AHU Guideline

AHU systems sustainability assessment

April 2025 issue

Manufacturers‘ Association for Air Handling Units [Herstellerverband RLT-Geräte e. V.]

Introductory Remarks

In the future, in addition to energy efficiency considerations, further criteria regarding the environmental impact of products used in technical building equipment will play a role.

This guideline describes a method for calculating the environmental impact (CO_2 footprint) of central air handling units (AHUs). It is based on the requirements of EN 15804 and covers the entire life cycle from cradle to grave. Particular importance is given to the usage phase, as it accounts for more than 90 % of the CO_2 emissions.

This method allows the CO_2 emissions of an individually configured ventilation unit to be determined in a targeted manner in the context of the building.
This guideline reflects the approved rules of technology at the time of their creation.

Additional guidelines by the Manufacturers' Association for Air Handling Units have been published on the following topics related to central air conditioning units:
AHU Guideline 01: General requirements for Air Handling Units
AHU Guideline 02: Explosion protection requirements for air handling units
AHU Guideline 03: EC conformity assessment of Air Handling Units
AHU Guideline 04: Ventilation systems with smoke-extraction function. Air Handling Units with functional integrity during smoke extraction operation
AHU Guideline 05: Building Information Modelling for Air Handling Units
AHU Guideline Certification: Testing Protocol and Certification Scheme for Evaluating the Energy Efficiency of AHUs

Ludwigsburg, April 2025
Manufacturers' Association for Air Handling Units [Herstellerverband RLT-Geräte e. V.]

This AHU Guideline can be downloaded for free from the website of the Manufacturers' Association for Air Handling Units [Herstellerverband RLT-Geräte e. V.].

CONTENTS

1. Introduction to Sustainability

Sustainability is receiving increasing attention in the public eye, from policymakers, and in both national and international standards and regulatory frameworks. Within the European Green Deal concept, it is a declared objective of the European Commission to more strongly promote sustainability aspects in areas not directly related to energy consumption. Sustainability assessments are increasingly being integrated into residential and non-residential buildings, as well as the associated technical building equipment. This development is driven by the fact that 40% of energy consumption in the EU occurs in buildings, which account for one-third of greenhouse gas emissions.

Until now, the focus in air handling technology has primarily been on aspects of energy efficiency and qualitative requirements. In the course of the publication of the EU Building Directive EU/2024/1275, the environmental impact of buildings is now being addressed on top of energy efficiency. The goal is to achieve climate neutrality in the building sector by 2050. To this end, as of January 1, 2028, the EU Building Framework Directive (EPBD) requires a life cycle greenhouse gas quantification for all new buildings with a usable floor area exceeding 1.000 m². As of January 1, 2030, this requirement will apply to all new buildings. The detailed implementation of this EU framework regulation in Germany will take place through a revised version of the Building Energy Act (GEG). By January 1, 2027, at the latest, Member States must define maximum permissible values for the life cycle greenhouse gas potential of all new buildings. It should also become an integral part of the building energy certificate. This means that life cycle assessment will become part of future building regulations.

The objective of this AHU guideline is to consider the aspects of material efficiency (grey CO_2 emissions) and other ecological topics for the field of ventilation and air handling units. This guideline is intended to present the most important framework conditions for assessing the sustainability of air handling units.

According to the EU Buildings Sustainability Directive, the issue of good indoor air quality should always be taken into account in all regulatory considerations.

2. Eco-design Requirements for Sustainable Products

With EU Regulation 2024/1781 'Eco-design Requirements for Sustainable Products' (ESPR), the EU Commission issued a new Eco-design Framework Directive on 13 July 2024 establishing a legal framework to make products placed on the EU market more sustainable. These are the essential characteristics in addition to energy efficiency:

- Environmental impact
- Durability and reparability
- Availability of spare parts
- Recyclability / circular economy
- Transparency through a Digital Product Passport
- Avoidance of hazardous chemicals

Starting in 2027, these new requirements are expected to be applied specifically to selected priority product groups.

Digital Product Passport

The introduction of a Digital Product Passport aims to promote sustainable production, accelerate the transition to a circular economy, open up new business opportunities for economic operators, support consumers in choosing sustainable products, and enable authorities to verify compliance with legal obligations. This too will be based on an environmental impact assessment.

