# Environmental Product Declaration


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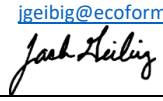
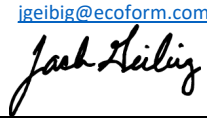
|---|---|
| EPD Program and Program Operator Name, Address, Logo, and Website | NSF Certification, LLC<br>789 North Dixboro Road.<br>Ann Arbor, MI, 48105, United States<br>https://www.nsf.org/ |
| General Program Instructions and Version Number | Part A: Life Cycle Assessment Calculations and Report Requirements Version 3.2 |
| Manufacturer Name and Address | Carrier Corporation<br>13995 Pasteur Boulevard<br>Palm Beach Gardens, Florida 33418 |
| Declaration Number | EPD10924 |
| Product and Functional Unit | AquaEdge® 19MV Water-Cooled Centrifugal Chiller, 1 ton chilling capacity |
| Reference PCR and Version Number | Part A: Life Cycle Assessment Calculation Rules and Report Requirements (UL Environment, V3.2, 2018)<br>Part B: Water Cooled Chiller EPD Requirements (UL Environment V2.0, 2018) |
| Product's Intended Application and Use | The AquaEdge® 19MV is a water-cooled centrifugal chiller that utilizes a two-stage back-to-back compressor and an oil-free magnetic bearing system to deliver more operating range and consistent efficiency. The function of the chillers included in this study is to provide chilled water for use in cooling the interior of a building. |
| Product RSL | 25 years |
| Markets of Applicability | North America |
| Date of Issue | January 5, 2024 |
| Period of Validity | 5 years from date of issue |
| EPD Type | Product Specific |
| Range of Dataset Variability | N/A |
| EPD Scope | Cradle-to-Grave |
| Year of reported manufacturer primary data | 2021 |
| LCA Software and Version Number | Sphera LCA for Experts 10.7.0.183 |
| LCI Database and Version Number | Sphera Managed LCA Content, CUP 2023.1 |
| LCIA Methodology and Version Number | TRACI 2.1+IPCC AR5 |
| The sub-category PCR review was conducted by: | Lise Laurin, EarthShift Global<br>Sean Beilman, BCER Engineering, Inc.<br>François Charron-Doucet, Group AGÉCO |
| This declaration was independently verified in accordance with ISO 14025: 2006. The PCR chosen conforms to ISO 21930:2017.<br>☐ INTERNAL ☒ EXTERNAL | Jack Geibig - EcoForm<br>jgeibig@ecoform.com<br>  |
| This life cycle assessment was conducted in accordance with ISO 14044 and the reference PCR by: | Lindsay Bonney, Nicholas Hammond WAP Sustainability Consulting, LLC |
| This life cycle assessment was independently verified in accordance with ISO 14044 and the reference PCR by: | Jack Geibig - EcoForm<br>jgeibig@ecoform.com<br>  |

Limitations:
Environmental declarations from different programs (ISO 14025) may not be comparable.
Comparison of the environmental performance of products using EPD information shall be based on the product's use and impacts at the building level, and therefore EPDs may not be used for comparability purposes when not considering the building use phase as instructed under this PCR. Previous versions of the PCR vary in the prescribed default refrigerant leakage rate and do not necessitate the reporting of B4 impacts. These variations make it imperative to ensure that EPDs are aligned with all the following conformance requirements for comparisons.

Full conformance with the PCR for Water Chillers allows EPD comparability only when all stages of a life cycle have been considered, when they comply with all referenced standards, use the same sub-category PCR, and use equivalent scenarios with respect to construction works. However, variations and deviations are possible. Example of variations: Different LCA software and background LCI datasets may lead to differences results for upstream or downstream of the life cycle stages declared.

No use phase grid mix is explicitly defined by the PCR. As such, Carrier has elected to report multiple use phase electricity demand scenarios for increased reader utility. This reporting is described in the text of the EPD.

# 1 – GENERAL INFORMATION

## Description of Company

Carrier Corporation, headquartered in Palm Beach Gardens, FL, is the leading global provider of healthy, safe, and sustainable building and cold chain solutions. Carrier operates in the industries of HVAC and Refrigeration. Founded by the inventor of modern air conditioning, Carrier is a world leader in high-technology heating, air-conditioning and refrigeration solutions. Carrier experts provide sustainable solutions, integrating energy-efficient products, building controls and energy services for residential, commercial, retail, transport and food service customers. Carrier is a part of Carrier Global Corporation, global leader in intelligent climate and energy solutions that matter for people and our planet for generations to come.

## Product Description

This environmental product declaration covers the following products from CSI division 23 64 16.16: AquaEdge® 19MV Water-Cooled Centrifugal Chiller. Further explanatory material may be obtained through the company website: https://www.carrier.com/commercial/en/us/products/chillers-components/water-cooled-chillers/.

The AquaEdge® 19MV is a water-cooled centrifugal chiller that utilizes a two-stage back-to-back compressor and an oil-free magnetic bearing system to deliver more operating range and consistent efficiency.

*Figure 1: AquaEdge® 19MV Water-Cooled Centrifugal Chiller Product Image*

Three configurations of the AquaEdge® 19MV were assessed for the purpose of this EPD. The chiller base model allows for a nearly endless amount of variability in configuration based on the specifications and needs of the ultimate consumer. Each configuration allows for a range of refrigerant options, namely, R134a, R513A, and R515B. To capture the full range of product offerings within the AquaEdge® 19MV line, the following configurations were assessed:

- The most common configuration by sales volume utilizing the R134a refrigerant option was reviewed. This configuration is representative of all other configurations utilizing R134a because results for other configurations with this refrigerant fall within 10% of results for the reviewed R134a configuration.
- The most common configuration by sales volume utilizing the R513A refrigerant option was reviewed. This configuration is representative of all other configurations utilizing R513A because results for other configurations with this refrigerant fall within 10% of results for the reviewed R513A configuration.
- The most common configuration by sales volume utilizing the R515B refrigerant option was reviewed. This configuration is representative of all other configurations utilizing R515B because results for other configurations with this refrigerant are lower than the results for the reviewed R515B configuration.

Results for each refrigerant option are presented separately.

No substances required to be reported as hazardous according to the US Resources Conservation and Recovery Act, Subtitle 3 are associated with the production of this product.

## Technical Data

The AquaEdge® 19MV chiller series is certified to the following standards:

- ANSI/ASHRAE 15 (latest revision), safety code for mechanical refrigeration
- ETL conformance to:
    - UL STD 60335-1

  - UL STD 60335-2-40
  - CSA STD C22.2 # 60335-1
  - CSA STD C22.2 # 60335-2-40
- ASME Section VIII Div. 1 "U" stamped certified
- AHRI Standards 550/590 and 551/591 (accessible via https://www.ahridirectory.org/Search/SearchHome?ReturnUrl=%2f by searching for the "AquaEdge® 19MV" model number)

Table 1 shows the technical specifications of the products, including any testing data as appropriate.

*Table 1: Technical Data*

| | Value | Unit |
|---|---|---|
| **Chiller Capacity** | 500 | tons of refrigeration |
| **Energy Efficiency*** | 100% load at 85°F (29°C)<br>75% load at 75°F (24°C)<br>50% load at 65°F (18°C)<br>25% load at 65°F (18°C) | kW/ton at load % and entering condenser water temperature |

*Values from AHRI 550/590 Standard

The dimensions of the configurations as delivered to the customer are shown below. Product dimensions are identical for all refrigerant options.

*Table 2: Product Dimensions*

| | Value | Unit |
|---|---|---|
| **Length** | 4.6 | m |
| **Width** | 1.8 | m |
| **Height** | 1.9 | m |

**Application**

The function of the chillers included within this study is to provide chilled water for use in cooling the interior of a building, for a functional unit of 1 ton chilling capacity. In this study, the reference service life (RSL) of the products is 25 years. Therefore, after initial installation in a building with an estimated service life (ESL) of 75 years there will be two replacements needed.

## Material Composition

The raw materials for the product were obtained from suppliers in the United States, China, and Mexico. The general compositions of the products are represented in Table 3.

