | Cut-off, S[1]	The indicator's pallet is 25kg and is estimated to be used 25 times, which makes it 1kg per use. Dividing that value by 9600 units, it is 1.04E-4kg of pallet per unit of frame.	Weight estimated for the common pallet.

It refers to the attributable inventory of one functional unit of the reference product, a 3-module frame and mounting grid, that includes the packaging.

2.1.3. Transport of raw materials

Concept	Quantity	Unit	Reference flow	Comment	Indicators (1) Ecoinvent 3.6 (2) ELCD	Calculation method	Data origin
Transport of raw material from the suppliers' warehouse	1305	km	1 reference product (3 module frame and mounting grid)	Mitsubishi in Dusseldorf to ABB Niessen in Oyarzun. Both components come from the same supplier.	Articulated lorry transport, Euro 0, 1, 2, 3, 4 mix, 40 t total weight, 27 t max payload RER S[2]	Among the different plastic suppliers in Niessen, the worst-case scenario has been taken. The data must be given in tkm, so the kg of material is converted to tons and multiplied by 1000km.	Knowing the exact origin and destination, the distance has been calculated with Google Maps knowing that the transportation method is a lorry.

Transport of packaging- from the packaging suppliers' warehouse	32.4 km	1 reference product (3 module frame and mounting grid)	Transport from the packaging supplier. Cartonajes Limousin in Usabal to ABB Niessen in Oyarzun	Articulated lorry transport, Euro 0, 1, 2, 3, 4 mix, 40 t total weight, 27 t max payload RER S[(2)]	The data must be given in tkm, so the kg of material is converted to tons and multiplied by the 1000km.	Knowing the exact origin and destination, the distance has been calculated with Google Maps knowing that the transportation method is a lorry.
Transport of the screws from the supplier's warehouse	1570 km	1 reference product (3 module frame and mounting grid)	Vi.S.AF in Serra de Conti, Italy to ABB Niessen in Oyarzun	Articulated lorry transport, Euro 0, 1, 2, 3, 4 mix, 40 t total weight, 27 t max payload RER S[(2)]	The data must be given in tkm, so the kg of material is converted to tons and multiplied by the 1000km.	Knowing the exact origin and destination, the distance has been calculated with Google Maps knowing that the transportation method is a lorry.

It refers to the attributable inventory of one functional unit of the reference product, a 3-module frame and mounting grid, that includes the packaging.

2.1.4. Energy consumption

Concept	Quantity	Unit	Reference flow	Comment	Indicators (1) Ecoinvent 3.6 (2) ELCD	Calculation method	Data origin
Phase 1: change in the state of the plastic from solid to liquid.	7.03E-03	kWh	1 reference product (3 module frame and mounting grid)	Energy consumption of the manufacturing processes	Electricity grid mix, AC, consumption mix, at consumer, 230V ES S[(2)]	The power of the machine in kWh (2.53 kWh) and the number of pieces per hour (360 p/h) known. Dividing both, the result is the kWh per piece. This process is the same for both, the frame and the mounting grid, which means that the kWh calculated previously must be multiplied by 2 to have the amount for the whole reference product system	The information of the power of the machine, as well as the number of units per hour, have been given by the company.
Phase 2: Injection	8.64E-03	kWh			Electricity grid mix, AC, consumption mix, at consumer, 230V ES S[(2)]	The power of the machine in kWh (3.11 kWh) and the number of pieces per hour (360 p/h) known. Dividing both, the result is the kWh per piece. This process is the same for both, the frame and the mounting grid, which means that the kWh calculated previously must be multiplied by 2 to have the amount for the whole reference product system	The information of the power of the machine, as well as the number of units per hour, have been given by the company.

