Environmental Product Declaration

according to ISO 14025 and EN 15804

Declaration holder:	Vaillant GmbH
Publisher:	Kiwa-Ecobility Experts
Programme operator:	Kiwa-Ecobility Experts
Registration number:	EPD-Vaillant-129-EN (Rev.1_21.11.2022)
Issue date:	30.04.2021
Valid until:	29.04.2026

Vaillant aroTHERM Split VWL /5 AS & uniTOWER VWL /5 IS

This EPD is based on the life cycle assessment of the Vaillant heat pumps with the outdoor modules aroTHERM Split VWL /5 AS and the indoor modules uniTOWER VWL /5 IS.

1. General information

Vaillant GmbH	aroTHERM Split VWL /5 AS & uniTOWER VWL /5 IS
Programme operator: Kiwa-Ecobility Experts Voltastr. 5 13355 Berlin Germany	**Declaration holder:** Vaillant GmbH Berghauser Straße 40 42859 Remscheid Germany
Declaration number: EPD-Vaillant-129-EN (Rev.1_21.11.2022)	**Declared product / declared unit:** 3-6 kW
Issue date: 30.04.2021	**Valid until:** 29.04.2026
Scope: The declaration is valid for one heat pump unit with a capacity between 3 and 6 kW. The aroTHERM Split VWL /5 AS are the outdoor modules and the uniTOWER VWL /5 IS are the indoor modules of the Vaillant heat pumps. The owner of the declaration shall be liable for the underlying information and evidence. Kiwa-Ecobility Experts shall not be liable with respect to manufacturer information, life cycle assessment data and evidences.	**Product category rules:** Product Category Rules (PCR) from the Ecobility Experts EPD programme: "Environmental Product Declaration Requirements for Heat Pumps (Draft 02-2021)" **Verification:** The CEN Norm EN 15804+A2 serves as the core PCR. Independent verification of the declaration and data according to ISO 14025:2011 ☐internally ☒externally
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2. Product

2.1 Product description

The declared Vaillant heat pumps consist of an outdoor module (aroTHERM Split VWL /5 AS) and an indoor module (uniTOWER VWL /5 IS). This EPD is valid for different versions of the Vaillant heat pumps, because they are exactly the same in design and only differ in capacity, which is influenced by the software.

The following combinations of the outdoor and indoor modules are possible and considered in this EPD. These are the exact names of the constructionally identical heat pump modules:

- aroTHERM Split VWL 35/5 AS 230V & uniTOWER VWL 58/5 IS
- aroTHERM Split VWL 55/5 AS 230V & uniTOWER VWL 58/5 IS
- aroTHERM Split VWL 35/5 AS 230V S2 & uniTOWER VWL 58/5 IS
- aroTHERM Split VWL 55/5 AS 230V S2 & uniTOWER VWL 58/5 IS
- aroTHERM Split VWL 45/5 AS 230V S3 & uniTOWER VWL 68/5 IS
- aroTHERM Split VWL 65/5 AS 230V S3 & uniTOWER VWL 68/5 IS

The aroTHERM Split VWL /5 AS is an air water heat pump with a refrigerant-split heat pump design, in which most of the refrigeration circuit components are located in the outdoor unit. Only the condenser heat ex-changer is housed in a separate indoor unit inside the building. Both appliances are connected to each other via refrigerant pipes. The refrigerant pipes are not included in the EPD because the required length varies. So they have to be considered on the building level.

The uniTOWER VWL /5 IS includes all the hydraulic components and a 190 liter hot water tank for domestic hot water supply. The declared product can be supplemented with the Vaillant system controller multiMATIC 70. Since the controller is optional and not required, it is not included in the EPD.

The refrigerant circuit of the heat pump is prefilled with 1.5 kg refrigerant R410A.

The heat pump is offered in different capacities of 3, 4, 5, 6 and 7, 10 and 12 kW. The first four capacities are considered in this EPD, since they are the same physical products in terms of design, materials as well as supply chain and manufacturing processes. The products are also identical in terms of packaging, distribution, reference service life and end-of life treatment. Hence all life cycle modules are identical.

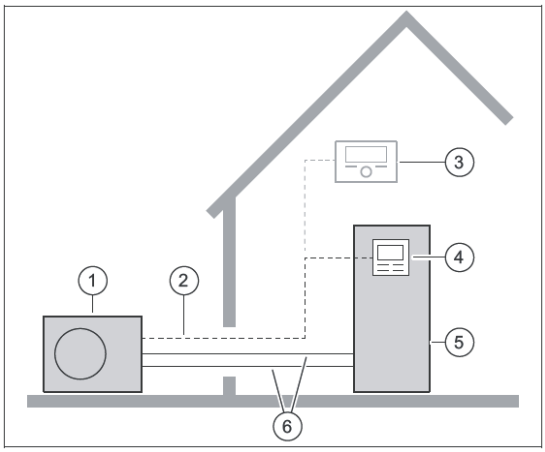

Figure 1: The design of a heat pump system with typical split technology: (1) heat pump, outdoor module; (2) eBus-channel; (3) system controller (optional); (4) controller indoor unit, (5) heat pump, inside unit, (6) Refrigerant circuit

The individual product components are shown in Figure 2 to Figure 4.

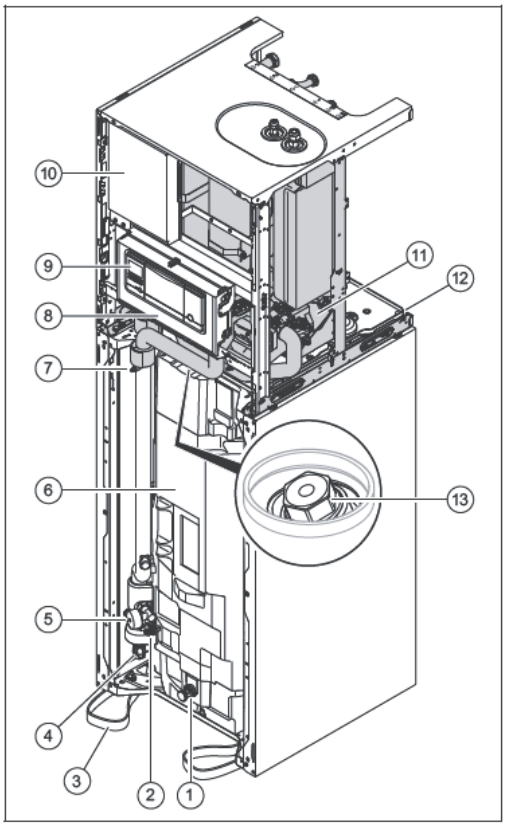

Figure 2: Design of the uniTOWER VWL /5 IS (indoor module): (1) drain tap hot water tank; (2) filling and draining tap; (3) carrying loops; (4) drain tap heating circuit; (5) pressure gauge heating circuit; (6) hot water tank; (7) bleed and drain valve; (8) Control box with controller PCB; (9) Indoor unit controller; (10) mains connection PCB; (11) hydraulic block; (12) condensate drain; (13) magnesium protective anode