The corresponding requirements will be defined in future revisions of ecodesign regulations for specific product groups, which will also include air handling units among others.

3. Sustainability Assessment of Air Handling Units (AHUs)

A life cycle assessment (LCA) has the task of recording all energy and material flows as well as their environmental impacts over the life cycle of the subject under consideration (in this case, a building or even a product). In the life cycle assessment, both the building and its life cycle are represented over a defined period of observation (typically 50 years). The building life cycle is divided into phases. The information for each phase is described using modules. According to EN 15804, these are:

- Production and Construction Phase (Module A) Includes raw materials extraction, manufacturing of construction products, and building construction up to completion/handover.
- Use and Operation Phase (Module B): Covers energy and water supply, maintenance, replacement investments, and, if applicable, planned modernisations.
- End-of-Life Phase (Module C): Involves dismantling, processing, and disposal.

Additionally, the recycling potential is separately specified in Module D, as it exclusively describes effects that occur outside the defined system boundaries of the life cycle.

Life cycle assessments are already being incorporated into various building certification schemes, such as DGNB, BNB, and QNG.

AHUs represent a key component of the technical building systems within a building. With the introduction of sustainability assessments for buildings, the environmental impacts of all installed technical building products must also be evaluated, and relevant data must be provided in line with the previously mentioned structures.

The members of the Manufacturers' Association for Air Handling Units [Herstellerverband RLT-Geräte e. V.] have developed a method for the sustainability assessment of AHUs, based on currently applicable guidelines and standards.

The method is based on the following normative references: ISO 14025, EN 15804, DIN EN 15643, and prEN 15978-1.

The sustainability assessment of AHUs is based on the life cycle requirements defined in EN 15804. It covers the entire life cycle from production to disposal and initially quantifies environmental impacts using a CO_2 equivalent.

The calculation method takes into account the production phase, construction phase, use phase, and end-of-life phase of an individually configured AHU. In addition, data on the recycling potential is also determined. The modules are assigned to the respective life cycle phases as defined in EN 15804. The method describes cradle-to-grave data collection, including the use phase.

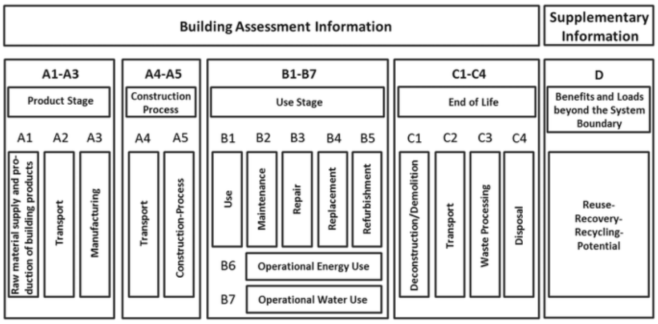


Fig. 1 Extract from EN 15804 – Life cycle phases

The methodology for life cycle assessment of air handling units described below is intended to provide a standardized procedure for all members of the Manufacturers' Association for Air Handling.

Product Description / Product Definition – Central Air Handling Units

Central air handling units are designed to ventilate, condition, and extract targeted pollutants from spaces within buildings.

Their fields of application are diverse and range from ventilating public areas, assembly halls and medical facilities to industrial applications, where specific room conditions regarding temperature, humidity, and dust concentration must be ensured.

The construction of these devices is modular and based on the required air treatment functions and spatial constraints of the installation site. As a result, AHUs are typically custom-configured to meet these specific requirements.

Depending on the application, the following functions and air treatment stages can be integrated into AHUs:

- Air transport
- Air filtration
- Heat and cooling recovery
- Heating
- Cooling
- Humidification / Dehumidification

AHUs cover airflow ranges from 250 m³/h to well over 100.000 m³/h. A distinction is made between unidirectional and combined supply and exhaust air units. Efficiency requirements for ventilation units are defined by the Ecodesign Regulation EU 1253/2014. Further requirements concerning unit quality are established by both national and European regulations.

