Ref. Ares(2024)3550501 - 16/05/2024

RE-SKIN

D6.2 - Manufacturing design of the technical components II

Funded by the European Union

Deliverable Information Sheet

Version	1.0
Grant Agreement Number	101079957
Project Acronym	RE-SKIN
Project Title	Renewable and Environmental-Sustainable Kit for building Integration
Project Call	HORIZON-CL5-2021-D4-02-02
Project Duration	42
Deliverable Number	D6.2
Contractual Delivery Date	30/01/2024
Actual Delivery Date	16/05/2024
Deliverable Title	Manufacturing design of the technical components II
Deliverable Type	R
Deliverable Dissemination Level	PU
Work Package	WP6
Lead Partner	HELIO
Authors	M. Kim
Contributing Partners	HELIO, POLIMI, ENELX, PSC, CTIC, SOLAR, STI
Reviewers	C. Del Pero, A. Vallan

History of changes

Version	Date	Comments	Main Authors
0.1	15/8/2023	First draft, establishing document structure	M. Kim
0.2	18/4/2024	First version, incorporating input from all participants	M. Kim, all industrial partners
0.3	28/4/2024	Quality review	R. Adhikari, F. Leonforte, A. Vallan
1.0	09/5/2024	Final version addressing all further comments	M. Kim

Table of Contents

1. Executive summary 6

2. DC Heat pump 7

2.1. General description 7

2.2. System/component design 7

2.2.1. Main unit 7

2.2.2. Indoor heat exchanger 10

2.2.3. Buffer and DHW storage tank 11

2.3. Installation mode 12

2.3.1. Space requirements of the main unit 13

2.3.2. Installation requirements 14

2.3.3. Indoor heat exchanger air flow direction 15

2.3.4. Installation site of the heat pump 16

2.3.5. Packaging and storage environment 16

2.4. Operation mode 17

3. Smart fan-coil 19

3.1. General description 19

3.2. System/component design 19

3.2.1. Unit design 20

3.2.2. Compressor and controller 22

3.2.3. Fan 22

3.2.4. Water heat exchanger 23

3.3. Installation mode 24

3.3.1. Electrical connection installation 24

3.3.2. Mechanical installation 24

3.4. Operation mode 25

4. Multi-Input/Multi-Output converter (MIMO) 26

4.1. General description 26

4.2. System/ component design 26

4.3. Installation mode 28
4.4. Operation mode 29
5. EV-charger 30
5.1. General description 30
5.2. System/ component design 30
5.3. Installation mode 32
5.3.1. Version A 32
5.3.2. Version B 34
5.4. Operation mode 35
5.4.1. Version A 35
5.4.2. Version B 36
6. Battery pack 41
6.1. General description 41
6.2. System/ component design 41
6.3. Installation mode 44
6.4. Operation mode 45
7. Smart Control System (SCS) 46
7.1. General description 46
7.2. System/ component design 46
7.3. Installation mode 49
7.4. Operation mode 52

List of Figures

Figure 1. Heat pump main unit 8
Figure 2. Heat pump main unit dimensions 9
Figure 3. Dimensions of indoor heat exchanger of heat pump 10
Figure 4. Buffer/ DHW storage tank 11
Figure 5. Minimum distances for the heat pump installation 13
Figure 6. Correct suction line installation (left) and wrong suction line installation (right) 14
Figure 7. Air flow direction - Indoor heat exchanger 15

Figure 8. Heating curve control by online 18
Figure 9. Fan-coil unit overview 20
Figure 10. Side, front and top view of the fan-coil unit 21
Figure 11. Rotary compressor and controller in the fan-coil unit 22
Figure 12. Fan in the fan-coil unit 3d model 22
Figure 13. Plate heat exchanger in fan-coil unit 23
Figure 14. MIMO block diagram 26
Figure 15. Inverter converter prototype 27
Figure 16. DAB converter prototype 27
Figure 17. MIMO main unit physical aspects 28
Figure 18. MIMO remote unit physical aspect 29
Figure 19. Version A 30
Figure 20. Version A (dimensions in mm) 31
Figure 21. Version B (dimensions in mm) 32
Figure 22. Version B front panel pre-dispositioning 34
Figure 23. Detail of Version B 36
Figure 24. Initial display 37
Figure 25. Display when it is readied to read RFID card 37
Figure 26. Display when RFID card is accepted 37
Figure 27. Display when R side socket is plugged in 38
Figure 28. Display when second RFID card is accepted 38
Figure 29. Display when L side socket is ready to be plugged in 39
Figure 30. Display when charging session starts – L side display 39
Figure 31. Display when the session ends 39
Figure 32. Display when charging in the R side socket ends and the socket is available again 40
Figure 33. Display when the charging at L side ends 40
Figure 34. Overview of battery pack enclosure 42
Figure 35. Battery cell 43
Figure 36. 8 battery cells in series 43
Figure 37. Slave BMS unit dimensions 43
Figure 38. Master BMS unit dimensions 43
Figure 39. Architecture of the SCS including interactions with cloud services 47
Figure 40. Rear view of the SCS hardware platform 49
Figure 41. Back view of the cellular router 50
Figure 42. Installation diagram of the SCS 51

Disclaimer

1. Executive summary

This document provides a comprehensive overview of the RE-SKIN toolkit, encompassing its general description, detailed design of each subcomponent, and instructions for installation and operation modes.

More in detail, the focus of this document is the description of design updates of each component from what already presented in deliverable D6.1 – Manufacturing design of the technical components I.

The general description outlines the design concept, the features and the operating logic of each component, highlighting its intended applications.

The system design sections focus on physical and functional designs of each subcomponent, providing necessary information for proper presentation and harmonization in selected building.

The instruction of installation and operation modes is presented in an accessible manner to facilitate seamless implementation and use, and related section provides guidance on setting up each component, ensuring that users can easily navigate its functionalities. Additionally, detailed information on operating modes is described.

The toolkit components considered in this document are following:

- DC heat pump
- Smart fan coil
- MIMO (Multi-Input/Multi-Output power converter)
- EV charger
- Battery pack
- SCS (smart control system)

2. DC Heat pump

2.1. General description

The initial proposed heat pump model was characterized by a monoblock design, with all components housed within a single unit. However, due to condensation issue, this configuration required modification. Consequently, the heat pump was reconfigured into a split model, comprising two units: the main unit and the indoor heat exchanger.
The hydrobox and powerbox, previously introduced in the earlier release of the document (D6.1), have been omitted as they are unnecessary in the split model design.
Nevertheless, the original concept of the heat pump remained unchanged: all components comprising the heat pump are located inside the building, while it draws in outside air through an air duct system. The indoor heat exchanger is a device to take outside air as an energy source.
The system is also equipped with a tank adopted as a buffer tank where water is stored. Buffer tank is connected to the heat pump main unit and the fan-coil units. Therefore, the heat pump heats or cools the water inside the buffer tank to prepare water with required temperature and fan coil units get supplied heated or cooled water from the buffer tank. DHW tank is also connected to the heat pump main unit and store thermal energy. But it has special heat exchanger where it heats fresh water, to allow domestic hot water preparation.
Detailed explanations of the sub-components are provided alongside detailed figures in the subsequent sections.

2.2. System/component design

The main technical drawings and information of the different subcomponents are reported hereafter.

2.2.1. Main unit

This heat pump unit (Fig. 1) is equipped with essential components for the refrigerant cycle, including the compressor, heat exchanger, and expansion valve. Specifically designed to operate in air temperatures ranging from -25 to 45°C, it has a heating and cooling capacity of up to 20 kW.
The unit can efficiently raise water temperatures to 60°C, catering to both domestic hot water and space heating needs. In the main unit, two pumps facilitate water circulation between tanks dedicated to domestic hot water and space heating. The unit incorporates automatic control devices programmed to regulate electrical components, ensuring smooth operation and high efficiency.