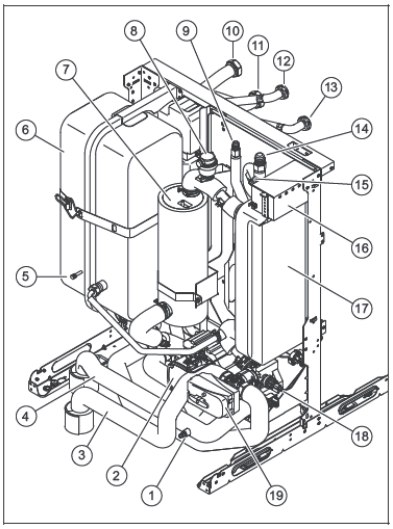

Figure 3: Design of the hydraulic block: (1) bleed and drain valve; (2) heating pump; (3) heating return flow (hot water); (4) heating flow (hot water); (5) expansion tank valve; (6) expansion vessel; (7) electric auxiliary heater, (8) quick air vents, (9) liquid line connection; (10) heating return flow; (11) heating flow; (12) hot water connection; (13) cold water connection; (14) Hot gas line connection; (15) Service valve, hot gas line,

refrigerant circuit; (16) safety temperature limiter; (17) condenser; (18) pressure sensor heating circuit; (19) priority switching valve, heating circuit / storage charging

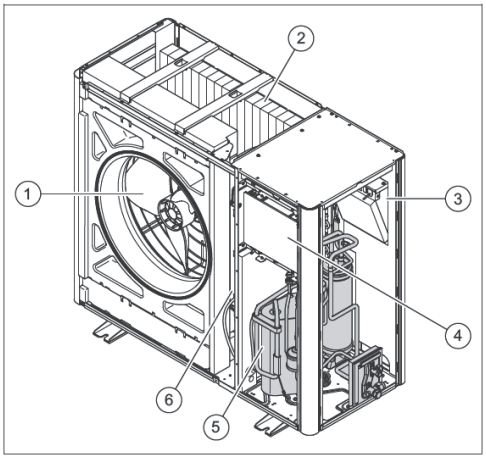

Figure 4: Design of the aroTHERM Split VWL /5 AS (outdoor module): (1) fan;(2) evaporator (heat exchanger); (3) circuit board INSTALLER BOARD; (4) printed circuit board HMU; (5) compressor; (6) INVERTER module

2.2 Application

The Vaillant heat pump is designed for heating, domestic hot water and cooling in one family or multi-family houses.

2.3 Technical data

The specific technical data of the heat pumps are shown in Table 1.

Table 1: Technical data

Parameter	Unit	VWL 35/5 AS 230V (S2) & VWL 58/5 IS	VWL 55/5 AS 230V (S2) & VWL 58/5 IS	VWL 45/5 AS 230V S3 & VWL 68/5 IS	VWL 65/5 AS 230V S3 & VWL 68/5 IS
Current voltage	V	230	230	230	230
Nominal Heating volume flow	m^3/h	0.54	0.79	0.54	0.79
Power consumption at A7/W35 according to EN 14511:2018	kW	0.64	0.95	0.87	1.27
Heating output at A7/W35 according to EN 14511:2018	kW	3.13	4.42	4.48	5.83
Energey efficiency class average climate (Heating 55°C/DHW)	-	A++ / A	A++ / A	A++ / A	A++ / A
Frequency	Hz	50	50	50	50
Height (Outdoor / Indoor)	mm	765 / 1880	765 / 1880	765 / 1880	765 / 1880
Width (Outdoor / Indoor)	mm	1100 / 599	1100 / 599	1100 / 599	1100 / 599
Deepth (Outdoor / Indoor)	mm	450 / 693	450 / 693	450 / 693	450 / 693
Weight (Outdoor / Indoor)	kg	92.2 / 154.4	92.2 / 154.4	92.2 / 154.4	92.2 / 154.4

2.4 Placing on the market & application rules

The designated products comply with the regulations of the following directives and standards in their currently applicable versions at the time they are issued. This declaration of conformity is issued under the sole responsibility of the manufacturer:

- EMC directive 2014/35/EU
- Energy labelling directive 2010/30/EU 811/2013
- Ecodesign directive 2009/125/EC 813/2013
- RoHS directive 2011/65/EU
- EN 60335-2-40:2003 + A1 + A11 + A12 + A1 + C + A2 + C + A13 + AC: 2013
- EN 55014-2: 2015
- EN 60335-1:2012 + AC2014 + A11:2014EN 61000-3-2: 2014
- EN 61000-3-3: 2013
- EN 61000-3-11: 2000
- EN 61000-3-12: 2011

The CE-marking takes into account the proof of conformity with the respective harmonized norms based on the legal provisions above.

2.5 Manufacturing

The assembly, manufacturing and functional test takes place at the production and development site in Nantes (France).

2.6 Raw materials

As shown in Table 2, the main raw materials of the heat pump are steel, paint, polyurethane and copper. The following table does not include packaging materials.

Table 2: Mass percentages of the raw materials

Raw material	Value	Unit
ABS	1,87E-02	m%
Aluminium	3,22E-02	m%
Brass	1,48E-02	m%
Copper	5,30E-02	m%
EPDM	7,68E-05	m%
Paint	5,67E-02	m%
Polyamide	3,92E-03	m%
Polycarbonate	1,07E-04	m%
Polyethylene	4,40E-03	m%
Polyurethane	5,52E-02	m%
PVC	4,63E-03	m%
Refrigerant R410A	5,76E-03	m%
Rubber	1,30E-02	m%
Silicone	1,80E-04	m%
Silver	1,54E-05	m%
Steel	7,37E-01	m%

2.7 Reference service life

According to the manufacturer the reference service life (RSL) is more than 10 years, subject to correct installation conditions. Life expectancy is generally influenced using the system and maintenance regime. Based on the RSL of category 3 heat pumps, a RSL of 15 years is assumed.