Phase 3: cooling and solidification	8.58E-03 kWh		Electricity grid mix, AC, consumption mix, at consumer, 230V ES S[(2)]	The power of the machine in kWh (3.09 kWh) and the number of pieces per hour (360 p/h) known. Dividing both, the result is the kWh per piece. This process is the same for both, the frame and the mounting grid, which means that the kWh calculated previously must be multiplied by 2 to have the amount for the whole reference product system	The information of the power of the machine, as well as the number of units per hour, have been given by the company.
Air compressor	3.44E-1 kWh	Energy consumption of the air compressor	Electricity grid mix, AC, consumption mix, at consumer, 230V ES S[(2)]	Data calculated for each unit of frame and mounting grid: $\frac{1h}{360\ units} \cdot \frac{582\ m^3}{1h} \cdot \frac{0.21285714\ kWh}{1\ m^3} = 0.344$ kWh/unit	The information of the quantity of compressed air has been given by the company, being calculated the average liters per minute: From 6AM to 10PM, 12600l/min; from 10PM to 6AM, 3900l/min. 0.21285714 kWh electricity taken from the indicator Compressed air, 700 kPa gauge {RER}| compressed air production, 700 kPa gauge, >30kW, average generation | Cut-off, U

		Being the pressure of the air compressor used in the company 680 kPa.

It refers to the attributable inventory of one functional unit of the reference product, a 3-module frame and mounting grid, that includes the packaging.

2.1.5. Water and auxiliary materials consumption

Concept	Quantity	Unit	Reference flow	Comment	Indicators (1) Ecoinvent 3.6 (2) ELCD	Assignation	Data origin
Water	1.39E-04	m^3	1 reference product (3 module frame and mounting grid)	Estimated indicator The water used for the manufacturing is taken from the river	Water, river, ES (1)	The data given is for the whole factory (4952 m^3), so in order to have it assigned for each unit, a monetary assignation has been made considering that the total income in 2019 was 27.4M€ and the prize of the system (frame + mounting grid) 0.77€. With this assignation, for each reference product, the consumption of water is 8.86E-5 m^3	The information of the quantity of water, which is extracted from the river, was taken from the "Quality System and Environment Act 2019" document. The prize of the system was taken from the inventory software, SAP.
Diesel for the water extraction	1.49E-05	MJ		Estimated consumption of diesel in the extraction of 1kg of water	Diesel, burned in building machine {GLO}| processing | Cut-off, S(1)	The data is given for 1kg of water, then it is physically assigned for the corresponding quantity of water.	Information taken from the indicator Tap water {Europe without Switzerland}| tap water production, underground water without treatment | Cut-off, U

Electricity for the extraction of water	3.99E-04	kWh	Energy consumption during the extraction of 1kg of water	Electricity grid mix, AC, consumption mix, at consumer, 230V ES S[2]	Data estimated	Electricity taken from the indicator Tap water {Europe without Switzerland}| tap water production, underground water without treatment | Cut-off, U
PP	5.61E-07	kg	Plastic containers containing hazardous waste	Polypropylene, granulate {RER}| production | Cut-off, S [1] Injection moulding {RER}| processing | Cut-off, S[1]	The plastic containers that contain hazardous waste, the percentage of hazardous waste is unknown, so it is estimated that this plastic containers are PP. To assign the quantity of the whole factory (20 kg) the same monetary assignation has been made.	The information available in the company was the list of materials that go to waste in the factory. From this list, the auxiliary materials have been assumed.
Steel	2.75E-06	kg	Empty metallic containers	Steel, low-alloyed, hot rolled {RER}| production | Cut-off, S[1] Sheet rolling, steel {RER}| processing | Cut-off, S[1]	Another material in the list of waste was empty metallic containers, and they have been assumed to be steel. For this assignation of 98kg of the whole factory, the same monetary assignation has been made.	The information available in the company was the list of materials that go to waste in the factory. From this list, the auxiliary materials have been assumed.

It refers to the attributable inventory of one functional unit of the reference product, a 3-module frame and mounting grid, that includes the packaging.

2.1.6. Transport of auxiliary materials

Concept	Quantity	Unit	Reference flow	Comment	Indicators (1) Ecoinvent 3.6 (2) ELCD	Calculation method	Data origin
Transport from the supplier's warehouse	1000	km	1 reference product (3 module frame and mounting grid)	Estimation according to PCR	Articulated lorry transport, Euro 0, 1, 2, 3, 4 mix, 40 t total weight, 27 t max payload RER S[(2)]	It is estimated to be transported 98kg of empty metallic containers and 20kg of plastic containers, 118kg in total. The data must be given in tkm, so the kg of material is converted to tons and multiplied by the 1000km.	The distance from the auxiliary material supplier's warehouse to ABB Niessen was unknown, so the distance that the PCR states for local transport by lorry is 1000km.

It refers to the attributable inventory of one functional unit of the reference product, a 3-module frame and mounting grid, that includes the packaging.