Users can control the heat pump manually using a surface-installed remote controller, allowing switching between heating and cooling modes and controlling desired heating temperature. Moreover, it features a remote-control gateway device for online control, enabling technicians in remote locations to inspect and manage the system.
The unit is designed to work synergistically with a DC/AC converter, allowing it to accept DC power from the Multi-Input and Multi-Output (MIMO) device and operate the Brushless Direct Current (BLDC) compressor.
With the dimensions of 670/600/1700 (L/W/H) [mm] and a weight of 185 kg, the unit is detailed further in Fig. 2.

Figure 1. Heat pump main unit

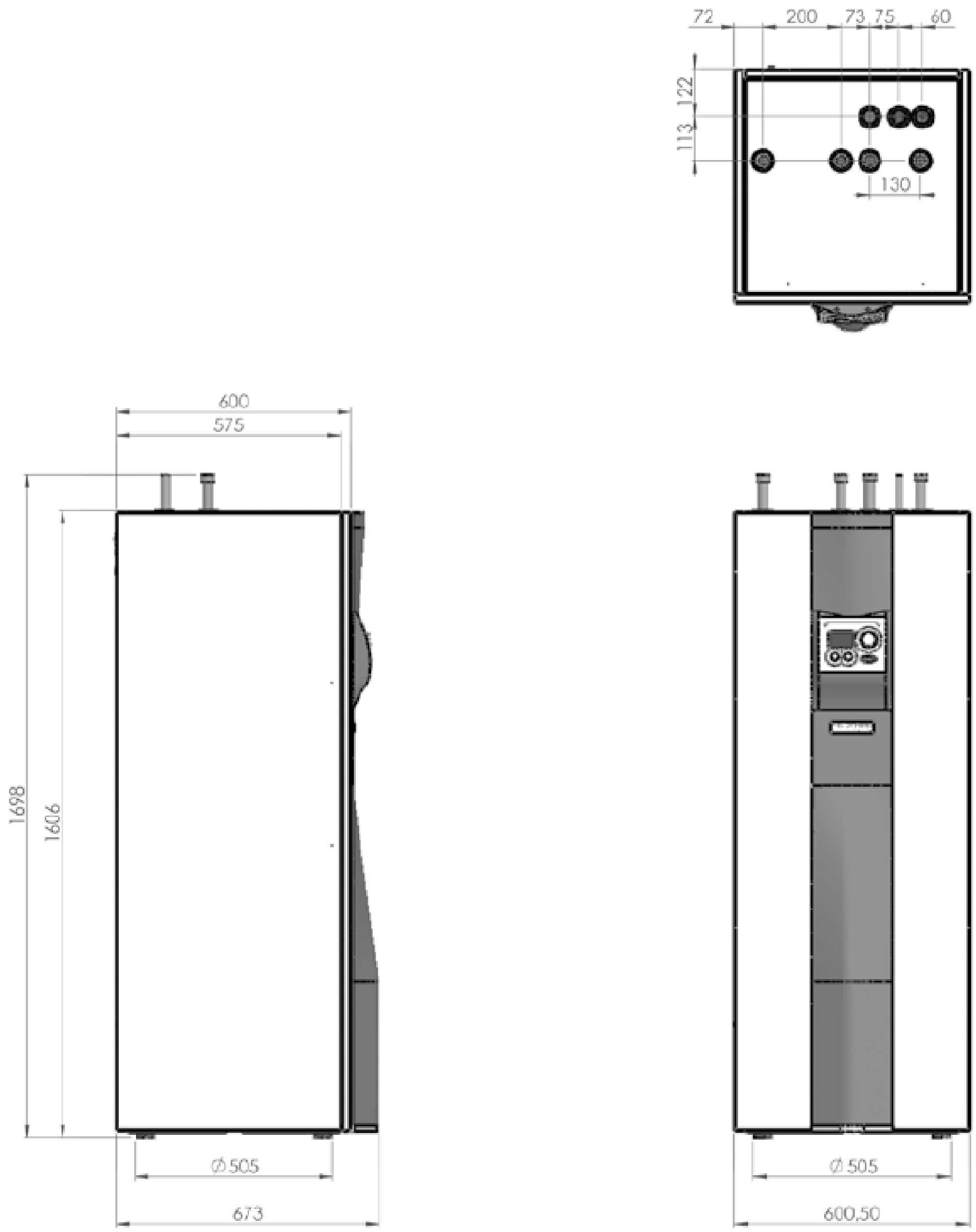


Figure 2. Heat pump main unit dimensions [mm]

2.2.2. Indoor heat exchanger

This unit is designed to be able to be coupled with ducts, therefore the unit can stay indoor and takes air source from outside. Inside the unit, an air heat exchanger and a fan are installed. It is designed to have 90° or 180° of angle between the air inlet port and air outlet port. The heat exchanger has an area of 120 m^2 that needs maximum air flow rate of 6000 m^3/h to reach maximum desired heating and cooling capacity. Each port has frames including rubber to buffer the shock on the connection part. The dimensions of it are 1145-1195/940-990/1240 (L/W/H) [mm], and the total weight is 125 kg. The dimensional details of unit are shown in Fig. 3.

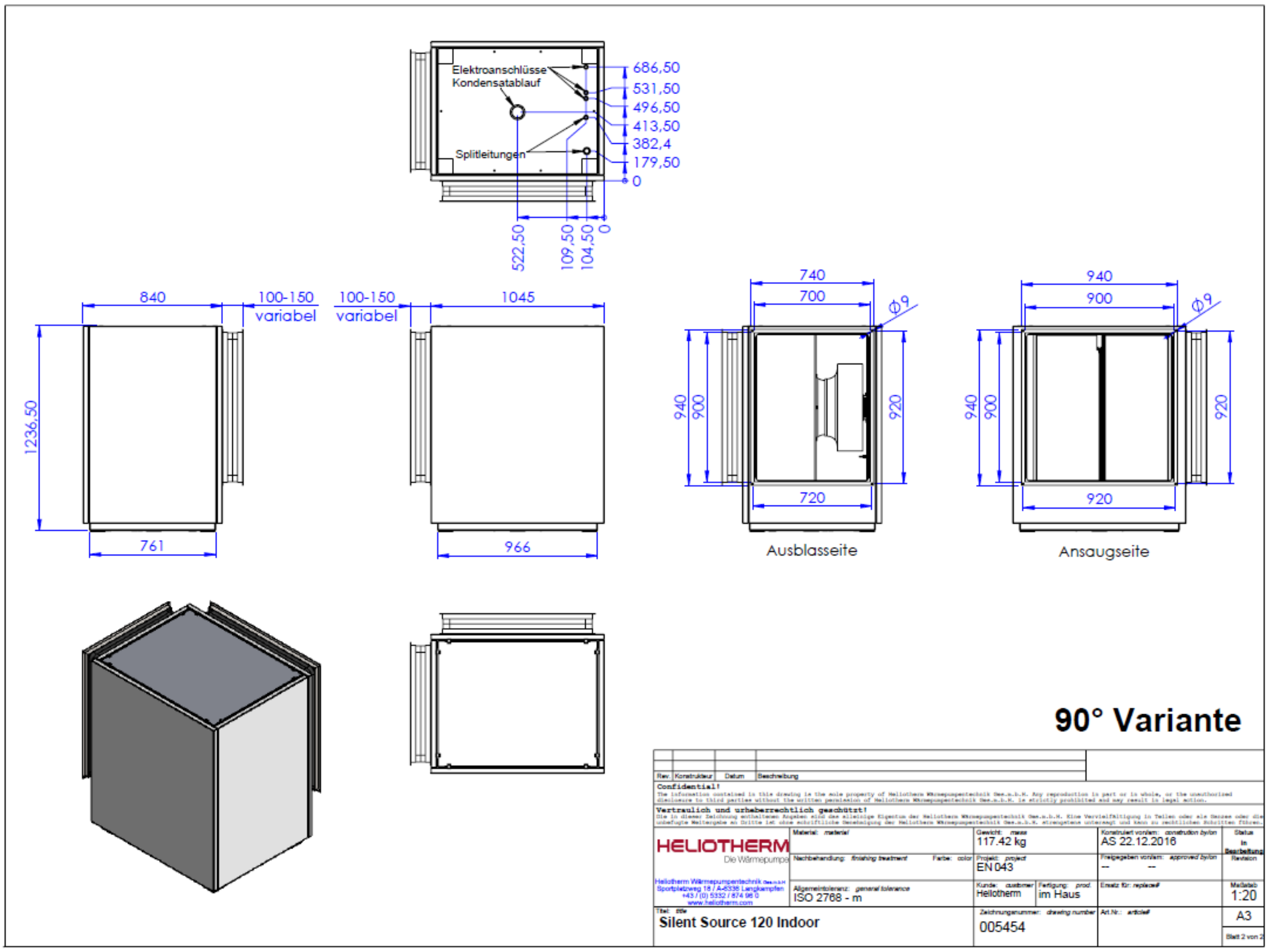


Figure 3. Dimensions of indoor heat exchanger of heat pump [mm]