3. LCA: Calculation rules

3.1 Declared unit

According to "Nationale Milieudatabase (NMD) – Bepalingsmethode Milieuprestatie Bouwwerken, Versie 1.0, juli 2020", the declared unit is the capacity of the heat pump unit, which includes specific internal and external modules. The individual product modules are shown in Figure 2 to Figure 4. The connecting pipes and the optional external controller multiMATIC 700 are not considered. The considered heat pumps (aroTHERM Split VWL /5 AS & uniTOWER VWL /5 IS) have a capacity between 3 and 6 kW. As explained before, the heat pumps are exactly the same in design (see dimensions in Table 1) and only differ in capacity, which is influenced by the software.

Table 3: Declared unit

Description	Value	Unit
Declared unit	3-6	kW

3.2 System boundary

This EPD was created in accordance with DIN EN 15804 and monitors the production, the construction process, the use and the end of life stage as well as the benefits and loads beyond the system boundary. According to DIN EN 15804 this corresponds to the product phases A1-A5, B1-B5, C1-C4 and D. Therefore, the type of the EPD is "cradle to grave".

The following production steps are considered:

- A1: Raw material extraction and processing as well as processing of secondary materials serving as input (e.g. recycling processes)
- A2: Transport to manufacturer
- A3: Production
- A4: Transport to construction site
- A5: Installation process
- B1: Use or application of the installed product
- B2: Inspection, maintenance, cleaning
- B3: Repair
- B4: Replacement
- B5: Refurbishment
- C1: De-construction
- C2: Transport for waste treatment
- C3: Waste treatment for reuse, recovery and/or recycling
- C4: Disposal
- D: Re-use, recovery and/or recycling potentials, expressed as net flows and benefits

The operational energy use per year is not considered since the module B6 is excluded in the determination method.

The process tree of the heat pump is shown in Figure 5.

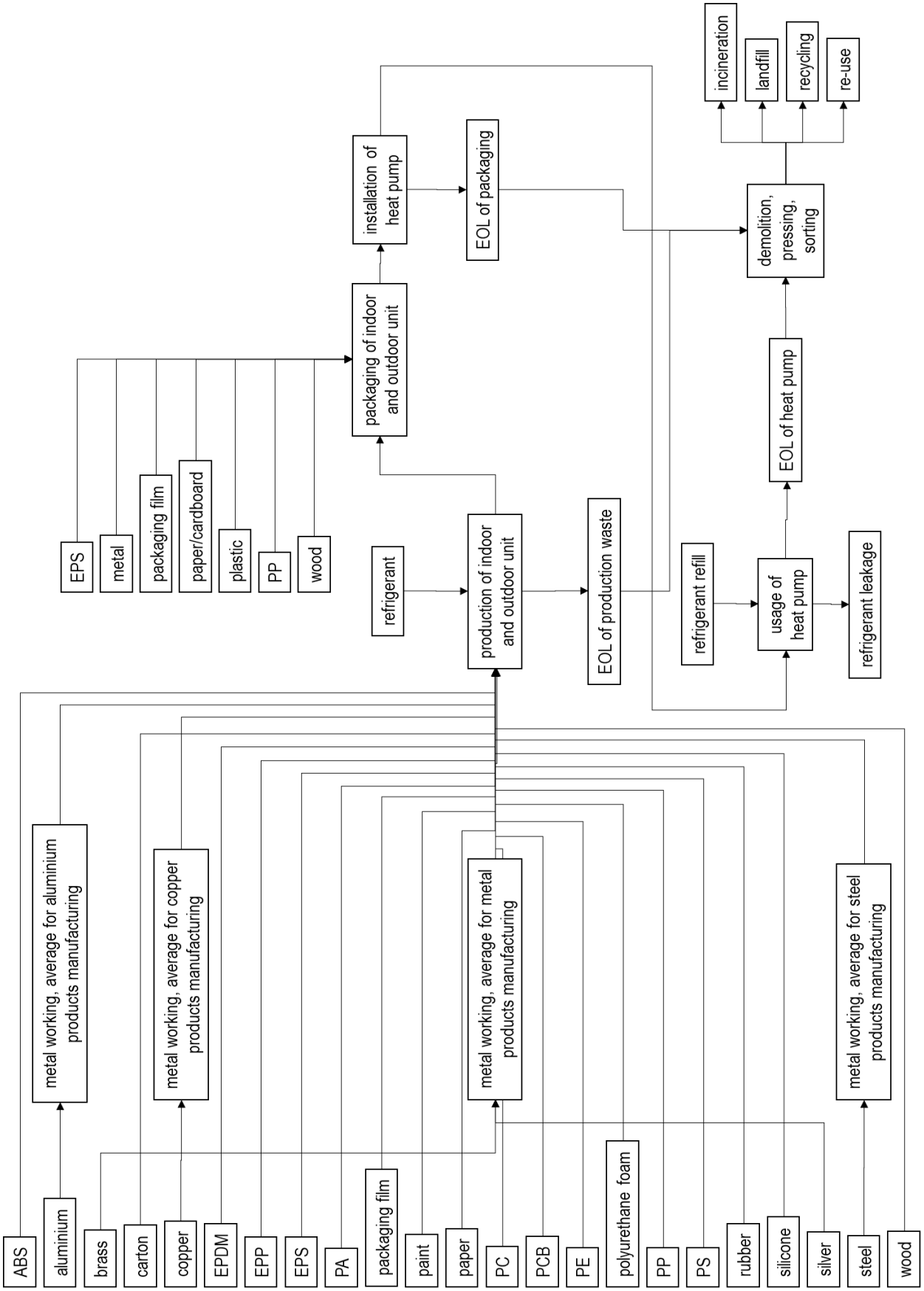
incineration
landfill
recycling
re-use
installation of heat pump
EOL of packaging
demolition, pressing, sorting
packaging of indoor and outdoor unit
EOL of heat pump
EPS
metal
packaging film
paper/cardboard
plastic
PP
wood
refrigerant
production of indoor and outdoor unit
EOL of production waste
refrigerant refill
usage of heat pump
refrigerant leakage
metal working, average for aluminium products manufacturing
metal working, average for copper products manufacturing
metal working, average for metal products manufacturing
metal working, average for steel products manufacturing
ABS
aluminium
brass
carton
copper
EPDM
EPP
EPS
PA
packaging film
paint
paper
PC
PCB
PE
polyurethane foam
PP
PS
rubber
silicone
silver
steel
wood

Figure 5: Process tree

3.3 Estimates and assumptions

All installed raw materials of the heat pump were analysed and the masses were determined. The water consumption and production-specific energy consumption were measured and provided by the Vaillant Deutschland GmbH & Co. KG. All specific transport distances of the starting materials were recorded and considered.