*Table 3: Material Composition per Functional Unit*

| | R134a | R513A | R515B |
|---|---|---|---|
| **Material Composition per Functional Unit [kg]** | | | |
| **Steel** | 4.71 | 4.71 | 4.71 |
| **Iron** | 2.80 | 2.80 | 2.80 |
| **Copper** | 1.79 | 1.79 | 1.79 |
| **Aluminum** | 0.03 | 0.03 | 0.03 |
| **Refrigerant** | 1.66 | 1.52 | 1.52 |
| **Other** | 0.12 | 0.12 | 0.12 |
| **Contribution to Total Material Composition [%]** | | | |

| | R134a | R513A | R515B |
|---|---|---|---|
| **Steel** | 42.4% | 42.9% | 42.9% |
| **Iron** | 25.2% | 25.5% | 25.5% |
| **Copper** | 16.1% | 16.3% | 16.3% |
| **Aluminum** | 0.3% | 0.3% | 0.3% |
| **Refrigerant** | 15.0% | 13.9% | 13.9% |
| **Other** | 1.1% | 1.1% | 1.1% |

## Manufacturing

All major components are manufactured within the US and the final assembly occurs at the main US manufacturing facility in Charlotte, NC. Components include the tube sheets, the evaporator, the condenser, and the control box.

Manufacture impacts of capital goods and infrastructure flows are excluded as they are estimated to impact, at most, 0.12 kg $CO_2e$ per ton of chilling capacity over the life cycle of the manufacturing infrastructure, which is considered negligible. This assumption is in alignment with typical building product LCA practice.

The functional unit according to the PCR is one (1) ton of chilling capacity. The products under study have a reference service life (RSL) of 25 years. Table 4 shows additional details related to the functional unit, reporting the values for the chiller with R134a.

*Table 4: Functional Unit Details*

| | Value | Unit |
|---|---|---|
| **Functional Unit** | 1 ton chilling capacity | |
| **Mass of one delivered product** | 5,542 | kg |
| **Conversion factor (kg per Functional Unit)** | 11.1 | kg/ton of chilling capacity |

## Transportation

The product is delivered to the customer via truck. Transportation distances are set by the PCR and are shown in Table 5, along with additional transportation data. It is assumed that each chiller is shipped individually using a flatbed truck. Additionally, it is assumed that the return route for the truck is empty. These factors contribute to a low-capacity utilization factor, as seen in the table.

*Table 5: Transport to Building Site (A4) per Functional Unit*

| | Value |
|---|---|
| **Vehicle Type** | 15,422 kg payload Flatbed Truck |
| **Fuel Efficiency [L/100km]** | 36.3 |
| **Fuel Type** | Diesel |
| **Distance [km]** | 500 |
| **Capacity Utilization [%]** | 16% |
| **Gross density of products transported [kg/m³]** | 405 |
| **Capacity utilization volume factor** | <1 |

Chillers are removed from the truck and positioned in HVAC rooms where all required connections to the HVAC system of the building are made.

## Installation

A crane is necessary to unload the chiller from the truck it is delivered on. It is assumed that 5,130 MJ of energy from diesel fuel are required for this unloading process. Other than unloading, installation procedures are assumed to be manual and require no operational energy use as described by the default assumptions in the PCR. It is assumed that no product loss occurs to the chiller during installation. The packaging waste is entirely TPE film and, as a shrink-wrapped film product, it only has one useful life and is assumed to be disposed of via landfilling. No single use accessories are required for the installation of the chillers.

*Table 6: Installation Scenario Details per Functional Unit*

| | Value | Unit |
|---|---|---|
| **Other energy carriers by type – Diesel Fuel** | 10.3 | MJ |
| **Packaging Waste to Landfill** | 0.0135 | kg |

## RSL and ESL Scenarios

Standard interior building operating conditions are assumed throughout the use phase of the chiller. The Reference Service Life (RSL) of the chiller is 25 years as described by the PCR. Details regarding the RSL and replacement of each configuration are provided in Table 7.

*Table 7: Reference Service Life and Estimated Service Life of Chillers*

| | Value | Unit |
|---|---|---|
| **Product RSL** | 25 | years |
| **Building ESL** | 75 | years |
| **Replacement Cycles** | 2 | cycles |
| **Use Conditions (Annual Energy Demand based on R134a refrigerant)** | 574,000 | kWh |

## Modules B2-B5 Scenarios

Tables describing use phase scenarios developed for modules B2-B5 are provided below.

Impacts from refrigerant loss are assigned to the maintenance impacts module (B2). A 2% refrigeration loss and replacement rate is assumed based on guidance from the PCR.

*Table 8: Maintenance (Module B2)*

| | Value | Unit |
|---|---|---|
| **Maintenance process information** | Replacement of leaked refrigerant assuming a 2% annual loss rate | n/a |
| **Maintenance cycle (per RSL)** | 25 | cycles |
| **Maintenance cycle (per ESL)** | 75 | cycles |
| **Refrigerant replacement, R134a** | 16.6 | kg |
| **Direct emissions to ambient air, soil and water (refrigerant to air)** | 16.6 | kg |

No inputs or outputs are associated with Module B3 (repair).

*Table 9: Replacement (Module B4)*

| | Value | Unit |
|---|---|---|
| **Replacement cycles (ESL/RSL-1)** | 2 | cycles |
| **Direct emissions to ambient air, soil and water (refrigerant to air) (R134a)** | 83 | kg |
| **Further assumptions for scenario development** | 90% of refrigerant is recovered at end of life but 10% is emitted to ambient air | As appropriate |

No inputs or outputs are associated with Module B5 (refurbishment).

## Operational Energy Use (Module B6)

Water cooled chillers transfer heat away from spaces that require climate control by cooling water and allowing it to absorb heat from an environment. The process involves a significant expenditure of electricity and requires a large charge of refrigerant. The operational energy requirements of chillers are highly dependent on the climate and demands of the location of installation. As such, the PCR has developed a calculation tool for generating a life cycle energy demand estimation.

Operational efficiencies of each chiller configuration are reported in Table 6. These values are imported into a standardized formula for determining the annual hours of operation and ultimate annual energy demand. This formula has been tested in compliance with ANSI/ASHARE Standard 140-2007, 2007 and was approved for use by UL. After determining the configuration efficiency, the calculator is used to determine the energy usage for each of 55 global city locations, independent of actual production markets. To determine the annual hours of operation and efficiency, calculations in the Centrifugal Chiller Average Efficiency Calculator excel file are based on actual weather data from the following 55 global cities:

> Atlanta, Bangkok, Beijing, Berlin, Boston, Buenos Aires, Cairo, Cancun, Cape Town, Caracas, Chicago, Dallas, Denver, Dubai, Hanoi, Ho Chi Minh, Hong Kong, Houston, Jerusalem, Kansas City, London, Los Angeles, Madrid, Manila, Melbourne, Mexico City, Miami, Moscow, Mumbai, New Delhi, Ottawa, Paris, Perth, Phoenix, Raleigh, Riyadh, Rome, San Diego, San Francisco, San Juan, Sao Paulo, Seattle, Seoul, Shanghai, Singapore, Sydney, Taipei, Tokyo, Toronto, Vancouver, Venice, Warsaw, and Washington, D.C.

Annual hours of operation and chiller capacity are defined as per the appended document for each respective chiller configuration. Chiller capacity is defined as the chilling capacity declared on the product.

*Table 10: Operational Energy Efficiencies and use (B6)*

| | R134a | R513A | R515B |
|---|---|---|---|
| **Annual Energy Demand [kWh]** | 574,000 | 587,000 | 718,000 |
| **Annual Energy Demand [kWh/Ton Chilling Capacity]** | 1,150 | 1,170 | 1,440 |

Use phase results for each impact category are highly dependent on the secondary dataset used to represent possible grid mixes. To display the variation in grid mix impacts, four sets of results are provided for module B6 and are represented in a separate table. The following grid mixes are represented within the results:

- Low - The lowest impact US grid mix (US: Electricity grid mix – NYUP Sphera)*
- Average - The US average grid mix (US: Electricity grid mix (eGRID) Sphera)
- High - The highest impact US grid mix ( US: Electricity grid mix – HIOA Sphera)*
- SWA - A sales weighted average grid mix from 2021 sales data**

*note that highest and lowest are defined according to IPCC AR5 GWP 100 Excluding Biogenic Carbon
**note that the sales weighted average grid mix is used to report LCA Indicators required by the PCR

Additionally, results are presented according to the ESL of 75 years, as required by the PCR, and the RSL of the product (25 years).