2.1.7. Transportation to end-of-life of the manufacturing waste

Concept	Quantity	Unit	Reference flow	Comment	Indicators (1) Ecoinvent 3.6 (2) ELCD	Calculation method	Data origin

Transport to end of life of the manufacturing waste	124	km	1 reference product (3 module frame and mounting grid)	ABB Niessen- Ekonor Zierbena, Bizkaia	FCC	Articulated lorry transport, Euro 0, 1, 2, 3, 4 mix, 40 t total weight, 27 t max payload RER S[(2)]	It is estimated to be transported 98kg of empty metallic containers and 20kg of plastic containers, 413kg of laboratory waste and 759kg of impregnated materials, as well as 493kg of water with oil and 705kg of alkaline waters, which are estimated to count only as outputs. The data must be given in tkm, so the kg of material is converted to tons and multiplied by 1000km.	Knowing the exact origin and destination, the distance has been calculated with Google Maps knowing that the transportation method is a lorry.

It refers to the attributable inventory of one functional unit of the reference product, a 3-module frame and mounting grid, that includes the packaging.

2.1.8. End of life of the manufacturing waste

It refers to the attributable inventory of one functional unit of the reference product, a 3-module frame and mounting grid, that includes the packaging.

Concept	Quantity	Unit	Reference flow	Comment	Indicators (1) Ecoinvent 3.6 (2) ELCD	Assignation	Data origin
Hazardous waste treatment	2.39E+03	kg	1 reference product (3 module frame and mounting grid)		Hazardous waste, for underground deposit {DE}| treatment of hazardous waste, underground deposit | Cut-off, S[(1)]	The manufacturing waste that has been treated as hazardous have been: 20kg of plastic containers, 759kg of impregnated materials, 413kg of laboratory waste, 493kg of water with oils and 705kg of water alkaline. This amount is then assigned monetarily.	The information available in the company was the list of hazardous waste available in the company
Metallic waste treatment	98	kg			Scrap steel {Europe without Switzerland}| treatment of scrap steel, inert material landfill | Cut-off, S[(1)]	The 98kg of metallic packaging from the list of manufacturing waste. This amount is then assigned monetarily.	The information available in the company was the list of hazardous waste available in the company

Wastewater treatment	1.33E+03	kg		Wastewater, average {Europe without Switzerland}| treatment of wastewater, average, capacity 1E9l/year | Cut-off, S[(1)]	Input water= alkaline water + water with oil + wastewater. So, Wastewater= input water-alkaline water-water with oil. Knowing that there is 705kg of alkaline water, 493kg of water with oil and the input water is 1329kg, the wastewater is 1330kg in total. This amount is then assigned monetarily.	The information available in the company was the list of hazardous waste available in the company