2.2.3. Buffer and DHW storage tank

The buffer and DHW tanks are basically similar but the difference is the tank for DHW has additional hydraulic system including heat exchanger and water pump to supply fresh water. The tank is designed to have connection ports to interact with heat pump, fan-coil units, and fresh water hydraulic system.

The details of the connection ports are explained in Fig. 4 and Table 1.

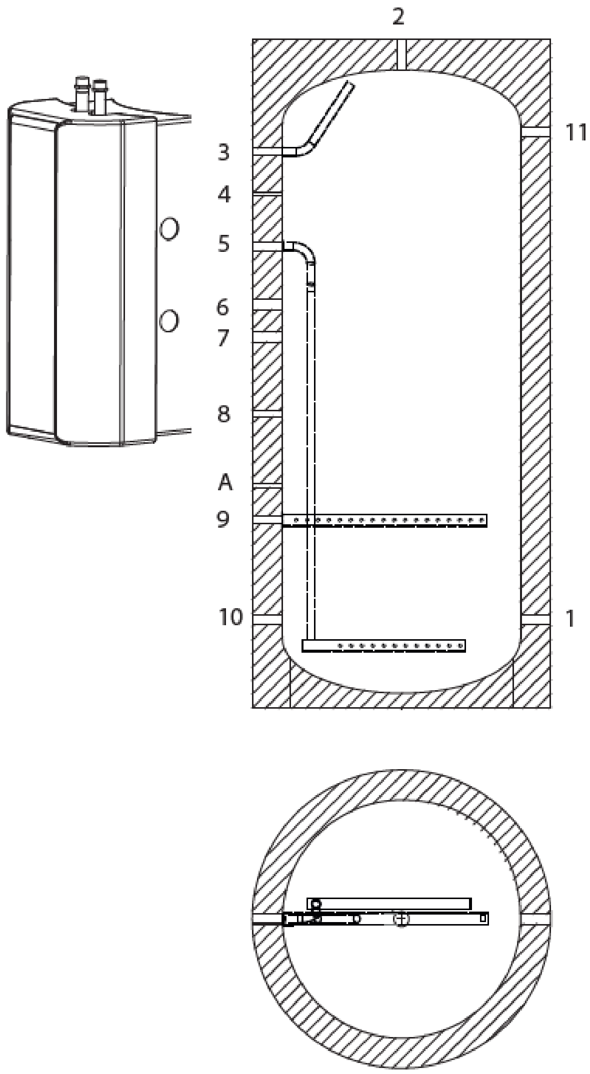


Figure 4. Buffer/ DHW storage tank

Table 1. Buffer&DHW storage connections

	Buffer storage			DHW storage		
No.	**connection**	**size**	**length**	**connection**	**size**	**length**
1	Heating HI	IT 1 1/4"	255mm	Drain	IT 2"	255mm
2	Heat pump HO	IT 1 1/4"	1930mm	Deaerate	IT 2"	1990mm
3	-	IT 1"	1550mm	Fresh water system HO	IT 1"	1570mm
4	-	IT 1 1/2"	1422mm	Fresh water system mount	IT 1/2"	1442mm
5	-	IT 1"	1295mm	Fresh water system HI	IT 1"	1315mm
6	Heating element aperture	IT 1 1/2"	1130mm	-	IT 1 1/2"	1150mm
7	-	IT 1 1/4"	1030mm	-	IT 1 1/4"	1050mm
8	-	IT 3/4"	855mm	-	IT 3/4"	855mm
9	-	IT 1 1/4"	500mm	Heat pump HO	IT 2"	500mm
10	Heat pump HI	IT 1 1/4"	255mm	Heat pump HI	IT 2"	255mm
11	Heating HO	IT 1 1/4"	1670mm	-	IT 2"	1670mm
A	Buffer sensor	IT 1/2"	640mm	Buffer sensor	IT 1/2"	640mm

2.3. Installation mode

The heat pump must be installed by an authorized specialized company. In addition, their employees are required to attend and have completed the Heliotherm expert training program. In particular it must be ensured that:

- The technical personnel read and understands the manual for the installation, commissioning, maintenance, service and Heat Pump operation and has understood all safety instructions.
- The electrical connections are installed by a certified electrician who is qualified to perform work and is qualified for electrical systems and approved by the utility company.
- The service and maintenance work is performed only by certified refrigeration technicians that are familiar with the refrigerant cycle, qualified to work on electrical systems and approved by the utility company.

This section covers mainly installation place requirements for the components and detailed electrical and hydronic connections are not included.

2.3.1. Space requirements of the main unit

The space requirements of the main unit have been shown schematically in Fig. 5 and the minimum distances of unit from different positions are provided in Table 2.

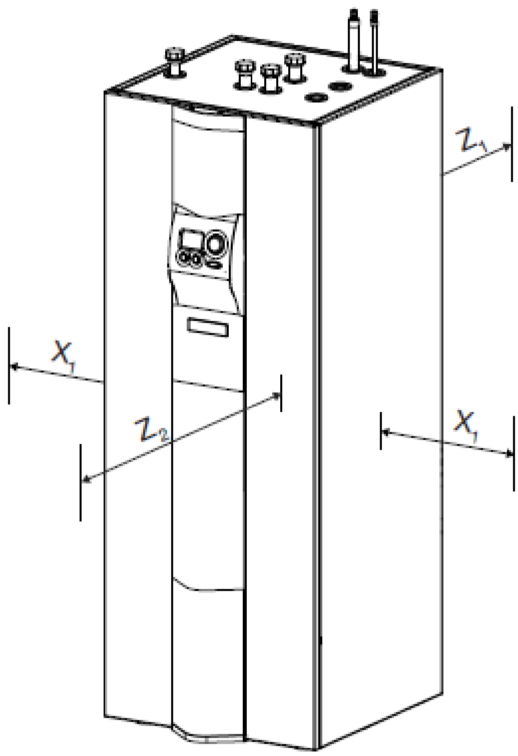


Figure 5. Minimum distances for the heat pump installation

Table 2. Minimum distances of main unit

Position	Description	Distance
X1	Side distance	40cm
Z1	Rear distance	10cm
Z2	Front distance	80cm

2.3.2. Installation requirements

The main installation requirements are summarized as follows.

- The pipes between indoor heat exchanger and the main unit should be as simple as possible. It should be noted that they are to be kept as short as possible.
- Bends in the split pipes must be applied with a bending radius of at least 3.5 times in the outer diameter.
- The pipe connections to the heat pump are soldered solid and filled with nitrogen. These closures must be removed with a pipe cutter before connection is made. The nitrogen in the refrigerant circuit should be drained through the incorporated valves before removing the caps.
- All lines must be used immediately after opening or reclosed in such a way that moisture and dirt are prevented from entering.
- The lines must be insulated and laid in a KG pipe. The KG pipe must be sealed watertight at both ends.
- The lines must be laid with a slight declining slope to the heat pump main unit.
- Standpipe must always be laid vertically.
- If the suction line to the heat pump main unit is on an inclined slope, oil sacks must be made at the beginning of the slope and then subsequently at every 2.5 m. At the end of the inclining tube, it should be completed with an over bend. A maximum height difference of 5m between outdoor evaporator to the heat pump must not be exceeded (Fig. 6).