## Disposal

The chiller, in its entirety, is assumed to be delivered via truck to a recycling facility for dismantling and further product disposal. After separation at the facility, all metal components are assumed to be recycled and all plastic components are assumed to be landfilled. The refrigerant charge in the chiller at the time of disposal is assumed to be recycled at 90% with the remaining 10% lost to the atmosphere during disassembly. Table 11 shows the parameters for the end-of-life scenario utilized in the model for each model charged with R134a. Currently, products are not reused from chillers at the end-of-life.

*Table 11: End-of-Life Scenario Details (C1-C4)*

| | Value |
|---|---|
| **Collected separately** | 0 |
| **Collected as mixed construction waste [kg]** | 4,692 |
| **Waste to Reuse [kg]** | 0 |
| **Distance to Reuse [km]** | 0 |
| **Waste to Landfill [kg]** | 38 |
| **Distance to Landfill [km]** | 100 |
| **Waste to Incineration [kg]** | 0 |
| **Distance to Incineration [km]** | 0 |
| **Waste to Recycling [kg]** | 4,692 |
| **Distance to Recycling [km]** | 100 |

# 2 – LIFE CYCLE ASSESSMENT METHODOLOGY

*This LCA is a Cradle-to-Grave study. An overview of the system boundary is shown in Figure 2 and a summary of the life cycle stages included in this LCA is presented in Table 12.*

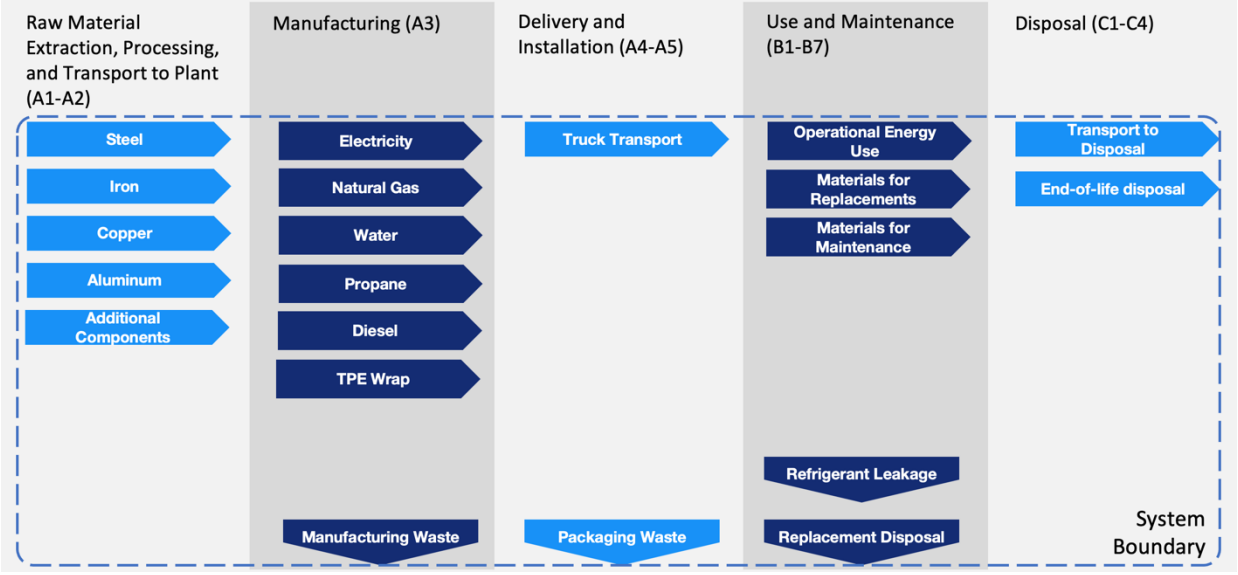



*Figure 2: System Boundary Diagram*

*Table 12: Life Cycle Stages Included in the Study*

| Production | | | Construction | | Use | | | | | | | End of Life | | | | Benefits & Loads Beyond System Boundary |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A1 | A2 | A3 | A4 | A5 | B1 | B2 | B3 | B4 | B5 | B6 | B7 | C1 | C2 | C3 | C4 | D |
| Raw Material Supply | Transport | Manufacturing | Transport to Site | Assembly/Install | Use | Maintenance | Repair | Replacement | Refurbishment | Operational Energy Use | Operational Water Use | Deconstruction | Transport | Waste Processing | Disposal | Reuse, Recovery, Recycling Potential |
| X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | ND |

X = Module Included in LCA Report, ND = Module not Declared

## Cut-off Criteria

Material inputs greater than 1% (based on total mass of the final product) were included within the scope of analysis. Material inputs less than 1% were included if sufficient data were available to warrant inclusion and/or the material input was thought to have significant environmental impact. Cumulative excluded material inputs and environmental impacts are less than 5% based on total weight of the functional unit.
The list of excluded materials and energy inputs include:

- As the tools used during the installation of the product are multi-use tools and can be reused after each installation, the per-declared unit impacts are considered negligible and therefore are not included.

- Some material inputs may have been excluded within the Sphera Managed LCA Content (MLC) version 2023.1 datasets used for this project. All MLC datasets have been critically reviewed and conform to the exclusion requirement of the PCR, Part A: "Calculation Rules for the Life Cycle Assessment and Requirements on the Background Report".

No known flows are deliberately excluded from this EPD.

## Allocation

General principles of allocation were based on ISO 14040/44. There are no products other than the product under study that are produced as part of the manufacturing processes. Since there are no co-products, no allocation based on co-products is required.

To derive a per-unit value for manufacturing electricity, the manufacturer provided data that reported an electricity demand value per kg of material used by specifying material type. This value was scaled to all materials of the same type to arrive at the total energy demand for the chiller. The proportion of the energy demand for one chiller of a given configuration to the total electricity consumed by the facility was applied to other manufacturing inputs such as thermal energy and water. Scrap rates were also determined on a material basis using the same dataset. As a default, secondary LCA for Experts datasets use a physical basis for allocation.

Of relevance to the defined system boundary is the method by which recycled materials were handled. Throughout the study recycled materials were accounted for via the cut-off method. Under this method, impacts and benefits associated with the previous life of a raw material from recycled stock are excluded from the system boundary. Additionally, impacts and benefits associated with secondary functions of materials at end of life are also excluded (i.e., production into a third life or energy generation from the incineration plant). The study does include the impacts associated with reprocessing and preparation of recycled materials that are part of the bill of materials of the products under study.

This allocation methodology was used for the following inputs:

- Electricity
- Diesel
- Thermal Energy from Natural Gas
- Propane
- TPE Film
- Waste

## Data Quality

Primary data was collected from the manufacturer specific to the temporal and technological aspects of the chiller life cycle. All primary data is from calendar year 2021. Secondary data was sourced from Sphera MLC Datasets, taking into consideration the most accurate and representative options. The data included is considered complete.

The precision of the data is considered high and represents detailed Bills of Materials provided by facility engineers.

The data is considered complete and does not exclude any known energy or material flows except those clearly stated in the cut-off criteria section.

The consistency of the LCA is considered high with the Bills of Materials generated from regularly maintained internal documentation. Modeling assumptions are consistent across the model and preference of secondary datasets is given towards Sphera MLC data, where available.

This study is considered reproducible. Descriptions of the data and assumptions through this report would allow a practitioner to utilize the LCA tool to generate results for the products.

Uncertainty in primary data comes from utility data in water and natural gas consumption. Manufacturing electricity requirements were determined from product-specific internal estimations.

# 3 – LIFE CYCLE ASSESSMENT RESULTS

All results are given per functional unit, which is one Ton of Chilling Capacity.
Environmental Impacts were calculated using the LCA for Experts software platform. Impact results have been calculated using IPCC AR5 and TRACI 2.1 characterization factors (IPCC, 2021; US EPA, 2012). Results presented in this report are relative expressions and do not predict impacts on category endpoints, the exceeding of thresholds, safety margins, or risks.