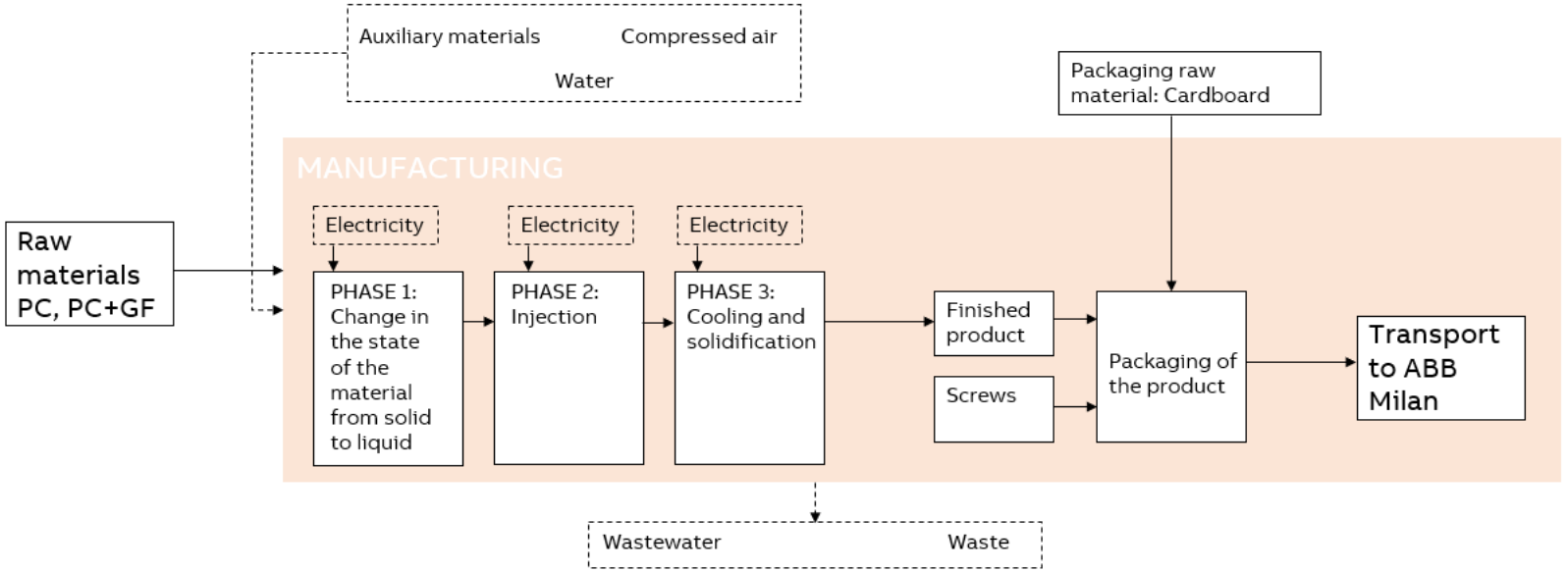

Figure 2. Flowchart of the manufacturing stage

2.1.9. Transport to the last manufacturer's logistic platform

It refers to the attributable inventory of one functional unit of the reference product, a 3-module frame and mounting grid, that includes the packaging.

Concept	Quantity	Unit	Reference flow	Comment	Indicators (3) Ecoinvent 3.6 (4) ELCD	Assignation	Data origin
Transport to ABB in Milan	1241	km	1 reference product (3 module frame and mounting grid)	From ABB Niessen in Oyarzun to ABB in Milan.	Articulated lorry transport, Euro 0, 1, 2, 3, 4 mix, 40 t total weight, 27 t max payload RER S[(2)]	The data must be given in tkm, so the kg of material is converted to tons and multiplied by the 1000km.	Knowing the exact origin and destination, the distance has been calculated with Google Maps knowing that the transportation method is a lorry.

2.2. Distribution stage

Concept	Quantity	Unit	Reference flow	Comment	Indicators (1) Ecoinvent 3.6 (2) ELCD	Calculation method	Data origin
Transport from ABB Milan to the rest of Italy	1000	km	1 reference product (3 module frame and mounting grid)	Estimated data with the PCR (local transport by lorry)	Articulated lorry transport, Euro 0, 1, 2, 3, 4 mix, 40 t total weight, 27 t max payload RER S[(2)]	The data must be given in tkm, so the kg of material is converted to tons and multiplied by the 1000km.	The distance from ABB Milan to the rest of Italy has been estimated with what the PCR states for local transport by lorry is 1000km.

It refers to the attributable inventory of one functional unit of the reference product, a 3-module frame and mounting grid, that includes the packaging.

2.3. Installation stage

Concept	Quantity	Unit	Reference flow	Comment	Indicators (1) Ecoinvent 3.6 (2) ELCD	Calculation method	Data origin
End of life of the packaging: Inert waste landfill	2.03E-02	kg	1 reference product (3 module frame and mounting grid)	End of life of the packaging	Landfill of glass/inert waste EU-27[(2)]	In the installation is considered only the end of life of the packaging.	The treatment is unknown, so it is estimated to be what the PCR states for inert waste end of life treatment

Transport to end of life of the packaging	1000	km		Unknown distance to end of life, so estimated.	Articulated lorry transport, Euro 0, 1, 2, 3, 4 mix, 40 t total weight, 27 t max payload RER S[(2)]	The transport to end of life of the packaging has an unknown distance, so it is estimated what the PCR states, 1000km by lorry. The data must be given in tkm, so the kg of material is converted to tons and multiplied by the 1000km.	The distance from the installation site to the end of life treatment site has been estimated with what the PCR states for local transport by lorry, 1000km.

It refers to the attributable inventory of one functional unit of the reference product, a 3-module frame and mounting grid, that includes the packaging.

It is estimated that no electrical screwdriver has been used for the installation.