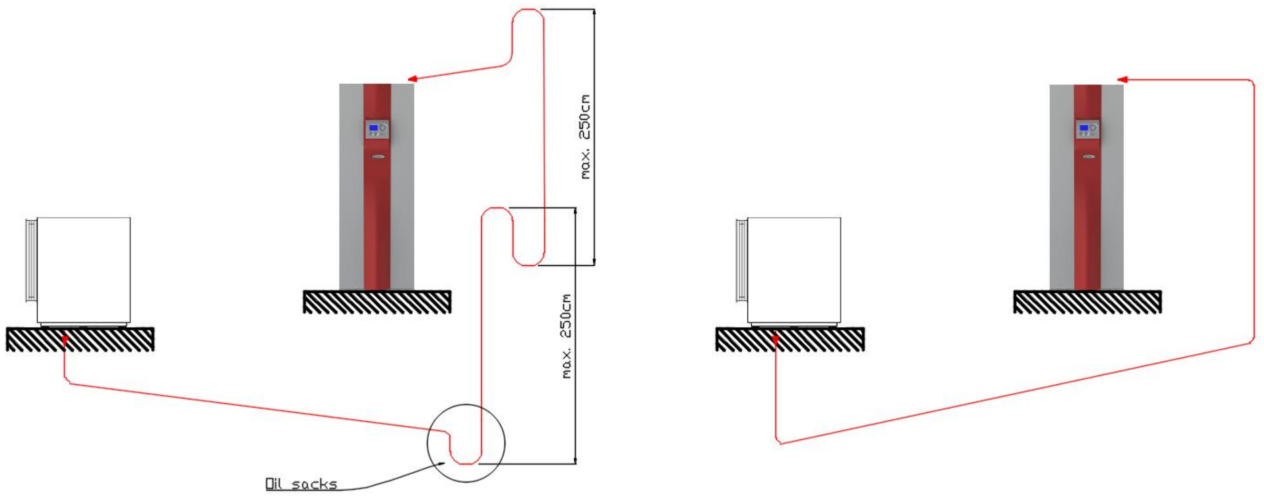


Figure 6. Correct suction line installation (left) and wrong suction line installation (right)

- After installing the split lines, a leak test is to be carried out by thoroughly pressuring the pipes. The pressure loss tolerance is specified in Table 3. Nitrogen 5.0 must be used for this. The test pressure must be carried out for at least 1 hour and at 15bar.

Table 3. Pressure loss tolerance

Season	Outdoor temperature	Pressure loss tolerance	Test duration
Winter	-10°C – +5°C	0 – 0.8bar	min. 1h
Summer	+6°C – +30°C	0 – 0.3bar	min. 1h

- If the lines are laid and installed before the heat pump is put into operation (e.g., during the raw construction phase), the lines must be filled with nitrogen be sealed to protect them, this prevents contamination and corrosion. All openings should be closed by hard soldering and each line should be equipped with a valve. The lines must be filled through this valve with 5bar nitrogen 5.0.

2.3.3. Indoor heat exchanger air flow direction

The air flow direction is to be noted when installing the indoor heat exchanger (Fig. 7). The air flows always in direction from the smaller passage to bigger passage.

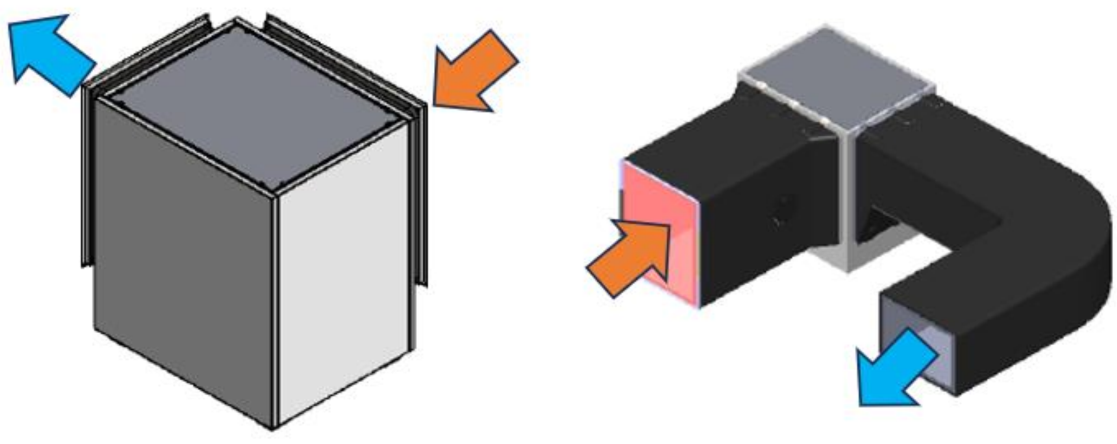


Figure 7. Air flow direction - Indoor heat exchanger

2.3.4. Installation site of the heat pump

When choosing an installation site, some essential things must be considered to ensure optimum heat pump function and to prevent conflicts:

- The heat pump should be installed in a dry indoor area.
- The installation site must be frost-free, the temperature may be max. 35°C.
- The heat pump should be placed on a permanently flat, smooth and even horizontal surface.
- The load-bearing capacity of the subsurface must be ensured.
- Inside the building, appropriate drainage facilities must be installed.
- Pay attention to local wall or floor implementations when installing the indoor heat exchanger.

2.3.5. Packaging and storage environment

The air water heat pump should only be stored in its original packaging and in a dry, frost and dust free location. In addition, it should only be positioned vertically and protected from direct sunlight. It is not allowed to put other objects on the heat pump. The climatic conditions described in Table 4 must prevail at the intended storage location.

Table 4. Storage conditions

Measurement	Unit	Value range
Ambient temperature	°C	-40 - +80
Maximum relative humidity (non-condensing)	-	60%

2.4. Operation mode

By the interaction between different subcomponents, required information to run the heat pump should be achieved. The satisfaction of required conditions allows the heat pump to be able to flexibly handle the fluctuating thermal loads.
As the heat pump is air-to-water type, it heats and cools water in the buffer tank by accepting energy source from air. In this respect, the operation features of the heat pump are as following:

Operation feature for air

- Maximum air flow rate in heating mode [m^3/h]: 6000
- Minimum air flow rate in heating mode [m^3/h]: 2500
- Maximum air flow rate in cooling mode [m^3/h]: 6000
- Minimum air flow rate in cooling mode [m^3/h]: 2500
- Maximum air inlet temperature [°C]: 45
- Minimum air inlet temperature [°C]: -25
- Maximum operating relative humidity (at max. temperature) [%]: 90
- Minimum operating relative humidity (at min. temperature) [%]: 25

Operation feature for water

- Maximum output water flow rate [l/s]: 1
- Minimum output water flow rate [l/s]: 0.5
- Maximum water output temperature (heating) [°C]: 60
- Minimum water output temperature (heating) [°C]: 15
- Maximum water input temperature (heating) [°C]: 55
- Minimum water input temperature (heating) [°C]: 10
- Maximum water output temperature (cooling) [°C]: 35
- Minimum water output temperature (cooling) [°C]: 10
- Maximum water input temperature (cooling) [°C]: 40
- Minimum water input temperature (cooling) [°C]: 5

Heat pump operation principle

The heat pump will heat up the water in the buffer tank and DHW storage tank until the water in the tanks reach the required temperature. Once it reaches the temperature, it stops running. When the water temperature in tank gets cold and go below the threshold, the heat pump runs again.
The target water temperature changes depending on outdoor temperature. The two parameters form a heating curve (Fig. 8), and the heat pump modulate the system automatically by the heating curve. Users can modify the heating curve setting to achieve desired heating conditions.
Besides, compressor speed affects the heat pump performance. Higher compressor speed helps to get higher heating or cooling capacity. For simple explanation, the higher speed the compressor rotates with, the faster the water in the tanks reach the target temperature.
Both heating curve and compressor speed can be controlled by users through manual control or remote control online.