The infrastructure of the production facilities is not considered due to the high mass flow. In addition, only the production-related energy consumption (excluding the administration and social areas) is considered and the energy consumption was averaged over the annual production volume.

Due to the production locations and the economic contexts, Germany is the geographical reference area. However, the environmental impact, such as the greenhouse effect, can be spatially and temporally highly offset.

In the Ecoinvent database Version 3.5 (2018) only the refrigerant data sets for R134A and R152A are available. The selection of the appropriate data set for the used refrigerant R410A is based on the GWP values (100 years). The GWP value for R134A with 1,430 is closer to the one for R410A with 2,087.5 than the GWP value for R152A with 124. According to the manufacturer Vaillant, 3.5 % refrigerant must be refilled every year. Since the refrigerant is obtained from France and Lithuania, “Europe” is selected as supplier. The leakage mass per year during the use phase is calculated and multiplied with the emission factor of R410A with 2,087.5 gram CO_2-equivalents per gram refrigerant. After the use phase of the heat pump, the refrigerant is collected and, in most cases, it can be re-used after an appropriate treatment. Therefore, no waste is generated and the waste scenario “No waste (empty scenario) (NMD ID 15)” is selected.

For the metallic raw materials, in addition to the data sets for the raw materials itself, the metal working was also considered with appropriate data sets.

The transport distances and types for the supplier regions A2 were provided by the manufacturer Vaillant.

The selection of the waste scenarios for the different materials is based on an educated guess. The waste scenarios are based on the “Nationale Milieudatabase” (NMD), the National Environmental Database of the Netherlands. This is due the fact that the used NIBE EPD online application is developed in the Netherlands. For all materials a production waste of 5 % (in-situ products) is estimated.

3.4 Cut-off criteria

For process modules A1 to A3, all process-specific data was collected. Nearly all flows could be assigned potential environmental impacts through the Ecoinvent database. Production, supply, disposal, maintenance and end-of-life treatment of capital goods are included. In the used Ecoinvent database 3.5 (Allocation, cut-off by classification) infrastructure and capital goods are included. All flows that contribute more than 1% of the total mass, energy or environmental impact of the system have been included in the LCA. It can be assumed that the neglected processes contributed less than 5% to the impact categories considered. It is assumed that the contribution of capital goods to each individual environmental impact category of the module (A1-A3) is less than 5%.

3.5 Period under review

All process-specific data was collected for the operating year 2017. The quantities of raw and auxiliary materials as well as energy consumption have been recorded and averaged over the entire operating

year 2017. Because there were no major changes in the manufacturing processes since then, the data is still representative these days. Also, the used refrigerant R410A is still up to date and can be used without any restrictions at least until 2025.

3.6 Comparability

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

To be able to compare the EPD data, the declared products need the same declared units, or the declared unit has to be converted with the proper conversion factors to make it comparable.

3.7 Background data

All the background data is taken from the Ecoinvent database version 3.5 (2018). The life cycle was modelled with the help of the NIBE EPD online application. Geographical reference space of the background data is Germany. Almost all consistent datasets contained in the Ecoinvent database version 3.5 (2018) are documented and can be viewed in the online documentation.

3.8 Data quality

Overall, the quality of the data can be considered as good. In the operating data survey, all relevant process-specific data could be collected. The data relating to the manufacturing, transports and construction phase of the heat pump were determined by the Vaillant Deutschland GmbH & Co. KG.

Secondary data were taken from the Ecoinvent database version 3.5 (2018). The database is regularly checked and thus complies with the requirements of DIN EN ISO 14044 (background data not older than 10 years). The background data meets the requirements of EN 15804. The quantities of raw materials, consumables and supplies used as well as the energy consumption have been recorded and averaged over the entire year of operation.

The general rule has been complied that specific data from specific production processes or average data derived from specific processes must be given priority when calculating an EPD or Life Cycle Assessment. Data for processes that the manufacturer cannot influence or choose, were backed up with generic data.

The selection of the best fitting data sets is based on research and the help of experts. The transport distances for the waste treatments as well as the used environmental profiles for loads and benefits are based on the data from the NIBE EPD online application.

3.9 Allocation

Specific information about allocations within the background data is included in the documentation of the Ecoinvent datasets. There are no co-products in the raw material supply phase, so no allocation methods were used at this stage. There are no allocations during the manufacturing phase at the plant.

3.10 Calculation methods

For life cycle assessment, the calculation methods described in ISO 14044: 2006, section 4.3.2 have been applied. The used determination method is “Nationale Milieudatabase (NMD) – Bepalingsmethode Milieuprestatie Bouwwerken, Versie 1.0, juli 2020”, which is based on the EN 15804. The evaluation is based on the phases in the system boundaries.

3.11 Data collection

The data collection was performed according to ISO 14044:2006, section 4.3.2. According to the target definition, all significant input and output flows that occur in connection with the products under consideration were identified and quantified. The inputs and outputs were attributed to the process in which they occur. For the process stages A1, A2 and A3, the input and output streams could be clearly assigned.

3.12 Electricity mix and CO_2 certificates

The electricity mix was chosen according to the geographic reference space and time reference. Since only the conventional electricity mix is used, no further energy sources were considered. The power mix composition is based on the Ecoinvent database version 3.5 (2018). No CO_2 certificates were counted.

4. LCA: Scenarios and additional technical information

No scenarios were analysed in this EPD.

5. LCA: Results

The following tables show the results of the indicators of the impact assessment, the resource input as well as the waste materials and other output-flows. The here shown results refer to the declared unit.