It is considered that the end of life of the pallet occurs in the installation stage, as it can be attributable.

2.4. Use stage

No consumption is considered.

2.5. End of life stage

Concept	Quantity	Unit	Reference flow	Comment	Indicators **(1) Ecoinvent 3.6** **(2) ELCD**	Calculation method	Data origin
Plastic landfill	3.48E-02	kg	1 reference product (3 module frame and mounting grid)	End of life of the PC	Landfill of plastic waste EU-27 [(2)]	3.48E-2 is the weight of the system of frame and mounting grid.	The end of life treatment for the product is unknown, so it is estimated to be what the PCR states for plastic end of life treatment

Metal landfill	1.69E-3	kg	End of life of the screws	Landfill of ferro metals EU-27[(2)]	1.69E-3 is the weight of the two screws.	The end of life treatment for the screws is unknown, so it is estimated to be what the PCR states for metals' end of life treatment
Transport to end of life	1000	km	Estimated with PCR	Articulated lorry transport, Euro 0, 1, 2, 3, 4 mix, 40 t total weight, 27 t max payload RER S[(2)]	The data must be given in tkm, so the kg of material is converted to tons and multiplied by the 1000km.	The distance is unknown, so it is taken what the PCR estimates for the transport to end of life.

It refers to the attributable inventory of one functional unit of the reference product, a 3-module frame and mounting grid, that includes the packaging.

3. Environmental impacts

3.1. Evaluation methodology

The methodology used for the evaluation of the mandatory indicators is CML-IA baseline version 4.2, as it complies with the unit and parameters required in the PCR. This method had to be constructed with the tables available in the Appendix A of the PCR.

For the resource use indicators, the “Cumulative energy demand” and “Hoekstra et al 2012 (Water scarcity) V1.02” methodologies have been used; and for the waste category indicators, the “EDIP 2003” methodology.

The database used are:

-Ecoinvent 3.6

-ELCD database (where the PCR required it)

3.2. LCA software

The software used for the realization of this lifecycle assessment is SimaPro, version 8.5.

3.3. Summary of impacts

This calculation is representative of the reference product system, the 3-module frame and mounting grid. For the other modules, the results must be multiplied by the extrapolation rules in 1.5.1.4 Extrapolation rules.

	Total for lifecycle		Raw material and manufacturing	Distribution	Installation	Use	End of life
Global warming	3.74E-01	kg CO2 eq.	3.65E-01	2.82E-03	1.26E-03	0.00E+00	4.28E-03
Ozone depletion	8.06E-09	kg CFC-11 eq.	7.94E-09	5.72E-12	8.57E-12	0.00E+00	1.07E-10
Acidification of soils and water	1.42E-03	kg SO2 eq.	1.38E-03	1.27E-05	6.16E-06	0.00E+00	1.64E-05
Water eutrophication	2.90E-04	kg (PO4)3- eq.	2.61E-04	2.90E-06	6.62E-06	0.00E+00	1.87E-05
Photochemical ozone formation	9.06E-05	kg C2H4 eq.	8.80E-05	9.01E-07	4.34E-07	0.00E+00	1.28E-06
Depletion of abiotic resources - elements	1.59E-06	kg Sb eq.	1.59E-06	1.12E-10	5.38E-11	0.00E+00	2.64E-10
Depletion of abiotic resources – fossil fuels	5.26E+00	MJ	5.14E+00	3.97E-02	1.75E-02	0.00E+00	6.10E-02

Water pollution	2.15E-01	m3	2.07E-01	1.53E-05	6.81E-05	0.00E+00	7.73E-03
Air pollution	4.03E+00	m3	3.87E+00	4.08E-02	2.45E-02	0.00E+00	8.94E-02

Regarding the category of *Depletion of abiotic resources – fossil fuels,* following the methodology that the PCR-ed3-EN-2015 04 02 indicates, the impact of every stage except for the raw material inside the manufacturing stage was zero, even if it included transport in it. That is why the energy substances were added to the calculation method so it gave more realistic results.