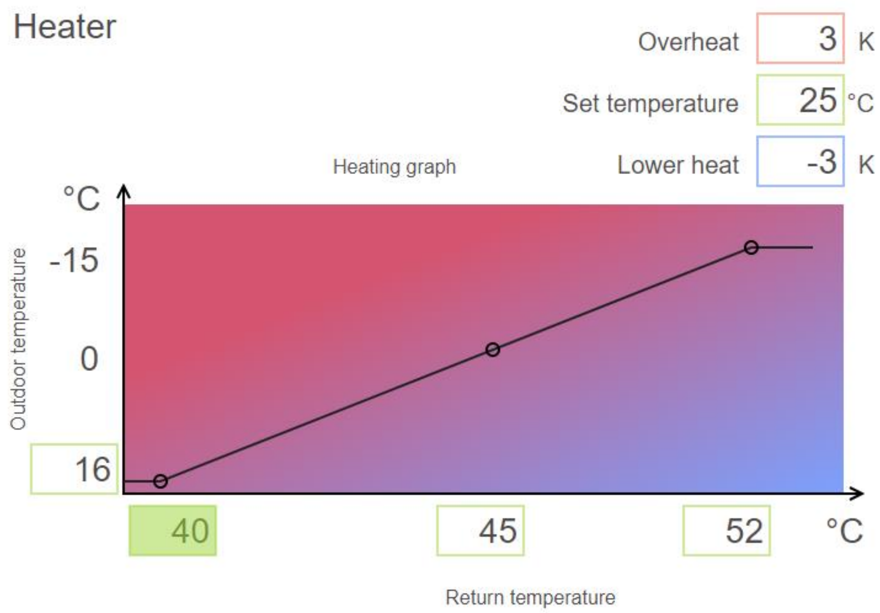


Figure 8. Heating curve control by online

3. Smart fan-coil

3.1. General description

The technical design of the smart fan-coils has been finalized and described in the previous release of this document (D6.1). Subsequently, the following sections provide a summary of the previously described information and present the updated design of the fan-coil unit. This includes detailed figures and relevant technical information about the sub-components housed within the unit.

3.2. System/component design

The unit is provided with a socket to allow 48V DC for electrical connection and 2½'' fittings as supply water. Additionally, a RJ45 socket is provided to allow external cabled connection. The first release of the fan-coil (the once that will be installed in the first demo-case) will operate using traditional R124 refrigerant. However, in order to reduce the GWP impact, a new release, able to use R290 is under development. Such refrigerant is characterized by a GWP (100Y) equal to 3 and an ODP equal to 0. The detail specification of the refrigerant is provided as follows.

General properties

- Propane > 99.5 % wt min
- Isobutane < 4000 ppm wt
- n-Butane < 4000 ppm wt
- Ethane < 2000 ppm wt
- Unsaturated < 250 ppm wt
- Residue < 00 ppm Vol
- Moisture (H2O) < 10 ppm wt
- Sulphur < 1 ppm wt

Chemical and physical properties

- Odour odourless
- Flammability Yes
- GWP 3
- ODP 0
- ADR/RID 2.1
- UN NUMBER 1978
- CAS 74-98-6
- EINECS 200-827-9
- ASHRAE A3

3.2.1. Unit design

The fan-coil unit is stand up unit, to be allocated vertically, and is configured as a radiator replacement. The physical features and dimensions of the unit are reported in Figs. 9-10.