Description of the system boundary (X = Included in LCA)														
Product stage			Construction process stage		Use stage					End of life stage				Benefits and loads beyond the system boundaries
Raw material supply	Transport	Manufacturing	Transport from manu-facturer to place of use	Construction-instal-lation process	Use	Maintenance	Repair	Replacement	Refurbishmen	De-construction / demolition	Transport	Waste processing	Disposal	Reuse-Recovery-Recycling-potential
A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	C1	C2	C3	C4	D
X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

Results of the LCA – Environmental impact catgories (set 1)

Impact cate-gory	Unit	A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	C1	C2	C3	C4	D
ADP-e	kg Sb	5,16E-02	2,16E-04	1,47E-03	7,99E-05	2,32E-03	0,00E+00	2,53E-05	0,00E+00	0,00E+00	0,00E+00	0,00E+00	8,68E-06	1,18E-04	1,70E-07	-2,52E-02
ADP-f	kg Sb	8,75E+00	6,48E-01	7,74E-01	2,37E-01	4,07E-01	0,00E+00	5,08E-02	0,00E+00	0,00E+00	0,00E+00	0,00E+00	2,28E-02	7,25E-02	1,76E-03	-3,34E+00
GWP	kg CO_2 eqv.	1,27E+03	8,60E+01	9,74E+01	3,14E+01	7,90E+01	1,64E+03	1,36E+01	0,00E+00	0,00E+00	0,00E+00	0,00E+00	3,05E+00	1,20E+02	7,46E-01	-5,53E+02
ODP	kg CFC-11 eqv.	1,81E-03	1,62E-05	8,50E-06	5,93E-06	9,07E-05	0,00E+00	8,50E-04	0,00E+00	0,00E+00	0,00E+00	0,00E+00	5,70E-07	2,87E-06	3,97E-08	-1,77E-05
POCP	kg Eth-ene eqv.	1,34E+00	5,25E-02	1,29E-01	1,89E-02	6,36E-02	0,00E+00	1,01E-02	0,00E+00	0,00E+00	0,00E+00	0,00E+00	1,81E-03	8,18E-03	2,42E-04	-2,98E-01
AP	kg SO_2 eqv.	1,02E+01	3,82E-01	6,19E-01	1,32E-01	4,43E-01	0,00E+00	4,16E-02	0,00E+00	0,00E+00	0,00E+00	0,00E+00	1,32E-02	8,31E-02	9,83E-04	-2,50E+00
EP	kg PO_4^{3-} eqv.	2,71E+00	7,48E-02	1,26E-01	2,64E-02	1,19E-01	0,00E+00	3,85E-03	0,00E+00	0,00E+00	0,00E+00	0,00E+00	2,67E-03	1,78E-02	3,16E-04	-8,90E-01
HTP	kg 1.4 Dichlo-roben-zene	3,48E+03	3,73E+01	1,79E+02	1,34E+01	1,47E+02	0,00E+00	2,38E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	1,25E+00	1,24E+01	8,39E-02	-3,11E+02
FAETP	kg 1.4 Dichlo-roben-zene	2,80E+01	1,03E+00	1,95E+00	3,79E-01	1,11E+00	0,00E+00	4,25E-02	0,00E+00	0,00E+00	0,00E+00	0,00E+00	3,63E-02	5,15E-01	3,09E-02	-3,86E+00
MAETP	kg 1.4 Dichlo-roben-zene	1,06E+05	3,82E+03	5,65E+03	1,40E+03	4,54E+03	0,00E+00	2,15E+02	0,00E+00	0,00E+00	0,00E+00	0,00E+00	1,30E+02	1,72E+03	3,23E+01	-2,02E+04
TETP	kg 1.4 Dichlo-roben-zene	8,51E+00	1,22E-01	1,17E+00	4,45E-02	2,84E-01	0,00E+00	2,00E-02	0,00E+00	0,00E+00	0,00E+00	0,00E+00	4,31E-03	4,36E-02	2,33E-04	3,36E+00

ADP-e = Depletion of abiotic resources – elements; ADP-f = Depletion of abiotic resources - fossil fuels; GWP Global warming potential; ODP = Ozone layer de-pletion; POCP = Photochemical oxidants creation; AP = Acidification of soil and water; EP = Eutrophication; HTP = Human toxicity; FAETP = Ecotoxicity fresh water; MAETP = Ecotoxicity marine water; TETP = Ecotoxicity terrestric