*Table 13: LCIA Indicators*

| Abbreviation | Parameter | Unit |
|---|---|---|
| **IPCC AR5** | | |
| **GWP** | Global warming potential (100 years, excludes biogenic $CO_2$) | kg $CO_2$ eq |
| **TRACI 2.1** | | |
| **AP** | Acidification potential of soil and water | kg $SO_2$ eq |
| **EP** | Eutrophication potential | kg N eq |
| **GWP** | Global warming potential (100 years, excludes biogenic $CO_2$) | kg $CO_2$ eq |
| **ODP** | Depletion of stratospheric ozone layer | kg CFC 11 eq |
| **Resources** | Depletion of non-renewable fossil fuels | MJ, surplus energy |
| **SFP** | Smog formation potential | kg $O_3$ eq |

These six impact categories are globally deemed mature enough to be included in Type III environmental declarations. Other categories are being developed and defined and LCA should continue making advances in their development, however the EPD users shall not use additional measures for comparative purposes.

Third party verified ISO 14040/44 secondary LCI data sets contribute more than 67% of total impact to the required impact categories identified by the applicable PCR.

Biogenic Carbon Removal and Emissions are required to be reported according to ISO 21930. However, no biogenic carbon is relevant to the product or its packaging. As such, no impacts are reported.

In addition to the environmental parameters described in the previous section, the following resource use and waste categories are also disclosed.

*Table 14: Resource Use, Waste, and Output Flow Indicators*

| Abbreviation | Parameter | Unit |
|---|---|---|
| **Resource Use Parameters** | | |
| **$RPR_E$** | Use of renewable primary energy excluding renewable primary energy resources used as raw materials | MJ, net calorific value (LHV) |
| **$RPR_M$** | Use of renewable primary energy resources used as raw materials | MJ, net calorific value |
| **$RPR_T$** | Total use of renewable primary energy resources | MJ, net calorific value |
| **$NRPR_E$** | Use of non-renewable primary energy excluding non-renewable primary energy resources used as raw materials | MJ, net calorific value |
| **$NRPR_M$** | Use of non-renewable primary energy resources used as raw materials | MJ, net calorific value |
| **$NRPR_T$** | Total use of non-renewable primary energy resources | MJ, net calorific value |
| **SM** | Use of secondary materials | kg |
| **RSF** | Use of renewable secondary fuels | MJ, net calorific value |
| **NRSF** | Use of non-renewable secondary fuels | MJ, net calorific value |
| **RE** | Recovered energy | MJ, net calorific value |
| **FW** | Net use of fresh water | $m^3$ |
| **Waste Parameters and Output Flows** | | |

| Abbreviation | Parameter | Unit |
|---|---|---|
| **HWD** | Disposed-of hazardous waste | kg |
| **NHWD** | Disposed-of non-hazardous waste | kg |
| **HLRW** | High-level radioactive waste, conditioned, to final repository | kg |
| **ILLRW** | Intermediate- and low-level radioactive waste, conditioned, to final repository | kg |
| **CRU** | Components for reuse | kg |
| **MR** | Materials for recycling | kg |
| **MER** | Materials for energy recovery | kg |
| **EEE** | Exported electrical energy | MJ |
| **EET** | Exported thermal energy | MJ |

## AquaEdge® 19MV Water-Cooled Centrifugal Chiller

The LCIA results presented below are for 1 ton of chilling capacity of AquaEdge® 19MV (R134a).

*Table 15: LCIA results for AquaEdge® 19MV (R134a), per 1 ton of chilling capacity*

| Impact Category | A1-A3 | A4 | A5 | B1 | B2 | B3 | B4 | B5 | B6 | B7 | C1 | C2 | C3 | C4 | D |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **IPCC AR 5 (Global)** | | | | | | | | | | | | | | | |
| **GWP [kg $CO_2$ eq]** | 7.98E+01 | 2.03E-01 | 1.05E+00 | 0.00E+00 | 2.63E+03 | 0.00E+00 | 5.89E+02 | 0.00E+00 | * | 0.00E+00 | 0.00E+00 | 2.56E-01 | 0.00E+00 | 2.13E+02 | ND |
| **TRACI LCIA Impacts (North America)** | | | | | | | | | | | | | | | |
| **AP [kg $SO_2$ eq]** | 1.71E-01 | 3.69E-04 | 9.18E-03 | 0.00E+00 | 5.25E-02 | 0.00E+00 | 3.64E-01 | 0.00E+00 | * | 0.00E+00 | 0.00E+00 | 8.46E-04 | 0.00E+00 | 1.75E-04 | ND |
| **EP [kg N eq]** | 8.14E-03 | 4.64E-05 | 7.01E-04 | 0.00E+00 | 1.72E-03 | 0.00E+00 | 1.80E-02 | 0.00E+00 | * | 0.00E+00 | 0.00E+00 | 8.29E-05 | 0.00E+00 | 3.16E-05 | ND |
| **GWP [kg $CO_2$ eq]** | 8.10E+01 | 2.00E-01 | 1.03E+00 | 0.00E+00 | 2.43E+03 | 0.00E+00 | 5.59E+02 | 0.00E+00 | * | 0.00E+00 | 0.00E+00 | 2.52E-01 | 0.00E+00 | 1.97E+02 | ND |
| **ODP [kg CFC 11 eq]** | 1.16E-10 | 5.20E-16 | 2.70E-15 | 0.00E+00 | 5.54E-13 | 0.00E+00 | 2.32E-10 | 0.00E+00 | * | 0.00E+00 | 0.00E+00 | 6.55E-16 | 0.00E+00 | 1.30E-15 | ND |
| **Resources [MJ]** | 6.15E+01 | 3.75E-01 | 1.94E+00 | 0.00E+00 | 3.58E+01 | 0.00E+00 | 1.29E+02 | 0.00E+00 | * | 0.00E+00 | 0.00E+00 | 4.73E-01 | 0.00E+00 | 5.34E-02 | ND |
| **SFP [kg $O_3$ eq]** | 1.93E+00 | 8.36E-03 | 3.21E-01 | 0.00E+00 | 4.53E-01 | 0.00E+00 | 4.57E+00 | 0.00E+00 | * | 0.00E+00 | 0.00E+00 | 1.94E-02 | 0.00E+00 | 2.57E-03 | ND |

The LCIA Module B6 Impact Scenarios presented below are for 1 ton of chilling capacity of AquaEdge® 19MV (R134a).

*Table 16: B6 LCIA results for AquaEdge® 19MV (R134a), per 1 ton of chilling capacity*

| Impact Category | Low | Average | High | SWA | Low | Average | High | SWA |
|---|---|---|---|---|---|---|---|---|
| | ESL Impacts (75 Years) | | | | RSL Impacts (25 Years) | | | |
| **IPCC AR 5 (Global)** | | | | | | | | |
| **GWP [kg $CO_2$ eq]** | 1.24E+04 | 3.84E+04 | 8.10E+04 | 3.67E+04 | 4.12E+03 | 1.28E+04 | 2.70E+04 | 1.22E+04 |
| **TRACI LCIA Impacts (North America)** | | | | | | | | |
| **AP [kg $SO_2$ eq]** | 1.74E+01 | 5.25E+01 | 4.31E+02 | 7.35E+01 | 5.79E+00 | 1.75E+01 | 1.44E+02 | 2.45E+01 |
| **EP [kg N eq]** | 2.57E+00 | 4.12E+00 | 1.28E+01 | 4.53E+00 | 8.57E-01 | 1.37E+00 | 4.26E+00 | 1.51E+00 |
| **GWP [kg $CO_2$ eq]** | 1.24E+04 | 3.84E+04 | 8.10E+04 | 3.57E+04 | 4.12E+03 | 1.28E+04 | 2.70E+04 | 1.19E+04 |
| **ODP [kg CFC 11 eq]** | 1.64E-09 | 4.48E-09 | 1.04E-08 | 1.22E-08 | 5.47E-10 | 1.49E-09 | 3.47E-09 | 4.07E-09 |
| **Resources [MJ]** | 2.58E+04 | 4.42E+04 | 1.03E+05 | 4.20E+04 | 8.60E+03 | 1.47E+04 | 3.45E+04 | 1.40E+04 |
| **SFP [kg $O_3$ eq]** | 3.50E+02 | 7.35E+02 | 4.43E+03 | 7.60E+02 | 1.17E+02 | 2.45E+02 | 1.48E+03 | 2.53E+02 |

The LCI results presented below are for 1 ton of chilling capacity of AquaEdge® 19MV (R134a).