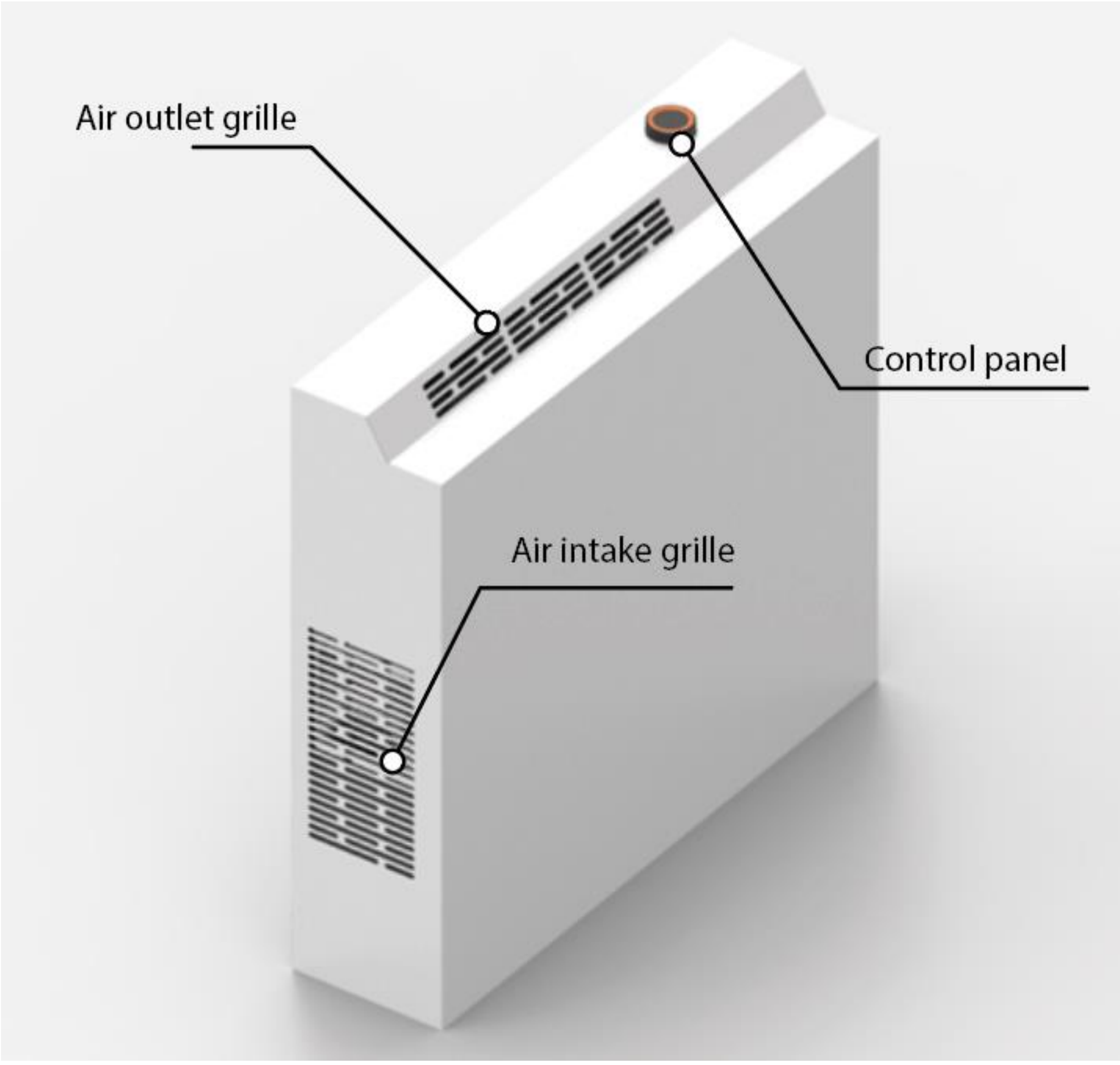


Figure 9. Fan-coil unit overview

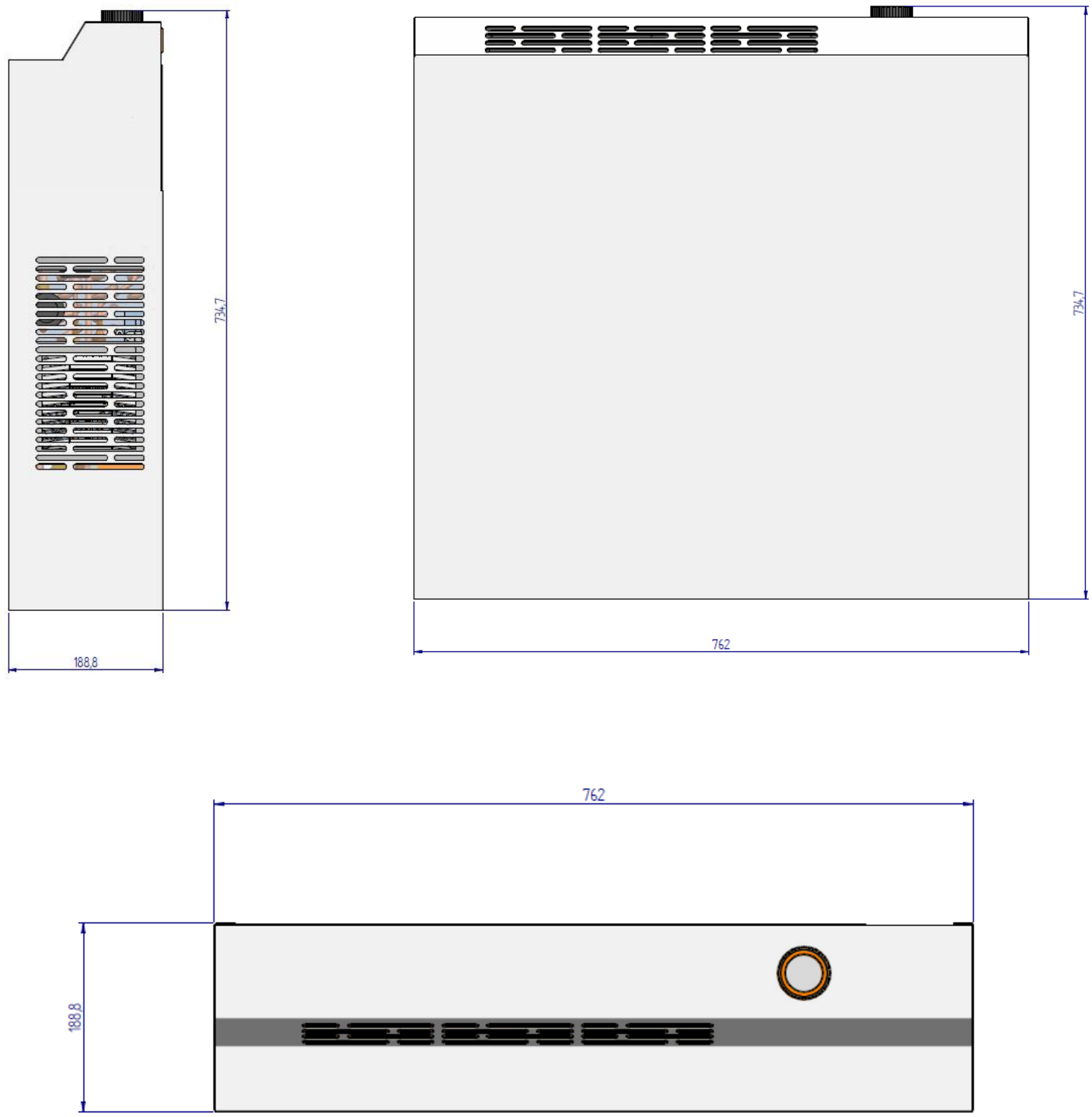
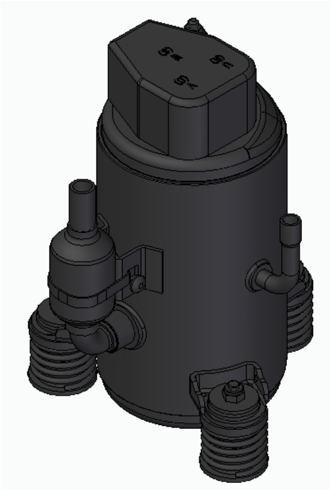


Figure 10. Side, front and top view of the fan-coil unit with main dimensions [mm]

3.2.2. Compressor and controller

The compressor is a rotary compressor with a revolution speed range between 900 to 5400rpm, regulated by a controller corresponding to the operational conditions (Fig. 11). It operates on an electrical input of 48V and is designed to handle a wide range of evaporation temperatures from -10 to +15°C and condensation temperatures ranging from 30 to +65°C. Utilizing R290 refrigerant, it efficiently manages heating and cooling tasks across diverse temperature environments.



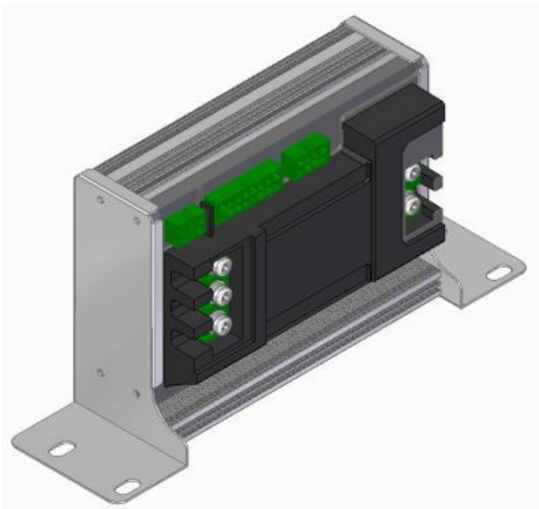


Figure 11. Rotary compressor and controller in the fan-coil unit

3.2.3. Fan

The fan is a tangential fan (Fig. 12) with a speed range of 400 to 2000 rpm. With dimensions of Ø65 x 420 mm, it offers efficient air movement within its compact form factor.

Figure 12. Fan in the fan-coil unit 3D model

3.2.4. Water heat exchanger

The water heat exchanger within the fan-coil unit utilizes a plate heat exchanger design (Fig. 13). It plays an important role in the heat exchange process, facilitating the transfer of thermal energy between the warm or cool water sourced from the buffer tank, which has been initially heated by the heat pump, and the refrigerant.

The heat exchanger performance in summer and winter seasons are shown in Tables 5-6.

Figure 13. Plate heat exchanger in fan-coil unit

Table 5. Heat exchanger performance in summer

Water flow rate [L/min]	Water inlet temperature [°C]	Water outlet temperature [°C]	Pressure loss [kPa]
3	25	35.82	0.865
3	15	25.98	0.905

Table 6. Heat exchanger performance in winter

Water flow rate [L/min]	Water inlet temperature [°C]	Water outlet temperature [°C]	Pressure loss [kPa]
3	25	35.82	0.865
3	15	25.98	0.905

3.3. Installation mode

The following information is intended exclusively at a specialized installer. It contains summary of necessary requirements to position the fan-coil unit within a specified installation place. Further information such as detail process of assembly and user guide can be found in the installation manual that will be distributed to the installer.

3.3.1. Electrical connection installation

Ensuring compliance with specified voltage and frequency parameters is essential for the proper functioning of the appliance, as indicated on its rating plate. Each unit requires a consistent 48V DC current to operate within its technical specifications. Any deviation from this, whether below 44V or above 49V, poses a risk of serious damage, resulting in voided warranties. Additionally, external overcurrent protection must be implemented in adherence to local regulations for added safety. The power supply line must feature robust positive and negative connections, appropriately sized to accommodate the unit's maximum power consumption. Power is exclusively supplied through a compatible plug and socket configuration. Replacement of the internal power cord should only be undertaken by authorized personnel to maintain safety and integrity. Furthermore, national installation rules mandate the inclusion of a suitable all-pole disconnect device within the appliance's power supply network, alongside ensuring effective grounding and protection against overloads or short circuits. Employing a type 30 AT time-delay fuse or equivalent safeguards is recommended for optimal protection.