Results of the LCA – Environmental impact categories (set 2)																
Impact category	**Unit**	**A1**	**A2**	**A3**	**A4**	**A5**	**B1**	**B2**	**B3**	**B4**	**B5**	**C1**	**C2**	**C3**	**C4**	**D**
AP	mol H+ eqv.	1,21E+01	5,03E-01	7,82E-01	1,75E-01	5,27E-01	0,00E+00	4,97E-02	0,00E+00	0,00E+00	0,00E+00	0,00E+00	1,76E-02	5,44E-02	7,90E-04	-2,22E+00
GWP-total	kg CO2 eqv.	1,26E+03	8,67E+01	5,14E+01	3,17E+01	1,20E+02	1,64E+03	1,49E+01	0,00E+00	0,00E+00	0,00E+00	0,00E+00	3,08E+00	1,59E+02	8,53E-01	-2,29E+02
GWP-b	kg CO2 eqv.	-2,79E+01	3,18E-02	-6,36E+01	1,13E-02	3,94E+01	0,00E+00	9,01E-03	0,00E+00	0,00E+00	0,00E+00	0,00E+00	8,93E-04	4,37E+01	1,90E-01	4,59E-01
GWP-f	kg CO2 eqv.	1,29E+03	8,67E+01	1,15E+02	3,17E+01	8,05E+01	1,64E+03	1,49E+01	0,00E+00	0,00E+00	0,00E+00	0,00E+00	3,08E+00	1,15E+02	6,63E-01	-2,29E+02
GWP-luluc	kg CO2 eqv.	2,22E+00	2,48E-02	2,23E-01	8,97E-03	1,03E-01	0,00E+00	4,48E-03	0,00E+00	0,00E+00	0,00E+00	0,00E+00	9,15E-04	6,65E-03	4,28E-05	-6,42E-01
ETP-fw	CTUe	1,09E+05	9,64E+02	4,25E+03	3,52E+02	4,19E+03	0,00E+00	1,71E+02	0,00E+00	0,00E+00	0,00E+00	0,00E+00	3,42E+01	9,00E+02	1,62E+02	-4,35E+04
PM	disease incidence	9,76E-05	7,86E-06	8,43E-06	2,89E-06	4,89E-06	0,00E+00	4,86E-07	0,00E+00	0,00E+00	0,00E+00	0,00E+00	2,79E-07	4,78E-07	1,42E-08	-1,65E-05
EP-m	kg N eqv.	1,71E+00	1,66E-01	1,05E-01	6,04E-02	9,08E-02	0,00E+00	6,96E-03	0,00E+00	0,00E+00	0,00E+00	0,00E+00	6,17E-03	1,60E-02	5,02E-04	-8,75E-01
EP-fw	kg PO4 eqv.	6,40E-01	1,25E-03	2,74E-02	4,56E-04	2,63E-02	0,00E+00	3,58E-04	0,00E+00	0,00E+00	0,00E+00	0,00E+00	4,62E-05	6,21E-04	2,55E-06	-1,39E-01
EP-T	mol N eqv.	1,77E+01	1,84E+00	1,41E+00	6,70E-01	9,06E-01	0,00E+00	8,34E-02	0,00E+00	0,00E+00	0,00E+00	0,00E+00	6,83E-02	1,85E-01	2,77E-03	-3,91E+00
HTP-c	CTUh	5,54E-06	3,29E-08	3,79E-07	1,20E-08	3,57E-07	0,00E+00	1,38E-08	0,00E+00	0,00E+00	0,00E+00	0,00E+00	1,30E-09	1,74E-07	6,60E-11	-2,98E-07
HTP-nc	CTUh	8,51E-05	1,21E-06	6,12E-06	4,44E-07	3,49E-06	0,00E+00	1,93E-07	0,00E+00	0,00E+00	0,00E+00	0,00E+00	4,36E-08	5,11E-07	2,93E-09	-1,29E-05
IR	kBq U235 eqv.	4,78E+01	5,80E+00	5,62E+00	2,12E+00	1,66E+00	0,00E+00	2,75E-01	0,00E+00	0,00E+00	0,00E+00	0,00E+00	2,03E-01	3,22E-01	9,10E-03	-4,06E+00
SQP	Pt	1,03E+04	1,24E+03	4,44E+03	4,58E+02	7,17E+02	0,00E+00	1,90E+01	0,00E+00	0,00E+00	0,00E+00	0,00E+00	3,97E+01	3,66E+01	4,66E+00	-5,15E+03
ODP	kg CFC 11 eqv.	1,48E-03	2,04E-05	8,65E-06	7,45E-06	7,42E-05	0,00E+00	6,85E-04	0,00E+00	0,00E+00	0,00E+00	0,00E+00	7,16E-07	2,32E-06	2,83E-08	-1,46E-05
POCP	kg NMVOC eqv.	5,65E+00	5,30E-01	5,22E-01	1,93E-01	3,03E-01	0,00E+00	3,39E-02	0,00E+00	0,00E+00	0,00E+00	0,00E+00	1,94E-02	4,77E-02	9,69E-04	-9,55E-01
ADP-f	MJ	1,64E+04	1,36E+03	1,82E+03	4,96E+02	7,45E+02	0,00E+00	1,02E+02	0,00E+00	0,00E+00	0,00E+00	0,00E+00	4,77E+01	7,92E+01	2,21E+00	-2,67E+03
ADP-mm	kg Sb-eqv.	5,16E-02	2,16E-04	1,46E-03	7,99E-05	2,31E-03	0,00E+00	2,53E-05	0,00E+00	0,00E+00	0,00E+00	0,00E+00	8,68E-06	3,36E-05	1,11E-07	-2,52E-02
WDP	m^3 world eqv.	6,04E+02	9,78E+00	5,05E+01	3,57E+00	2,99E+01	0,00E+00	5,08E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	3,39E-01	6,25E+00	8,40E-02	-5,28E+01

AP = Acidification; GWP-total = Global warming potential; GWP-b = Global warming potential – Biogenic; GWP-f = Global warming potential – Fossil; GWP-luluc = Global warming potential - Land use and land use change; ETP-fw = Ecotoxicity, freshwater; PM = Particulate Matter; EP-m = Eutrophication marine; EP-fw = Eutrophication, freshwater; EP-T = Eutrophication, terrestrial; HTP-c = Human toxicity, cancer; HTP-nc = Human toxicity, non-cancer; IR = Ionising radiation, human health; SQP = Land use; ODP = Ozone depletion; POCP = Photochemical ozone formation - human health; ADP-f = Resource use, fossils; ADP-mm = Resource use, minerals and metals; WDP = Water use

Results of the LCA – Environmental parameters																
Parame-ter	Unit	A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	C1	C2	C3	C4	D
PERE	MJ	2,19E+03	1,45E+01	5,02E+02	5,21E+00	1,07E+02	0,00E+00	5,17E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	4,99E-01	2,66E+01	1,26E-01	-1,22E+03
PERM	MJ	3,75E+02	0,00E+00	3,93E+02	0,00E+00	3,84E+01	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	-6,83E+00
PERT	MJ	2,57E+03	1,45E+01	8,95E+02	5,21E+00	1,45E+02	0,00E+00	5,17E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	4,99E-01	1,68E+01	8,86E-02	-1,22E+03
PENRE	MJ	1,65E+04	1,44E+03	1,67E+03	5,26E+02	7,41E+02	0,00E+00	1,10E+02	0,00E+00	0,00E+00	0,00E+00	0,00E+00	5,07E+01	2,26E+02	5,46E+00	-2,86E+03
PENRM	MJ	1,27E+03	0,00E+00	3,11E+02	0,00E+00	7,91E+01	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	-3,87E+01
PENRT	MJ	1,75E+04	1,44E+03	1,93E+03	5,26E+02	7,99E+02	0,00E+00	1,10E+02	0,00E+00	0,00E+00	0,00E+00	0,00E+00	5,07E+01	1,55E+02	3,90E+00	-2,88E+03
SM	kg	2,27E+01	0,00E+00	3,17E+00	0,00E+00	1,30E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
RSF	MJ	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
NRSF	MJ	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
FW	m^3	1,67E+01	2,61E-01	1,37E+00	9,52E-02	7,52E-01	0,00E+00	1,29E-01	0,00E+00	0,00E+00	0,00E+00	0,00E+00	9,00E-03	1,49E-01	3,83E-03	-1,84E+00
HWD	kg	5,95E-02	8,37E-04	7,14E-03	3,06E-04	5,28E-03	0,00E+00	1,21E-04	0,00E+00	0,00E+00	0,00E+00	0,00E+00	3,03E-05	5,23E-02	2,73E-06	-8,38E-03
NHWD	kg	3,81E+02	9,22E+01	2,42E+01	3,40E+01	2,85E+01	0,00E+00	8,97E-01	0,00E+00	0,00E+00	0,00E+00	0,00E+00	2,90E+00	4,75E+00	1,75E+01	-1,95E+02
RWD	kg	4,71E-02	9,15E-03	6,38E-03	3,34E-03	2,02E-03	0,00E+00	2,70E-04	0,00E+00	0,00E+00	0,00E+00	0,00E+00	3,21E-04	6,92E-04	2,28E-05	-4,32E-03
CRU	kg	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
MFR	kg	0,00E+00	0,00E+00	1,04E+01	0,00E+00	1,73E+01	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	2,09E+02	0,00E+00	0,00E+00
MER	kg	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
EET	MJ	0,00E+00	0,00E+00	3,48E+01	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	1,03E+03
EEE	MJ	0,00E+00	0,00E+00	2,20E+01	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	6,50E+02