*Table 17: Resource use, waste, and output flow results for AquaEdge® 19MV (R134a), per 1 ton of chilling capacity*

| Impact Category | A1-A3 | A4 | A5 | B1 | B2 | B3 | B4 | B5 | B6 | B7 | C1 | C2 | C3 | C4 | D |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Resource Use Indicators** | | | | | | | | | | | | | | | |
| **$RPR_E$ [MJ]** | 9.04E+01 | 1.13E-01 | 5.85E-01 | 0.00E+00 | 2.22E+01 | 0.00E+00 | 1.83E+02 | 0.00E+00 | 2.80E+05 | 0.00E+00 | 0.00E+00 | 1.42E-01 | 0.00E+00 | 4.97E-02 | ND |
| **$RPR_M$ [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 | ND |
| **$RPR_T$ [MJ]** | 9.04E+01 | 1.13E-01 | 5.85E-01 | 0.00E+00 | 2.22E+01 | 0.00E+00 | 1.83E+02 | 0.00E+00 | 2.80E+05 | 0.00E+00 | 0.00E+00 | 1.42E-01 | 0.00E+00 | 4.97E-02 | ND |
| **$NRPR_E$ [MJ]** | 6.92E+02 | 2.84E+00 | 1.47E+01 | 0.00E+00 | 3.03E+02 | 0.00E+00 | 1.43E+03 | 0.00E+00 | 6.62E+05 | 0.00E+00 | 0.00E+00 | 3.57E+00 | 0.00E+00 | 4.25E-01 | ND |
| **$NRPR_M$ [MJ]** | 2.72E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 5.43E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | ND |
| **$NRPR_T$ [MJ]** | 6.95E+02 | 2.84E+00 | 1.47E+01 | 0.00E+00 | 3.03E+02 | 0.00E+00 | 1.43E+03 | 0.00E+00 | 6.62E+05 | 0.00E+00 | 0.00E+00 | 3.57E+00 | 0.00E+00 | 4.25E-01 | ND |
| **SM [kg]** | 1.36E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 2.71E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | ND |
| **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 | ND |
| **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 | ND |
| **RE [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 | ND |
| **FW [$m^3$]** | 3.20E-01 | 3.87E-04 | 2.00E-03 | 0.00E+00 | 1.50E-01 | 0.00E+00 | 6.46E-01 | 0.00E+00 | 2.90E+02 | 0.00E+00 | 0.00E+00 | 4.88E-04 | 0.00E+00 | 5.26E-05 | ND |
| **Output Flows and Waste Categories** | | | | | | | | | | | | | | | |
| **HWD [kg]** | 2.71E-05 | 8.15E-12 | 4.23E-11 | 0.00E+00 | 1.01E-08 | 0.00E+00 | 5.42E-05 | 0.00E+00 | 2.59E-05 | 0.00E+00 | 0.00E+00 | 1.03E-11 | 0.00E+00 | 1.06E-11 | ND |
| **NHWD [kg]** | 1.17E+00 | 2.47E-04 | 1.29E-02 | 0.00E+00 | 1.79E-01 | 0.00E+00 | 4.91E+00 | 0.00E+00 | 2.15E+02 | 0.00E+00 | 0.00E+00 | 3.11E-04 | 0.00E+00 | 1.27E+00 | ND |
| **HLRW [kg]** | 2.43E-05 | 9.65E-09 | 5.00E-08 | 0.00E+00 | 1.06E-05 | 0.00E+00 | 4.88E-05 | 0.00E+00 | 8.78E-02 | 0.00E+00 | 0.00E+00 | 1.22E-08 | 0.00E+00 | 5.25E-09 | ND |
| **ILLRW [kg]** | 2.09E-02 | 8.12E-06 | 4.21E-05 | 0.00E+00 | 8.89E-03 | 0.00E+00 | 4.19E-02 | 0.00E+00 | 7.33E+01 | 0.00E+00 | 0.00E+00 | 1.02E-05 | 0.00E+00 | 4.70E-06 | ND |
| **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 | ND |
| **MR [kg]** | 2.37E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 2.08E+01 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 8.05E+00 | ND |
| **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 | ND |
| **EEE [MJ]** | 3.78E-05 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 7.55E-05 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | ND |
| **EET [MJ]** | 1.78E-05 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 3.55E-05 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | ND |

The LCIA results presented below are for 1 ton of chilling capacity of AquaEdge® 19MV (R513A).

*Table 18: LCIA results for AquaEdge® 19MV (R513A), per 1 ton of chilling capacity*

| Impact Category | A1-A3 | A4 | A5 | B1 | B2 | B3 | B4 | B5 | B6 | B7 | C1 | C2 | C3 | C4 | D |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **IPCC AR 5 (Global)** | | | | | | | | | | | | | | | |
| **GWP [kg $CO_2$ eq]** | 7.56E+01 | 2.03E-01 | 1.05E+00 | 0.00E+00 | 1.08E+03 | 0.00E+00 | 3.42E+02 | 0.00E+00 | * | 0.00E+00 | 0.00E+00 | 2.56E-01 | 0.00E+00 | 9.39E+01 | ND |
| **TRACI LCIA Impacts (North America)** | | | | | | | | | | | | | | | |
| **AP [kg $SO_2$ eq]** | 1.67E-01 | 3.69E-04 | 9.18E-03 | 0.00E+00 | 4.79E-02 | 0.00E+00 | 3.55E-01 | 0.00E+00 | * | 0.00E+00 | 0.00E+00 | 8.46E-04 | 0.00E+00 | 1.75E-04 | ND |
| **EP [kg N eq]** | 7.99E-03 | 4.64E-05 | 7.01E-04 | 0.00E+00 | 1.57E-03 | 0.00E+00 | 1.77E-02 | 0.00E+00 | * | 0.00E+00 | 0.00E+00 | 8.29E-05 | 0.00E+00 | 3.16E-05 | ND |
| **GWP [kg $CO_2$ eq]** | 7.66E+01 | 2.00E-01 | 1.03E+00 | 0.00E+00 | 1.00E+03 | 0.00E+00 | 3.29E+02 | 0.00E+00 | * | 0.00E+00 | 0.00E+00 | 2.52E-01 | 0.00E+00 | 8.66E+01 | ND |
| **ODP [kg CFC 11 eq]** | 1.16E-10 | 5.20E-16 | 2.70E-15 | 0.00E+00 | 5.06E-13 | 0.00E+00 | 2.32E-10 | 0.00E+00 | * | 0.00E+00 | 0.00E+00 | 6.55E-16 | 0.00E+00 | 1.30E-15 | ND |
| **Resources [MJ]** | 5.84E+01 | 3.75E-01 | 1.94E+00 | 0.00E+00 | 3.27E+01 | 0.00E+00 | 1.22E+02 | 0.00E+00 | * | 0.00E+00 | 0.00E+00 | 4.73E-01 | 0.00E+00 | 5.34E-02 | ND |
| **SFP [kg $O_3$ eq]** | 1.89E+00 | 8.36E-03 | 3.21E-01 | 0.00E+00 | 6.51E-01 | 0.00E+00 | 4.53E+00 | 0.00E+00 | * | 0.00E+00 | 0.00E+00 | 1.94E-02 | 0.00E+00 | 2.41E-02 | ND |

The LCIA Module B6 Impact Scenarios presented below are for 1 ton of chilling capacity of AquaEdge® 19MV (R513A).