3.3.2. Mechanical installation

Adequate spacing around the unit is imperative to facilitate maintenance operations effectively. This includes ensuring a minimum side distance of 0.2m, a top distance of 0.2m, and a front distance of 0.2m to allow for mobility and access. Additionally, it is crucial to maintain unobstructed airflow around the unit. Any hindrances such as curtains, plants, or furniture in the upper part of the expulsion or around the air intake could disrupt airflow, potentially impeding the proper operation of the appliance. Furthermore, when considering high wall mounting, it is essential to maintain a distance of at least 80mm from the ceiling to ensure optimal performance and airflow circulation. These guidelines help guarantee efficient functioning and longevity of the appliance while facilitating ease of maintenance and operation.

3.4. Operation mode

The smart fan-coil unit switches its operation mode between heat pump mode and water fan-coil mode by reacting variations of water supply condition (Table 7). In the heat pump mode, the compressor involves in the operation while, In the water fan-coil mode, the units exclude compressor from the operation. In the water fan-coil unit mode, the operation is conducted in complete silence with the minimum fan speed. This mode conversion is automatically carried out by programmed controller.

The smart fan-coil unit is also designed to switch between heating and cooling modes. The users can easily change the mode by controlling toggle button.

Table 7. Operation water supply temperature ranges in different modes

Heating mode		**Cooling mode**	
Heat pump mode	Water fan-coil mode	Heat pump mode	Water fan-coil mode
8 - 30°C	above 35°C	above 18°C	below 16°C

Another operational feature of the unit is the condensate ejection function. In weather conditions with high humidity and low air temperature, the condensate can be easily is accumulated on the liquid refrigerant line of the unit. When the condensate is melted down and becomes water, the water is collected on the internal condensate collection tray. The special ejection pump featured in the unit easily manages the condensed water.

4. Multi-Input/Multi-Output converter (MIMO)

4.1. General description

The following sections describe the updated design, structure, and capacities of MIMO system. MIMO system comprises several power converters in charge of managing the power flow between the roof PV panels, batteries pack, heat pump system, fan coils and the EV charging port.
The design of MIMO has evolved, utilizing cutting-edge SiC technology to enhance its capabilities, performance, and environmental sustainability. Additionally, efforts have been made to increase its lifespan and promote circularity.
MIMO prototype consists of 4-leg 3-phase inverter and DAB converters connected to batteries and PV panels. Further details of its technical design are described below.

4.2. System/ component design

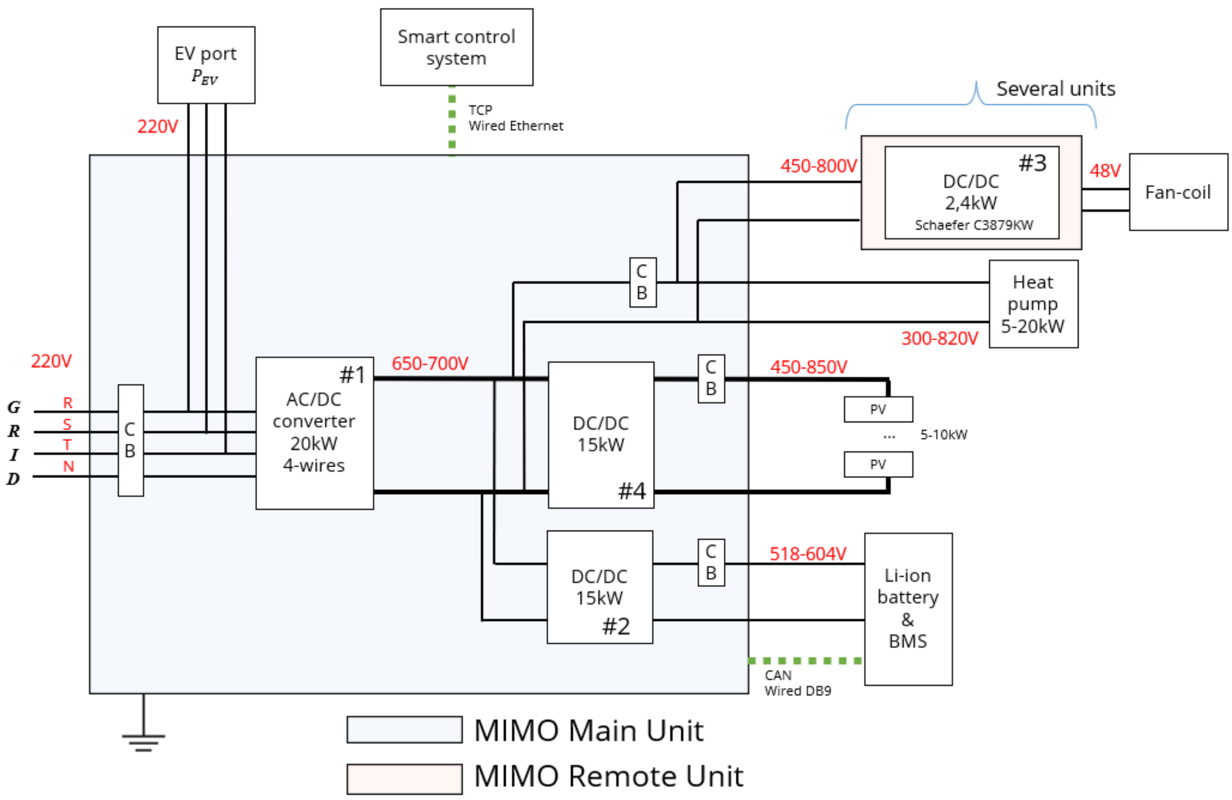


Figure 14. MIMO block diagram

MIMO system comprises 2 different units: Main unit and several remote units as shown in Fig. 14. Figure 15 provides an overview of the MIMO inverter converter prototype. This unit is used for programming tasks and for conducting various tests to check the converter response. This prototype has been industrialized and it is currently in production.
The prototype assists in completing engineering tasks during the assembly of industrial units. Since they share identical electrical details, the transition from prototype to industrial unit will be seamless.

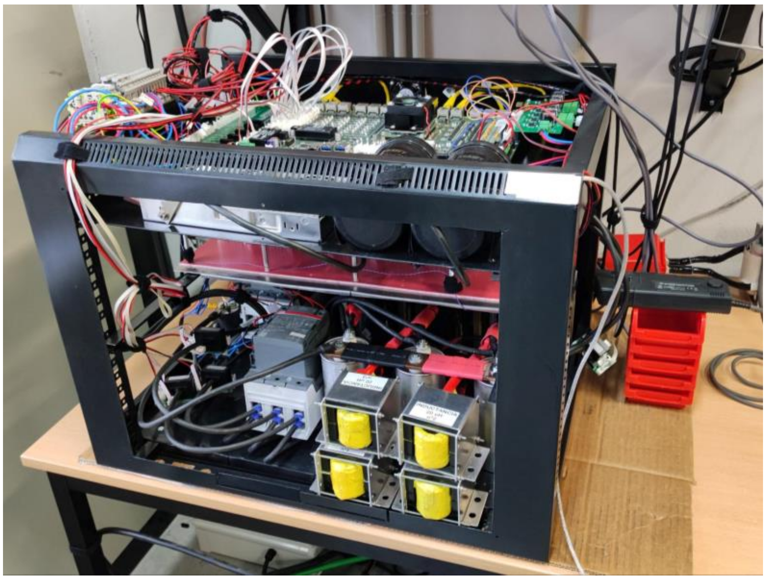


Figure 15. Inverter converter prototype

DAB converters function in the same way as the inverter (Fig. 16).

Figure 16. DAB converter prototype

4.3. Installation mode

In this section, installation requirements are described. MIMO main unit and the remote units should be installed in suitable places that meet the conditions described below.