System Components of Air Handling Units

AHU systems are designed to impact the quality and temperature of the air supply and to remove airborne pollutants. Centralized ventilation systems are constructed using a modular design. Based on the required indoor air quality, acoustic conditions, and spatial limitations, the necessary components are combined and dimensioned accordingly.

Filters

Air filters in AHUs clean the air compliant with hygiene standards to protect occupants from particulate contamination. They also protect devices and components such as fans or heat exchangers from contamination. Common types include bag filters and panel filters. Special filters such as activated carbon filters or HEPA filters are used for specific requirements related to odours or fine particles. Regular replacement of the filters is essential and typically takes place during routine maintenance.

Fans

Each AHU contains at least one fan in each air stream. The fan is a flow-generating machine that moves air through the unit at a defined volume flow rate. It creates the pressure increase required to overcome the pressure drop caused by resistance caused by all system components.

Heat Recovery Systems

Heat recovery systems are used to recover energy from the building exhaust air and use it to supply air conditioning. Various system components are available for this purpose. Depending on the system design, up to 80% of the exhaust air energy can be recovered.

Heating and Cooling Coils

Heating and cooling coils (also referred to as air heaters or coolers) are heat exchangers used to heat or cool the supply air. Finned tube heat exchangers consist of tubes with attached fins, through which flow heating or cooling media such as steam, hot or chilled water. The air passes through the component transversely across the tubes and fins. Additional types include electric air heaters. Direct expansion coils are also used for cooling and dehumidification. A refrigerant circulates inside them. Air coolers are also used for dehumidification by cooling the airflow below the dew point.

Humidifiers

Humidifiers maintain the humidity level of the incoming air at a certain value. They humidify with water or steam.

Sound Absorber

The fan is the largest source of sound in a ventilation unit. Integrated sound-absorbing elements ensure a reduced noise level at the connection points.

Louvre dampers / Connections

Shut-off dampers in the supply or exhaust air duct close the airways when the unit is not in use. The required air duct system is connected to the units via flexible unit connections.

The planning, production and construction of air handling units involves several steps:

- Customized AHU design using manufacturer software
- Generation of a parts list for device production

- Delivery of raw materials and semi-finished products, consumables and supplies
- Prefabrication of self-manufactured parts

- Delivery of bought-in components.
- Final assembly of complete or modular units

- Quality control / packaging
- Delivery to the installation site

- Installation of equipment / assembly of modules at the place of use
- Connection to the local air conduction network

- Connection to the local electricity, heating, cooling and, where appropriate, water supply
- Commissioning

After the commissioning is completed, the use phase and the disposal phase take place at the end of an assumed average service life of 25 years.

The service life of central ventilation units depends on the design, the materials used and the ambient conditions. When used as intended, the average service life is 25 years. This assumes that the requirements of the quality guidelines for air handling units, summarised in the RLT Guideline 01, have been met and that regular maintenance work is carried out. Annual maintenance of AHU systems, as described for example in the VDMA 24186 recommendation, ensures trouble-free operation over a long period.

The long-term experience of many device manufacturers supports the 25-year lifespan approach described above. Previous service life assessments have often been for between 15 and 20 years. These, however, do not take into consideration today's standard level of technical equipment and the quality requirements. In the 03/2013 TGA study final report on the research project "Energy inspection opportunities for legislators, plant operators and the industry", the average age for 160 inspected air handling systems turned out to be 28 years.

Descriptions of the classification of housing properties for air handling units can be found in EN 1886. AHUs that must withstand special environmental conditions, such as installation in the immediate vicinity of the sea or with corrosive exhaust air, are specially equipped for this and their service life may vary.

Declared unit: AHU

The declared unit refers to the production, installation, operation and disposal of a piece of individually manufactured ventilation unit with variable functional components and variable operating air volumes. The range of application covers a functional air volume in the range of 250 m³/h to 100.000 m³/h. Greater air volumes are also possible by segmenting individual units.

System boundary

The system boundary of the 'cradle to grave' type follows the modular structure according to EN 15804. The life cycle assessment of the products considers modules A, B, C and D, which are described below.