*Table 19: B6 LCIA results for AquaEdge® 19MV (R513A), per 1 ton of chilling capacity*

| Impact Category | Low | Average | High | SWA | Low | Average | High | SWA |
|---|---|---|---|---|---|---|---|---|
| | ESL Impacts (75 Years) | | | | RSL Impacts (25 Years) | | | |
| **IPCC AR 5 (Global)** | | | | | | | | |
| **GWP [kg $CO_2$ eq]** | 1.27E+04 | 3.93E+04 | 8.28E+04 | 3.75E+04 | 4.22E+03 | 1.31E+04 | 2.76E+04 | 1.25E+04 |
| **TRACI LCIA Impacts (North America)** | | | | | | | | |
| **AP [kg $SO_2$ eq]** | 1.78E+01 | 5.36E+01 | 4.40E+02 | 7.52E+01 | 5.92E+00 | 1.79E+01 | 1.47E+02 | 2.51E+01 |
| **EP [kg N eq]** | 2.63E+00 | 4.21E+00 | 1.31E+01 | 4.63E+00 | 8.76E-01 | 1.40E+00 | 4.36E+00 | 1.54E+00 |
| **GWP [kg $CO_2$ eq]** | 1.27E+04 | 3.93E+04 | 8.28E+04 | 3.65E+04 | 4.22E+03 | 1.31E+04 | 2.76E+04 | 1.22E+04 |
| **ODP [kg CFC 11 eq]** | 1.68E-09 | 4.58E-09 | 1.06E-08 | 1.25E-08 | 5.59E-10 | 1.53E-09 | 3.55E-09 | 4.17E-09 |
| **Resources [MJ]** | 2.64E+04 | 4.52E+04 | 1.06E+05 | 4.30E+04 | 8.80E+03 | 1.51E+04 | 3.53E+04 | 1.43E+04 |
| **SFP [kg $O_3$ eq]** | 3.58E+02 | 7.52E+02 | 4.53E+03 | 7.77E+02 | 1.19E+02 | 2.51E+02 | 1.51E+03 | 2.59E+02 |

The LCI results presented below are for 1 ton of chilling capacity of AquaEdge® 19MV (R513A).

*Table 20: Resource use, waste, and output flow results for AquaEdge® 19MV (R513A), per 1 ton of chilling capacity*

| Impact Category | A1-A3 | A4 | A5 | B1 | B2 | B3 | B4 | B5 | B6 | B7 | C1 | C2 | C3 | C4 | D |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Resource Use Indicators** | | | | | | | | | | | | | | | |
| **$RPR_E$ [MJ]** | 8.85E+01 | 1.13E-01 | 5.85E-01 | 0.00E+00 | 2.03E+01 | 0.00E+00 | 1.79E+02 | 0.00E+00 | 2.87E+05 | 0.00E+00 | 0.00E+00 | 1.42E-01 | 0.00E+00 | 4.97E-02 | ND |
| **$RPR_M$ [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 | ND |
| **$RPR_T$ [MJ]** | 8.85E+01 | 1.13E-01 | 5.85E-01 | 0.00E+00 | 2.03E+01 | 0.00E+00 | 1.79E+02 | 0.00E+00 | 2.87E+05 | 0.00E+00 | 0.00E+00 | 1.42E-01 | 0.00E+00 | 4.97E-02 | ND |
| **$NRPR_E$ [MJ]** | 6.65E+02 | 2.84E+00 | 1.47E+01 | 0.00E+00 | 2.76E+02 | 0.00E+00 | 1.37E+03 | 0.00E+00 | 6.76E+05 | 0.00E+00 | 0.00E+00 | 3.57E+00 | 0.00E+00 | 4.25E-01 | ND |
| **$NRPR_M$ [MJ]** | 2.72E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 5.43E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | ND |
| **$NRPR_T$ [MJ]** | 6.68E+02 | 2.84E+00 | 1.47E+01 | 0.00E+00 | 2.76E+02 | 0.00E+00 | 1.38E+03 | 0.00E+00 | 6.76E+05 | 0.00E+00 | 0.00E+00 | 3.57E+00 | 0.00E+00 | 4.25E-01 | ND |
| **SM [kg]** | 1.36E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 2.71E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | ND |
| **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 | ND |
| **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 | ND |
| **RE [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 | ND |
| **FW [$m^3$]** | 3.07E-01 | 3.87E-04 | 2.00E-03 | 0.00E+00 | 1.37E-01 | 0.00E+00 | 6.19E-01 | 0.00E+00 | 2.96E+02 | 0.00E+00 | 0.00E+00 | 4.88E-04 | 0.00E+00 | 5.26E-05 | ND |
| **Output Flows and Waste Categories** | | | | | | | | | | | | | | | |
| **HWD [kg]** | 2.71E-05 | 8.15E-12 | 4.23E-11 | 0.00E+00 | 9.19E-09 | 0.00E+00 | 5.42E-05 | 0.00E+00 | 2.64E-05 | 0.00E+00 | 0.00E+00 | 1.03E-11 | 0.00E+00 | 1.06E-11 | ND |
| **NHWD [kg]** | 1.16E+00 | 2.47E-04 | 1.29E-02 | 0.00E+00 | 1.63E-01 | 0.00E+00 | 4.88E+00 | 0.00E+00 | 2.19E+02 | 0.00E+00 | 0.00E+00 | 3.11E-04 | 0.00E+00 | 1.27E+00 | ND |
| **HLRW [kg]** | 2.34E-05 | 9.65E-09 | 5.00E-08 | 0.00E+00 | 9.70E-06 | 0.00E+00 | 4.70E-05 | 0.00E+00 | 8.97E-02 | 0.00E+00 | 0.00E+00 | 1.22E-08 | 0.00E+00 | 5.25E-09 | ND |
| **ILLRW [kg]** | 2.01E-02 | 8.12E-06 | 4.21E-05 | 0.00E+00 | 8.12E-03 | 0.00E+00 | 4.04E-02 | 0.00E+00 | 7.50E+01 | 0.00E+00 | 0.00E+00 | 1.02E-05 | 0.00E+00 | 4.70E-06 | ND |
| **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 | ND |
| **MR [kg]** | 2.37E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 2.08E+01 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 8.05E+00 | ND |
| **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 | ND |
| **EEE [MJ]** | 3.78E-05 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 7.55E-05 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | ND |
| **EET [MJ]** | 1.78E-05 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 3.55E-05 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | ND |

The LCIA results presented below are for 1 ton of chilling capacity of AquaEdge® 19MV (R515B).

*Table 21: LCIA results for AquaEdge® 19MV (R515B), per 1 ton of chilling capacity*

| Impact Category | A1-A3 | A4 | A5 | B1 | B2 | B3 | B4 | B5 | B6 | B7 | C1 | C2 | C3 | C4 | D |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **IPCC AR 5 (Global)** | | | | | | | | | | | | | | | |
| **GWP [kg $CO_2$ eq]** | 7.56E+01 | 2.03E-01 | 1.05E+00 | 0.00E+00 | 5.68E+02 | 0.00E+00 | 2.49E+02 | 0.00E+00 | * | 0.00E+00 | 0.00E+00 | 2.56E-01 | 0.00E+00 | 4.74E+01 | ND |
| **TRACI LCIA Impacts (North America)** | | | | | | | | | | | | | | | |
| **AP [kg $SO_2$ eq]** | 1.67E-01 | 3.69E-04 | 9.18E-03 | 0.00E+00 | 4.79E-02 | 0.00E+00 | 3.55E-01 | 0.00E+00 | * | 0.00E+00 | 0.00E+00 | 8.46E-04 | 0.00E+00 | 1.75E-04 | ND |
| **EP [kg N eq]** | 7.99E-03 | 4.64E-05 | 7.01E-04 | 0.00E+00 | 1.57E-03 | 0.00E+00 | 1.77E-02 | 0.00E+00 | * | 0.00E+00 | 0.00E+00 | 8.29E-05 | 0.00E+00 | 3.16E-05 | ND |
| **GWP [kg $CO_2$ eq]** | 7.66E+01 | 2.00E-01 | 1.03E+00 | 0.00E+00 | 4.81E+02 | 0.00E+00 | 2.35E+02 | 0.00E+00 | * | 0.00E+00 | 0.00E+00 | 2.52E-01 | 0.00E+00 | 3.95E+01 | ND |
| **ODP [kg CFC 11 eq]** | 1.16E-10 | 5.20E-16 | 2.70E-15 | 0.00E+00 | 5.06E-13 | 0.00E+00 | 2.32E-10 | 0.00E+00 | * | 0.00E+00 | 0.00E+00 | 6.55E-16 | 0.00E+00 | 1.30E-15 | ND |
| **Resources [MJ]** | 5.84E+01 | 3.75E-01 | 1.94E+00 | 0.00E+00 | 3.27E+01 | 0.00E+00 | 1.22E+02 | 0.00E+00 | * | 0.00E+00 | 0.00E+00 | 4.73E-01 | 0.00E+00 | 5.34E-02 | ND |
| **SFP [kg $O_3$ eq]** | 1.89E+00 | 8.36E-03 | 3.21E-01 | 0.00E+00 | 5.49E-01 | 0.00E+00 | 4.51E+00 | 0.00E+00 | * | 0.00E+00 | 0.00E+00 | 1.94E-02 | 0.00E+00 | 1.48E-02 | ND |