4. Other indicators

4.1. Inventory flow indicators

Table 5. Inventory flow indicators

	Total for lifecycle		Raw material and manufacturing	Distribution	Installation	Use	End of life
Total use of primary energy	9.76E+00	MJ	9.63E+00	4.24E-02	1.89E-02	0.00E+00	7.00E-02
Net use of fresh water	1.34E-02	m^3	1.34E-02	-6.22E-07	-1.05E-05	0.00E+00	-3.70E-05
Primary renewable energy resources used as energy carrier	3.90E+00	MJ	3.89E+00	4.51E-05	4.70E-05	0.00E+00	3.87E-04
Primary renewable energy resources used as raw materials	3.39E-01	MJ	3.39E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total use of primary resources- renewable	4.23E+00	MJ	4.23E+00	4.51E-05	4.70E-05	0.00E+00	3.87E-04
Primary non-renewable energy resources used as energy carrier	4.49E+00	MJ	4.36E+00	4.23E-02	1.89E-02	0.00E+00	6.96E-02
Primary non-renewable energy resources used as raw materials	1.04E+00	MJ	1.04E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Total use of primary resources- non-renewable	5.53E+00 MJ	5.40E+00	4.23E-02	1.89E-02	0.00E+00	6.96E-02
Secondary materials	4.12E-03 kg	4.12E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Renewable secondary fuels	0.00E+00 MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Non-renewable secondary fuels	0.00E+00 MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

For the calculation of the total use of primary energy during the lifecycle, the evaluation method “Cumulative energy demand” has been used, and for the net fresh water used the method “Hoekstra et al 2012 (Water scarcity) V1.02”. For the rest of the inventory indicators, the total use of resources (renewable and non-renewable) are calculated with “Cumulative energy demand”, and for the resources used as raw materials, the kg of PC are transferred to MJ using the heating value of the material (29.78 MJ/kg for the PC, 4.87E-06 MJ for the wood in the pallet, 0.34 MJ for the cardboard) and multiplying that value by the total weight of PC (0.0348kg). The resources used as energy carrier, are estimated to be the difference between the total use of resources and the resources used as raw materials.

The result of the secondary materials in the manufacturing stage is due to the percentage of recycled material in each indicator used both in the packaging and in the steel for the screws and secondary fuels is zero because there is no recovered raw material or combustible used.

4.2. Waste category indicators

	Total for lifecycle	Raw material and manufacturing	Distribution	Installation	Use	End of life
Hazardous waste disposed	5.24E-04 kg	5.22E-04	3.51E-09	1.83E-08	0.00E+00	1.34E-07
Non-hazardous waste disposed	2.78E-02 kg	2.77E-02	0.00E+00	2.49E-05	0.00E+00	1.07E-04
Radioactive waste disposed	4.15E-06 kg	4.15E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00

For the waste category indicators, the methodology “EDIP 2003” has been used, considering the slags and ashes as a hazardous waste and the bulk waste as non- hazardous.

4.3. Output flow indicators

	Total for lifecycle		Raw material and manufacturing	Distribution	Installation	Use	End of life
Components for reuse	0.00E+00	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Materials for recycling	0.00E+00	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Materials for energy recovery	0.00E+00	kg	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Exported energy	0.00E+00	MJ	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

All the indicators are zero, as the end of life of the product is unknown, so as the PCR states, the landfill treatment is estimated, which means that no material or energy is estimated to be recovered.

5. Conclusions

The table sums up the results of the lifecycle analysis with the mandatory environmental impact indicators of the reference product:

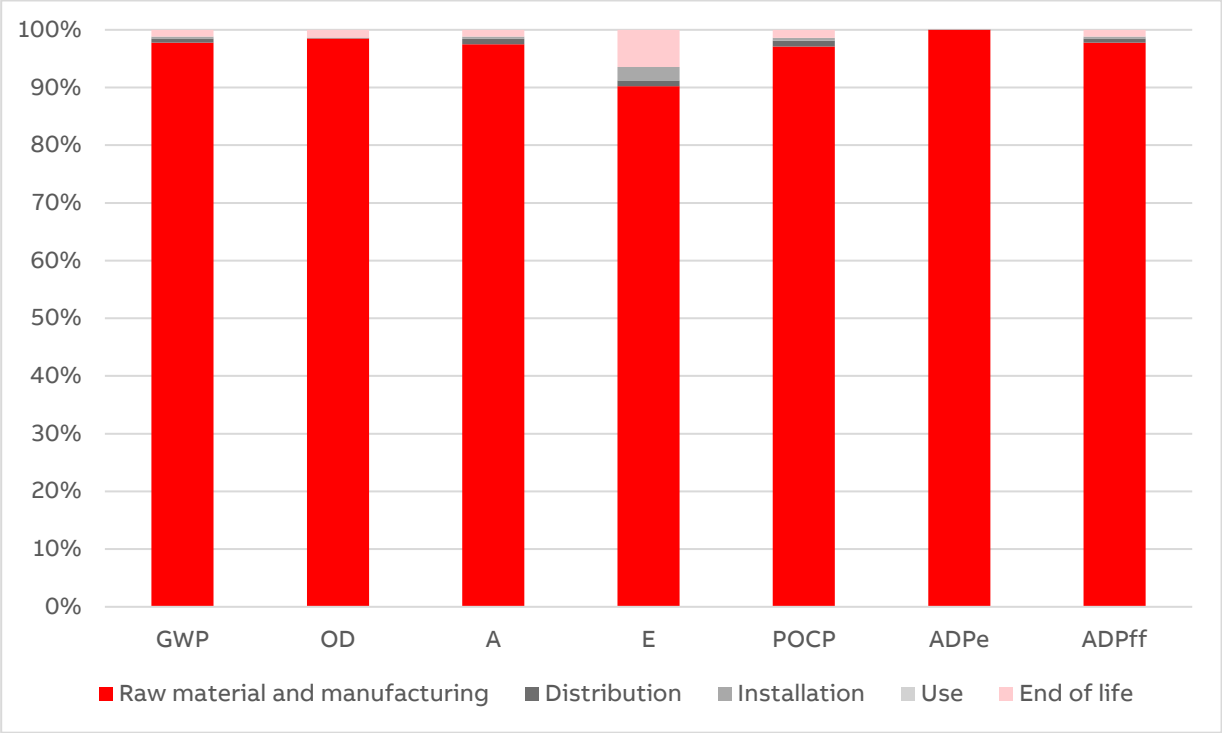

Figure 3. Impact of each lifecycle stage

The use stage is considered to have no impact, as it does not generate any consumption because the mechanism is not included.

The manufacturing stage is above the 90% of the whole impact, being more than the 90% of its impact the raw material, followed by importance by the manufacturing process itself. Transports (of raw materials and to the logistic platform in Milan), are below 2.5% in all categories.

Among the manufacturing process the following impacts are considered:

Table 6. Impact of manufacturing process

Category of impact	Unit	Raw material	Transport of raw material	Manufacturing process	Transport to Milan
Global warming	kg CO_2 eq.	3.36E-01	2.42E-03	2.31E-02	3.50E-03
Ozone depletion	kg CFC-11 eq.	7.16E-09	4.91E-12	7.71E-10	7.10E-12
Acidification of soils and water	kg SO_2 eq.	1.24E-03	1.09E-05	1.13E-04	1.57E-05
Water eutrophication	kg $(PO_4)^{3-}$eq.	2.48E-04	2.49E-06	6.97E-06	3.59E-06
Photochemical ozone formation	kg C_2H_4 eq.	7.93E-05	7.74E-07	6.77E-06	1.12E-06
Depletion of abiotic resources - elements	kg Sb eq.	1.59E-06	9.66E-11	2.17E-09	1.40E-10
Depletion of abiotic resources – fossil fuels	MJ	4.76E+00	3.41E-02	2.93E-01	4.92E-02
Water pollution	m^3	2.07E-01	1.32E-05	6.70E-04	1.90E-05
Air pollution	m^3	3.57E+00	3.50E-02	2.20E-01	5.06E-02

6. Sensitivity analysis

For the manufacturing process. one of the most influencing factors in the impact is the electricity consumption. For this analysis the indicator of electricity used has been the one in the ELCD database. as stated in the PCR. In case of being calculated with the Ecoinvent 3.6 indicator. The impact does not have a notorious change. as well as if other ELCD indicators are replaced with the ones in Ecoinvent 3.6.

Using the method CML-IA baseline version 4.2 and observing the impact category Global warming (GWP100a) it can be concluded that the variation on the impact is not as big but it happens to be quite lower using Ecoinvent 3.6 indicators.

Category of impact	Unit	Ecoinvent 3.6	ELCD	% of increase
Global warming	kg CO_2 eq.	2.92E-01	3.74E-01	-2%

Figure 4. Comparison of ELCD and Ecoinvent indicators for electricity