4. Life-cycle phases of air handling units

The German ÖKOBAUDAT database is a freely accessible source of life cycle assessment data on general building products and energy services. This database is maintained by the BBSR (Federal Institute for Research on Building, Urban Affairs and Spatial Development). Other notable database sources include the IBU [*Institut für Bauen und Umwelt e. V.*] and EPD International AB. Environmental assessments for sample air handling units are already available there. The operational phase is not currently under consideration. The level of equipment under consideration for the sample devices has also been kept rather basic. Thus, these specifications are rather general and do not adequately reflect the required variance in individual air handling units. From now on, however, significantly more detailed information on AHUs will be required as part of a comprehensive building assessment.

Manufacturing phase (A1-A3)

The manufacturing phases A1 to A3 include the provision of raw materials at the production plant and the energy required for product manufacturing.

The provision of raw materials and their transport by lorry to the production plant are already included in the environmental impact assessment of the raw materials used. The data source for this comes from a wide range of European databases.

Production expenses due to energy requirements are determined individually by the manufacturer and are apportioned to the product on a pro-rata basis.

Metal production waste typically ceases to be classified as waste immediately upon generation at the manufacturing site and is accounted for under Module D (recycling potential). Plastic profile waste is recycled by the suppliers in a material-specific process. Remaining waste is disposed of through general waste management systems.

The main material components in air handling units (AHUs) include sheet metal and profiles made of galvanized steel (optionally coated), stainless steel, or aluminium. Additionally, plastic profiles are used for thermal decoupling. Thermal and acoustic insulation of the housing components consists of mineral wool, glass wool, or PU foam elements. Built-in components for air treatment and conveyance also mainly consist of metals containing smaller amounts of plastic. Sealing elements are primarily made of EPDM or soft foam strips.

The units are equipped with fans that provide the required pressure and airflow. Fan units consist of an electric drive combined with an impeller made of metal or plastic. Heat exchangers and heat recovery components are made of galvanized steel, stainless steel, copper, and aluminium.

Metals account for more than 80 % of the total share of weight in AHUs. Plastic components and insulation materials each contribute approximately 10 % to the overall mass. The exact material proportions vary depending on the unit size and equipment level; however, metal consistently remains the primary component.

Transport protection packaging is included in the material balance.

Construction Phase (Modules A4–A5)

The final installation location of the AHU is not always known during the planning stages. Transport is carried out using lorries of at least Euro 5 emission class. An average transport distance of 500 km can be assumed for medium-distance lorry transport within Germany. Transport distances across national borders are correspondingly longer and can be extrapolated accordingly.

No significant additional energy is required for on-site assembly (module A5).

Usage phase (B1-B7):

No direct emissions are released during the use of the product (module B1). Indirect emissions arise from the energy demand during operation, which is described in Module B6. Annual maintenance with a corresponding filter change is required. This is taken into account in the sustainability assessment in the air handling unit in accordance with generally applicable requirements from current standards and guidelines, as well as the experience of the unit manufacturers.

Maintenance/servicing (B2-B5)

During the period of use under consideration, maintenance (module B2) and repair (module B3) or replacement of individual components (module B4) because of defects is only to be expected in the area of air transport (fans). The same applies to actuators around control engineering. The operating experience of equipment manufacturers and plant users shows that, depending on the daily operating time, a fan replacement is to be expected no more than once during the period of use (25 years). For actuators used to adjust flaps or valves in the field of control engineering, a one-time renewal is to be considered in the life cycle. Generally, annual maintenance is required, during which the air filter elements are replaced. The replacement intervals are based on the specifications given in VDI 6022.

Operational Phase (Modules B6–B7)

For air treatment and air exchange in buildings, electrical, heating, and cooling energy is required, depending on the usage profile of the ventilation system.

The energy consumption of air handling units is influenced by multiple parameters, which have varying degrees of influence on energy use. The dependencies are based on the following criteria:

- Air volume flows, supply air/exhaust air, full-load and part-load operating phases
- Required system pressure for supply and exhaust air
- Required air treatment functions (heating, cooling, humidifying, dehumidifying)
- Operating time (utilisation profile)
- Required supply air conditions (temperature, humidity, particle load, etc.)
- Installation location (climate zone)
- Efficiency of the individual components in the ventilation unit (heat recovery, fan technology, air humidification technology, etc.)