The LCIA Module B6 Impact Scenarios presented below are for 1 ton of chilling capacity of AquaEdge® 19MV (R515B).

*Table 22: B6 LCIA results for AquaEdge® 19MV (R515B), per 1 ton of chilling capacity*

| Impact Category | Low | Average | High | SWA | Low | Average | High | SWA |
|---|---|---|---|---|---|---|---|---|
| | ESL Impacts (75 Years) | | | | RSL Impacts (25 Years) | | | |
| **IPCC AR 5 (Global)** | | | | | | | | |
| **GWP [kg $CO_2$ eq]** | 1.55E+04 | 4.81E+04 | 1.01E+05 | 4.59E+04 | 5.16E+03 | 1.60E+04 | 3.38E+04 | 1.53E+04 |
| **TRACI LCIA Impacts (North America)** | | | | | | | | |
| **AP [kg $SO_2$ eq]** | 2.17E+01 | 6.56E+01 | 5.39E+02 | 9.20E+01 | 7.25E+00 | 2.19E+01 | 1.80E+02 | 3.07E+01 |
| **EP [kg N eq]** | 3.22E+00 | 5.15E+00 | 1.60E+01 | 5.66E+00 | 1.07E+00 | 1.72E+00 | 5.33E+00 | 1.89E+00 |
| **GWP [kg $CO_2$ eq]** | 1.55E+04 | 4.81E+04 | 1.01E+05 | 4.47E+04 | 5.16E+03 | 1.60E+04 | 3.38E+04 | 1.49E+04 |
| **ODP [kg CFC 11 eq]** | 2.05E-09 | 5.60E-09 | 1.30E-08 | 1.53E-08 | 6.84E-10 | 1.87E-09 | 4.34E-09 | 5.10E-09 |
| **Resources [MJ]** | 3.23E+04 | 5.53E+04 | 1.29E+05 | 5.26E+04 | 1.08E+04 | 1.84E+04 | 4.31E+04 | 1.75E+04 |
| **SFP [kg $O_3$ eq]** | 4.38E+02 | 9.20E+02 | 5.54E+03 | 9.50E+02 | 1.46E+02 | 3.07E+02 | 1.85E+03 | 3.17E+02 |

The LCI results presented below are for 1 ton of chilling capacity of AquaEdge® 19MV (R515B).

*Table 23: Resource use, waste, and output flow results for AquaEdge® 19MV (R515B), per 1 ton of chilling capacity*

| Impact Category | A1-A3 | A4 | A5 | B1 | B2 | B3 | B4 | B5 | B6 | B7 | C1 | C2 | C3 | C4 | D |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Resource Use Indicators** | | | | | | | | | | | | | | | |
| **$RPR_E$ [MJ]** | 8.85E+01 | 1.13E-01 | 5.85E-01 | 0.00E+00 | 2.03E+01 | 0.00E+00 | 1.79E+02 | 0.00E+00 | 3.51E+05 | 0.00E+00 | 0.00E+00 | 1.42E-01 | 0.00E+00 | 4.97E-02 | ND |
| **$RPR_M$ [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 | ND |
| **$RPR_T$ [MJ]** | 8.85E+01 | 1.13E-01 | 5.85E-01 | 0.00E+00 | 2.03E+01 | 0.00E+00 | 1.79E+02 | 0.00E+00 | 3.51E+05 | 0.00E+00 | 0.00E+00 | 1.42E-01 | 0.00E+00 | 4.97E-02 | ND |
| **$NRPR_E$ [MJ]** | 6.65E+02 | 2.84E+00 | 1.47E+01 | 0.00E+00 | 2.76E+02 | 0.00E+00 | 1.37E+03 | 0.00E+00 | 8.28E+05 | 0.00E+00 | 0.00E+00 | 3.57E+00 | 0.00E+00 | 4.25E-01 | ND |
| **$NRPR_M$ [MJ]** | 2.72E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 5.43E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | ND |
| **$NRPR_T$ [MJ]** | 6.68E+02 | 2.84E+00 | 1.47E+01 | 0.00E+00 | 2.76E+02 | 0.00E+00 | 1.38E+03 | 0.00E+00 | 8.28E+05 | 0.00E+00 | 0.00E+00 | 3.57E+00 | 0.00E+00 | 4.25E-01 | ND |
| **SM [kg]** | 1.36E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 2.71E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | ND |
| **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 | ND |
| **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 | ND |
| **RE [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 | ND |
| **FW [$m^3$]** | 3.07E-01 | 3.87E-04 | 2.00E-03 | 0.00E+00 | 1.37E-01 | 0.00E+00 | 6.19E-01 | 0.00E+00 | 3.63E+02 | 0.00E+00 | 0.00E+00 | 4.88E-04 | 0.00E+00 | 5.26E-05 | ND |
| **Output Flows and Waste Categories** | | | | | | | | | | | | | | | |
| **HWD [kg]** | 2.71E-05 | 8.15E-12 | 4.23E-11 | 0.00E+00 | 9.19E-09 | 0.00E+00 | 5.42E-05 | 0.00E+00 | 3.23E-05 | 0.00E+00 | 0.00E+00 | 1.03E-11 | 0.00E+00 | 1.06E-11 | ND |
| **NHWD [kg]** | 1.16E+00 | 2.47E-04 | 1.29E-02 | 0.00E+00 | 1.63E-01 | 0.00E+00 | 4.88E+00 | 0.00E+00 | 2.68E+02 | 0.00E+00 | 0.00E+00 | 3.11E-04 | 0.00E+00 | 1.27E+00 | ND |
| **HLRW [kg]** | 2.34E-05 | 9.65E-09 | 5.00E-08 | 0.00E+00 | 9.70E-06 | 0.00E+00 | 4.70E-05 | 0.00E+00 | 1.10E-01 | 0.00E+00 | 0.00E+00 | 1.22E-08 | 0.00E+00 | 5.25E-09 | ND |
| **ILLRW [kg]** | 2.01E-02 | 8.12E-06 | 4.21E-05 | 0.00E+00 | 8.12E-03 | 0.00E+00 | 4.04E-02 | 0.00E+00 | 9.17E+01 | 0.00E+00 | 0.00E+00 | 1.02E-05 | 0.00E+00 | 4.70E-06 | ND |
| **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 | ND |
| **MR [kg]** | 2.37E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 2.08E+01 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 8.05E+00 | ND |
| **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 | ND |
| **EEE [MJ]** | 3.78E-05 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 7.55E-05 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | ND |
| **EET [MJ]** | 1.78E-05 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 3.55E-05 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | ND |

# 4 – LIFE CYCLE ASSESSMENT INTERPRETATION

A dominance analysis was performed to show which of the life cycle modules contributes to most of the impacts. Due to the relevance of these impact categories to the product type and the manufacturer's interests, this dominance analysis will be provided for IPCC AR5 Global Warming Potential (GWP) results and TRACI Acidification Potential (AP) results.