PERE = Renewable primary energy ex. raw materials; PERM = Renewable primary energy used as raw materials; PERT = Renewable primary energy total; PENRE = Non-renewable primary energy ex. raw materials; PENRM = Non-renewable primary energy used as raw materials; PENRT = Non-renewable primary energy total; SM = Use of secondary material; RSF = use of renewable secondary fuels; NRSF = Use of non-renewable secondary fuels; FW = Use of net fresh water; HWD = Hazardous waste disposed; NHWD = Non-hazardous waste disposed; RWD = Radioactive waste disposed; CRU = Components for re-use; MFR = Materials for recycling; MER = Materials for energy recovery; EET = Exported energy thermic; EEE = Exported energy electric

6. LCA: Interpretation

For an easier understanding, the results are processed graphically, in order to recognize relationships and connections between the data more clearly.

6.1 Environmental impact categories

The following figures show the percentage of the product phases in the environmental impact categories. In Figure 6 the environmental impact categories of set 1 and in Figure 7 of set 2 of the NMD determination method (version 1.0; July 2020) are shown.

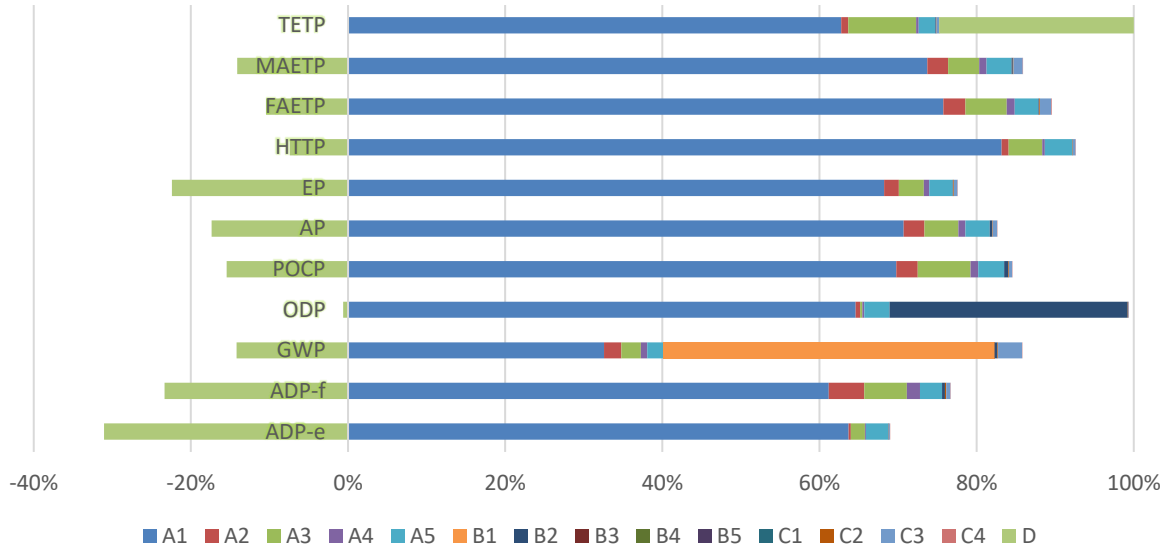

Figure 6: Percentage of the product phases in the environmental impact categories of set 1

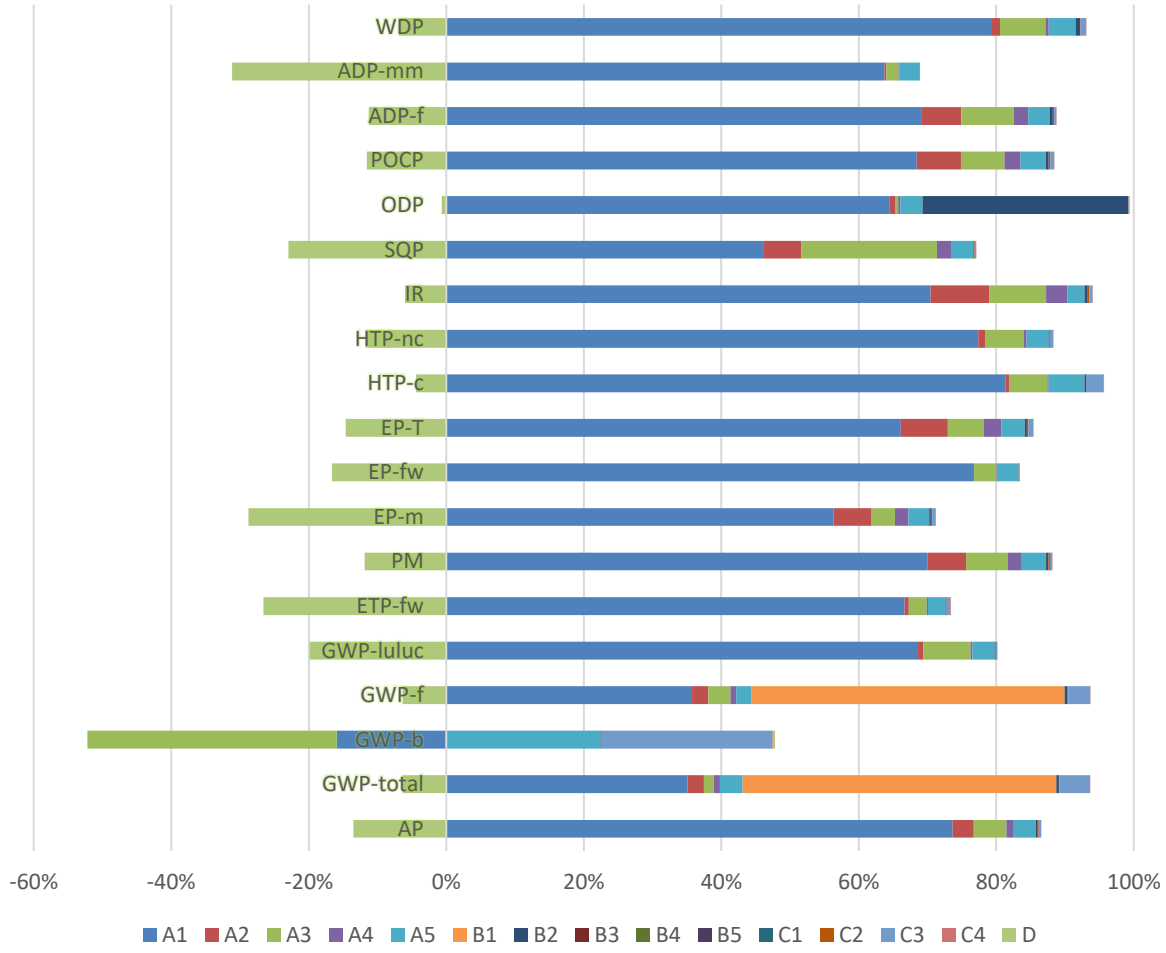

Figure 7: Percentage of the product phases in the environmental impact categories of set 2