Since these criteria have a significant influence on the energy demand, it must be determined individually using a system simulation. A standardised usage profile is helpful in this respect. DIN V 18599 T10 defines usage profiles for standardised average operating profiles that reflect average system operation. Operating times, partial operating factors and air temperatures are defined there for 41 different usage profiles. Use profiles exist which include office buildings, places of public assembly, rooms used for medical purposes, as well as for general industrial uses.

These standardised usage profiles make it possible to determine the average energy demand for building ventilation for all system configurations.

Table1: Extract usage profiles DIN 18599 T10

1		3	4	5	6
	Use case	Start operation	Stopp operation	dayly operation	yearly days of operation
				$t_{nutz,d}$	$d_{nutz,a}$
		[o´clock]	[o´clock]	[h/d]	[d/a]
1	Single office	07:00	18:00	11	250
2	group office 2-6 persons	07:00	18:00	11	250
3	group office >= 7 persons	07:00	18:00	11	250
4	meeting room	07:00	18:00	11	250
5	counter hall	07:00	18:00	11	250
6	retail trade (without cold products)	08:00	20:00	12	300
7	retail trade (with cold products)	08:00	20:00	12	300
8	classroom (school)	08:00	15:00	7	200
9	auditorium	08:00	18:00	10	150
10	hospital bed rooms	00:00	24:00	24	365
11	hotel rooms	21:00	08:00	11	365
12	canteen	08:00	15:00	7	250
13	restaurant	10:00	00:00	14	300
14	kitchen in non-residential buildings	10:00	23:00	13	300
15	kitchen preparation, storage	10:00	23:00	13	300
16	toilets, sanitary rooms in non-resdential buildings	07:00	18:00	11	250
17	other receation rooms	07:00	18:00	11	250
18	ancillary areas (without recreation rooms)	07:00	18:00	11	250
19	transport areas	07:00	18:00	11	250
20	storage-, technical- or archiv space	07:00	18:00	11	250
21	data centre	00:00	24:00	24	365
22,1	coomercial- or industrial halls (strenuous activity)	07:00	16:00	9	250
22,2	coomercial- or industrial halls (middle strenuous activity)	07:00	16:00	9	250
22,3	coomercial- or industrial halls (light activity)	07:00	16:00	9	250
23	audience area (theatre, event buildings)	19:00	23:00	4	250
24	foyer (theatre, event buildings)	19:00	23:00	4	250
25	stage area (theatre, event buildings)	13:00	23:00	10	250
26	exhibition / congress	09:00	18:00	9	150
27	exhibition spaces and museum with conservation requirements	10:00	18:00	8	250
28	library - Reading area	08:00	20:00	12	300
29	library - open acces area	08:00	20:00	12	300

Alternatively, individual user profiles may be used.

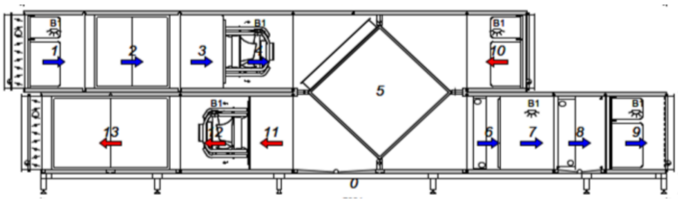
The energy demand determined in this way can then be evaluated using standardised CO_2 equivalents of different energy forms. For example, the following CO_2 conversions apply to Germany at the time this document was created:

Table2: CO_2 conversion factors as of 12/2023

Energy source	CO_2 eq data (incl. distribution losses)
Eletricity mix Germany	420 CO_2eq g / KWh
Electricity 100 % renewable	0 CO_2eq g / KWh
Natural gas	271 CO_2eq g / KWh
Liquid gas	323 CO_2eq g / KWh
Biogas	205 CO_2eq g / KWh
Landfill gas	7 CO_2eq g / KWh
Sewage gas	7 CO_2eq g / KWh
Hydrogen renewable	0 CO_2eq g / KWh
Light heating oil	359 CO_2eq g / KWh
Heavy fuel oil	389 CO_2eq g / KWh
Biodiesel	95 CO_2eq g / KWh
Bioethanol	58 CO_2eq g / KWh
Lignite	517 CO_2eq g / KWh
Hard coal	479 CO_2eq g / KWh
Local and district heating	378 CO_2eq g / KWh
Biomass Wood	36 CO_2eq g / KWh
Pellets	49 CO_2eq g / KWh
Heat mix	294 CO_2eq g / KWh
Heat pump with electricity mix	189 CO_2eq g / KWh
Cooling energy Chiller with electricity mi	126 CO_2eq g / KWh
Diesel fuel	2640 CO_2eq g / l