## Global Warming Potential (GWP)

Global warming potential (GWP) is a measure of how much heat a greenhouse gas traps in the atmosphere up to a specified time horizon and measured relative to carbon dioxide.

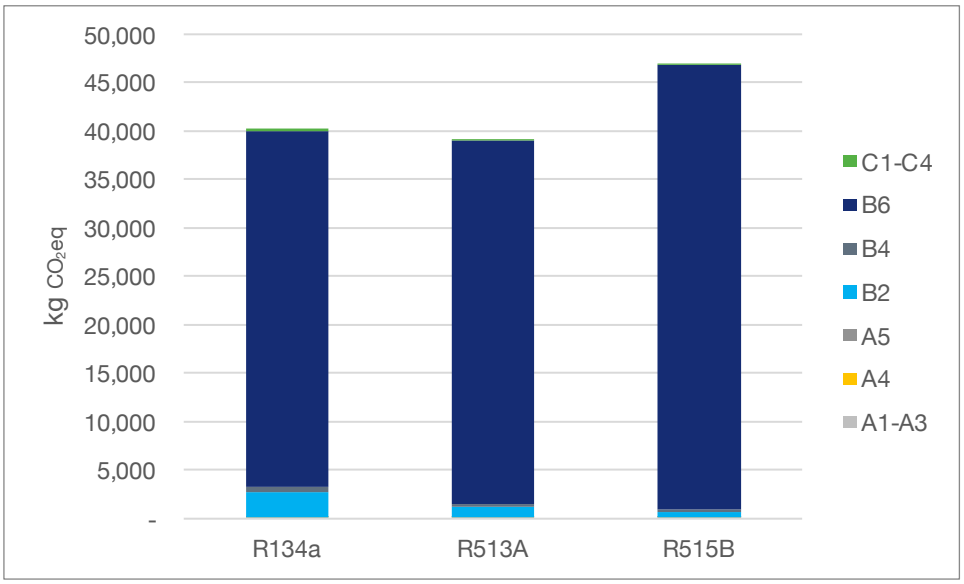



*Figure 3: GWP Dominance Analysis (impacts per Ton Chilling Capacity)*

GWP for this dominance analysis was calculated using IPCC AR5 emission factors as they are more up to date than TRACI GWP factors. The dominating driver of GWP impacts are the emissions associated with generating electricity used during the operational energy use module of the life cycle (B6). Additionally, B2 contributes somewhat to the total impacts as the leakage of refrigerant during the use phase results in significant impacts of refrigerant lost to the atmosphere. Impacts of B2 are driven both by the upstream manufacturing requirements to produce additional refrigerant and the emissions associated with the leaked refrigerant. Leaked refrigerant is the primary driver of B1 impacts, contributing to 98% of B2.

## Acidification Potential (AP)

Acidification Potential (AP) refers to the acidification of soils and water due to the release of gasses such as nitrogen oxides and sulfur oxides which increase the concentration of hydrogen ions (H+) within the local environment.

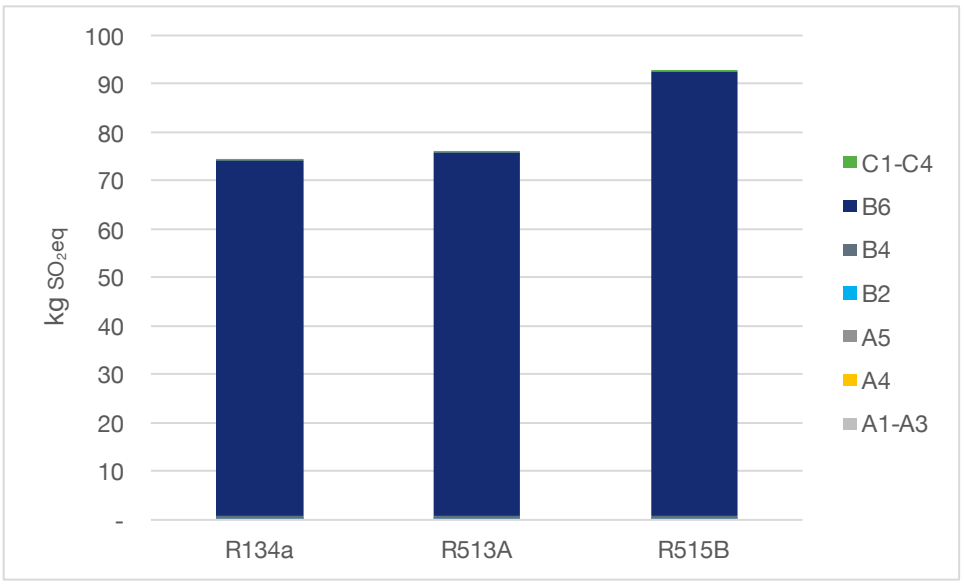



*Figure 4: System Boundary Diagram*

The release of refrigerants into the atmosphere do not meaningfully contribute to AP. The burning of coal or other fossil-based sources of energy for the generation of power contributes to AP. The energy associated with the operational energy use of the product is overwhelming. As a result, the only module which is visible in the figure is the use phase.
This is the case for all other impact categories considered including EP, ODP, SFP, and Resources.

## Further Analysis

Further analysis was performed for the product using R134a, as it is the default refrigerant to show which of the life cycle modules contributes to most of the impacts. Impacts from operational energy use were removed from the life cycle impacts to determine the driving impacts across all other modules.

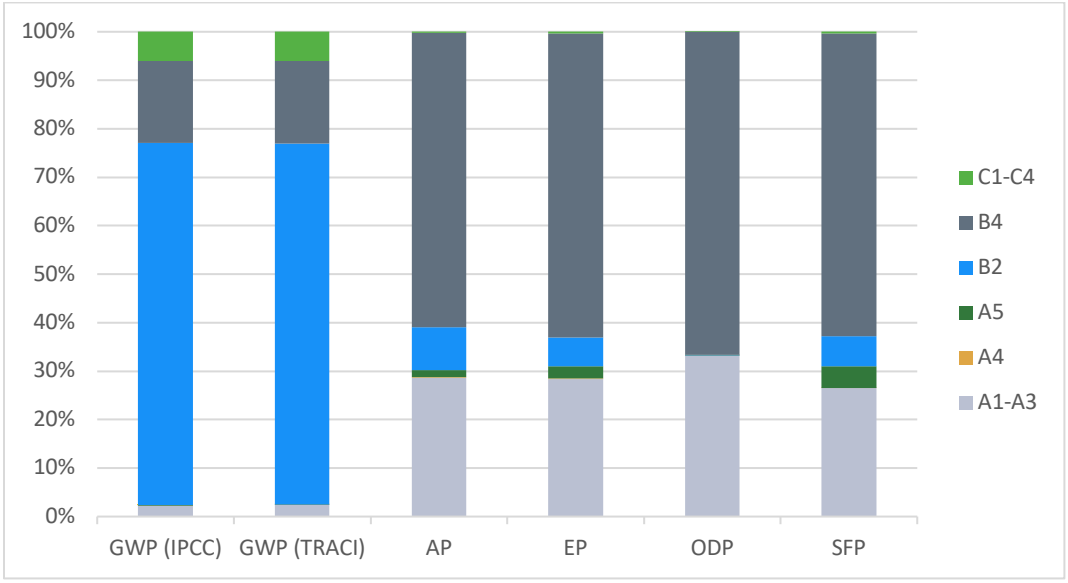



*Figure 5: Contribution of modules excluding B6 to overall impacts*

Two replacements are required for the chiller to satisfy the ESL of the building. The impacts associated with these replacements dominate the categories of AP, EP, ODP, and SFP. The emissions associated with refrigerant leakage during the maintenance phase (B2) dominate the GWP impacts.

## Assumptions and Limitations

The use and selection of secondary datasets from Sphera's MLC database. The selection of which generic dataset to use to represent an aspect of a supply chain is a significant value choice. However, no generic data can be a perfect fit. Improved supply chain specific data would improve the accuracy of results.

Use phase calculations are based on default scenarios provided by an excel calculator sheet as described by the PCR and do not reflect actual consumption in a specific location.

Availability of geographically more accurate datasets would have improved the accuracy of the study.

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