The figures show that for all the environmental impact categories the raw material supply A1 during the production phase has the highest percentages. It can also be seen that the advantages in D predominate, represented by the negative percentage values of D, in all categories except for terrestric ecotoxicity (TETP). In addition, the impact of the emission due the refrigerant leakage in B1 on the global warming potential (GWP) is clearly shown.

6.2 Limitations

The limitations regarding the interpretation of the results are due to the assumptions made for the LCA, because it assesses the real world in a simplified model. It can be assumed that the results for the declared products are well representative, because the quality of the data used can classified as good overall. All relevant process-specific data could be collected in the operational data collection. Consistent data sets from the Ecoinvent database were available for almost all inputs and outputs.

In principle, a comparison of EPD data is only possible if all data sets to be compared were created according to same standard (EN 15804+A2) and all relevant data sets are from the same database. For an evaluation, the same heat pump in the building context or the product-specific performance characteristics have to be considered.

7. References

[1] Centrum voor Milieuwetenschappen Leiden (CML); CML-IA (Baseline) version 4.1 (2012); Characterization factors by the Institute of Environmental Sciences of the Faculty of Science at the Leiden University in the Netherlands; https://www.universiteitleiden.nl/en/research/research-output/science/cml-ia-characterisation-factors

[2] Commission Delegated Regulation (EU) No 811/2013 of 18 February 2013 supplementing Directive 2010/30/EU of the European Parliament and of the Council with regard to the energy labelling of space heaters, combination heaters, packages of space heater, temperature control and solar device and packages of combination heater, temperature control and solar device (Text with EEA relevance)

[3] DIN EN ISO 14040: 2009-11: Environmental management - Life cycle assessment - Principles and framework (ISO 14040:2006)

[4] DIN EN ISO 14044: 2018-05: Environmental management - Life cycle assessment - Requirements and guidelines (ISO 14044:2006 + Amd 1:2017)

[5] EN ISO 14025:2011-10: Environmental labels and declarations - Type III environmental declarations - Principles and procedures (ISO 14025:2006)

[6] DIN EN ISO 15804:2014-07: Sustainability of construction works - Environmental product declarations - Core rules for the product category of construction.

[7] DIN EN 55014-2:2015: Electromagnetic compatibility - Requirements for household appliances, electric tools and similar apparatus - Part 2: Immunity - Product family standard (CISPR 14-2:2015)

[8] DIN EN 60335-1:2012-10; VDE 0700-1:2012-10: Household and similar electrical appliances - Safety - Part 1: General requirements (IEC 60335-1:2010, modified)

[9] DIN EN 60335-2-40:2014: Household and similar electrical appliances - Safety - Part 2-40: Particular requirements for electrical heat pumps, air-conditioners and dehumidifiers (IEC 60335-2-40:2002, modified + A1:2005, modified + A2:2005, modified + Cor. 1:2006)

[10] DIN EN 61000-3-3:2013: Electromagnetic compatibility (EMC) - Part 3-3: Limits - Limitation of voltage changes, voltage fluctuations and flicker in public low-voltage supply systems, for equipment with rated current <= 16 A per phase and not subject to conditional connection (IEC 61000-3-3:2013)

[11] DIN EN 61000-3-11:2000: Electromagnetic compatibility (EMC) - Part 3-11: Limits - Limitation of voltage changes, voltage fluctuations and flicker in public low-voltage supply systems - Equipment with rated current <= 75 A and subject to conditional connection (IEC 77A/929/CDV:2016)

[12] DIN EN 61000-3-12:2011: Electromagnetic compatibility (EMC) - Part 3-12: Limits - Limits for harmonic currents produced by equipment connected to public low-voltage systems with input current > 16 A and <= 75 A per phase (IEC 61000-3-12:2011)

[13] Directive 2009/125/EC of the European Parliament and of the Council of 21 October 2009 establishing a framework for the setting of ecodesign requirements for energy-related products (Text with EEA relevance)

[14] Directive 2011/65/EU of the European Parliament and of the Council of 8 June 2011 on the restriction of the use of certain hazardous substances in electrical and electronic equipment (Text with EEA relevance)

[15] Directive 2014/35/EU of the European Parliament and of the Council of 26 February 2014 on the harmonisation of the laws of the Member States relating to the making available on the market of electrical equipment designed for use within certain voltage limits (Text with EEA relevance)

[16] Directive 2014/53/EU of the European Parliament and of the Council of 16 April 2014 on the harmonisation of the laws of the Member States relating to the making available on the market of radio equipment and repealing Directive 1999/5/EC

[17] Klöpffer, W., Grahl B.: Ökobilanz LCA) – Ein Leitfaden für die Ausbildung und Beruf, Wily-VCH Verlag GmbH & Co.Kg aA, Weinheim, 2007

[18] Stichting Bouwkwaliteit (SBK) – Foundation for Building Quality; “Determination Method: Environmental Performance of Buildings and Civil Engineering Works”

[19] Stichting Nationale Milieudatabase; Bepalingsmethode Milieuprestatie Bouwwerken; Version 1.0; July 2020; Berekeningswijze voor het bepalen van de milieuprestatie van bouwwerken gedurende hun gehele levensduur, gebaseerd op de EN 15804.

[20] Profil Environnemental Produit Collectif; Pompe à chaleur double service résidentielle air/eau; N° enregistrement : UNIC-00027-V01.01-FR

[21] Product Category Rules (PCR) from the Ecobility Experts EPD programme: “Environmental Product Declaration Requirements for Heat Pumps (Draft 02-2021)”

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