Corresponding distribution losses are to be applied for heating and cooling energy. For energy sources that are not known, mean values can be used for a mix of electricity or heat. Energy CO_2 equivalents only reflect the current value. With increasing decarbonisation, this will change over the lifetime of the product. There is currently no applicable standardised data available.

5. Example AHU 10.000 m³/h, heat recovery via plate heat exchanger



Components:

0	dampers	7	Maintenance area
1	Fresh-air filter stage	8	Air cooler
2	Silencer	9	Filter stage 2
3/4	Supply air fan	10	Exhaust air filter stage
5	Heat recovery	11/12	Exhaust air fan
6	Reheater	13	Silencer

User profile: Open-plan office

Operating hours: Monday to Friday, 7 am to 6 pm

Table3: Rough overview of material components

Material component (Weight proportions)	Proportion of air handling unit
Galvanised steel sheets/profiles	80 %
Plastics	10 %
Insulation	5 %
Other	5 %

Simulation of energy demand:

Power requirement of fans	17770 kWh/a
Heating energy savings through heat recovery	-63840 kWh/a
Residual heat energy after heat recovery	7230 kWh/a
Cooling energy	12030 kWh/a

The required heating energy is provided by a central gas heating system. Cooling energy comes from a chilled water unit. The electricity demand was assessed using the German electricity mix.

Table4: Result of CO_2eq assessment of HVAC unit over 25 years

Module	CO_2 balancing	CO_2eq AHU acc. to Configuration Life cycle 25 a
A1-A2	Material balancing Manufacturing	10.49 t
A3	Production costs (energy)	0.50 t
A4	Transport to the installation site	0.13 t
B1	Use (open-plan office)	274.10 t
B2-B4	Annual maintenance / Spare parts	3.60 t
C		not evaluated
D	Recycling potential (calculation)	6.29 t (60 %)

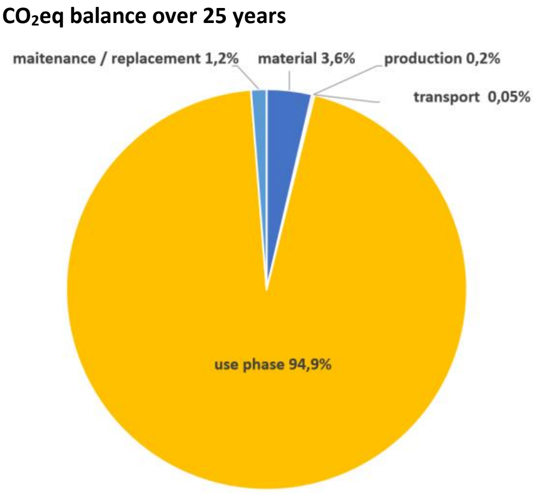


Fig.2 Balance shares CO_2 equivalents – life cycle 25 years

If the CO_2 assessment of this sample ventilation unit is compared with a comparable window ventilation system under the theoretical assumption of the same air volume flows to be provided, a comparable window ventilation system without heat recovery achieves a CO_2eq footprint that is about twice as high. In applications with long operating hours, a comparable window ventilation system generates a CO_2eq footprint that is up to three times as high.

6. References

prEN15978 Sustainability of construction works – Environmental quality of buildings

EN 15804 Environmental product declarations – Core rules for the product category of construction products

AHU Guideline 01: General requirements for ventilation and air handling units

Manufacturers‘ Association for Air Handling Units
[*Herstellerverband RLT-Geräte e. V.*]
Hoferstrasse 5
D–71636 Ludwigsburg
Phone.: +49 (0)7141 / 2588140
Fax.: +49 (0)7141 / 2588149
E-Mail: info@rlt-geraete.de