MIMO Main Unit

- Operating air temperature [°C]: 5-45
- Ambient humidity [%]: 5-80. Condensation is not allowed.
- Installation: 30cm offset is required from all sides. A service room with ventilation is required.
- The installer should handle the protection and connection of the PV strings outside the MIMO system (MIMO includes 1 DC circuit breaker inside).
- The installer should handle the protection and connection of the battery pack outside the MIMO system (MIMO includes 1 DC circuit breaker inside).
- The installer should handle the protection and connection of the EV charger outside the MIMO system. A Residual-Current-Circuit-Breaker and a Current-Limiting-Breaker are mandatory.

MIMO Remote Unit: DC-DC fan coils

- Operating air temperature [°C]: 5-45
- Ambient humidity [%]: 5-80. Condensation is not allowed.
- Installation: 30cm offset is required from all sides. A service room with ventilation.
- Air should flow from bottom to top.

The physical aspects of MIMO main unit is shown in Fig. 17.

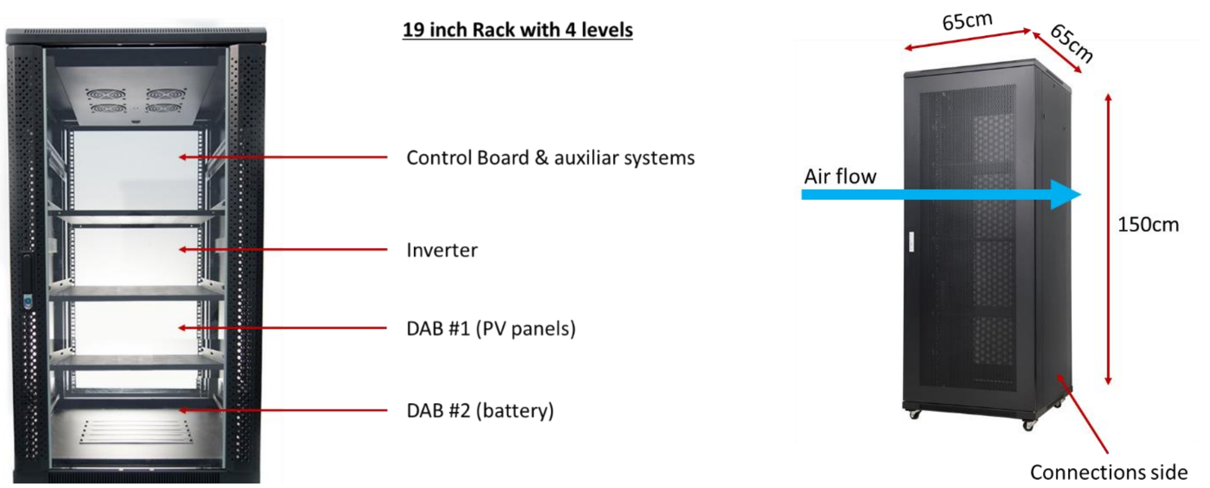


Figure 17. MIMO main unit physical aspects

The physical dimensions of MIMO remote unit are shown in Fig. 18.

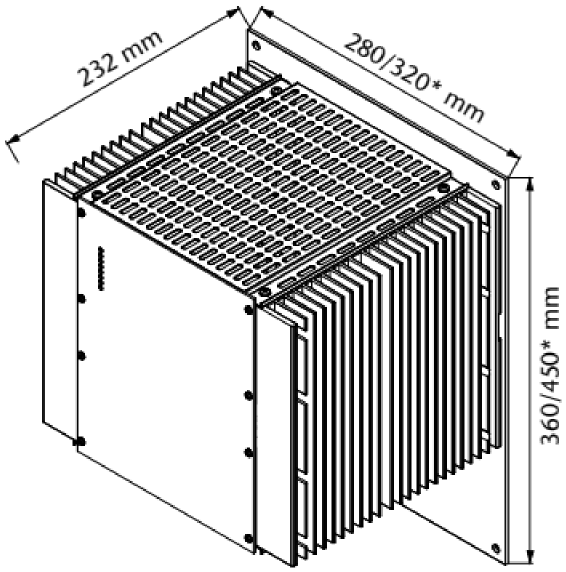


Figure 18. MIMO remote unit physical aspect

4.4. Operation mode

The MIMO system can effectively control and adjust the power levels and electrical characteristics of each connected component as illustrated in Fig. 14. MIMO also communicates with SCS by Ethernet RJ45 UDP and interacts with battery master BMS module by DB9 CAN communication.

MIMO operates autonomously with the assistance of SCS to optimize resource utilization and execute high-level control commands efficiently.

MIMO serves multiple functions within the grid. It can act as a grid load, such as when charging batteries from the grid in the absence of available PV power. Additionally, it can function in grid-feeding mode, balancing the excess PV power generated compared to consumption. Furthermore, MIMO can operate in grid-forming mode, ensuring stability and continuity in the event of a grid failure. During this mode, it handles unbalanced 3-phase loads, consistently ensuring that individual phase nominal power limits are not exceeded.

5. EV-charger

5.1. General description

The configuration and technical specifications of the proposed EV-chargers already presented in the first release of this document (D6.1) are confirmed. For sake of completeness, they are summarized below in this section.
Figures 19-21 below show the high-level design of the Version A and B of the EV charger, respectively, detailed in the following sections.

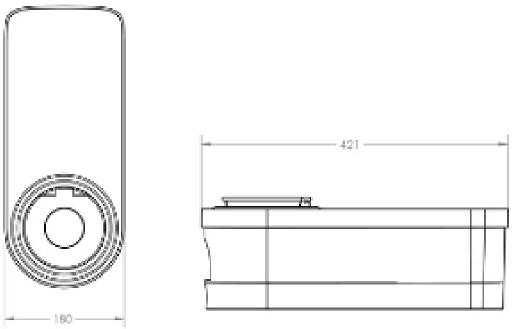
5.2. System/ component design

Version A

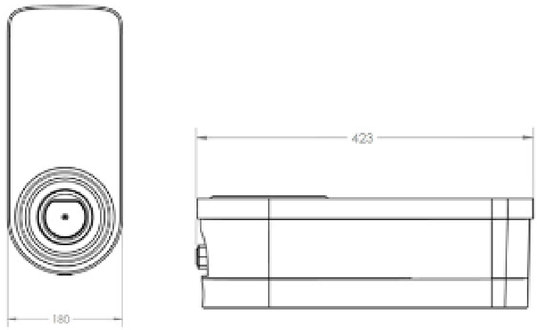
The Version A is an AC charging infrastructure, capable of charging one vehicle at a time. It has power ranging from 3.7 kW to 22 kW.
Suitable for parking at the workplace, in garages, apartment blocks, company fleets and curbside parking.
Considering an 80kWh battery from 0% to 100%, recharging takes 4-20 hours.

Figure 19. Version A

Version A

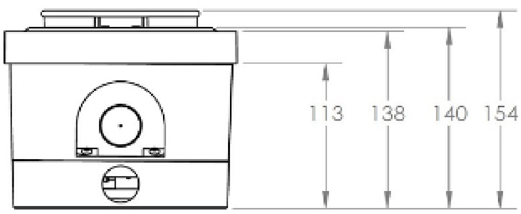


Version with socket

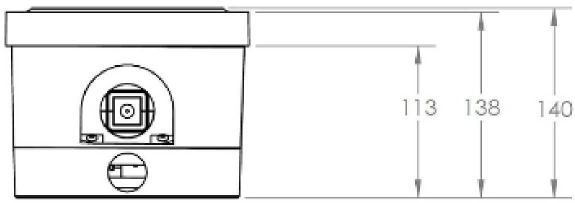


Version with cable

Version A charger and wall frame



Version with socket



Version with cable

Figure 20. Version A main dimensions [mm]

Version B

The version B of the AC charging infrastructure, able to charge up to two vehicles simultaneously is characterized by a power up to 22 kW.

Suitable for public areas, petrol stations and car parks.

Considering an 80kWh battery from 0% to 100%, charging takes approximately 4 hours.

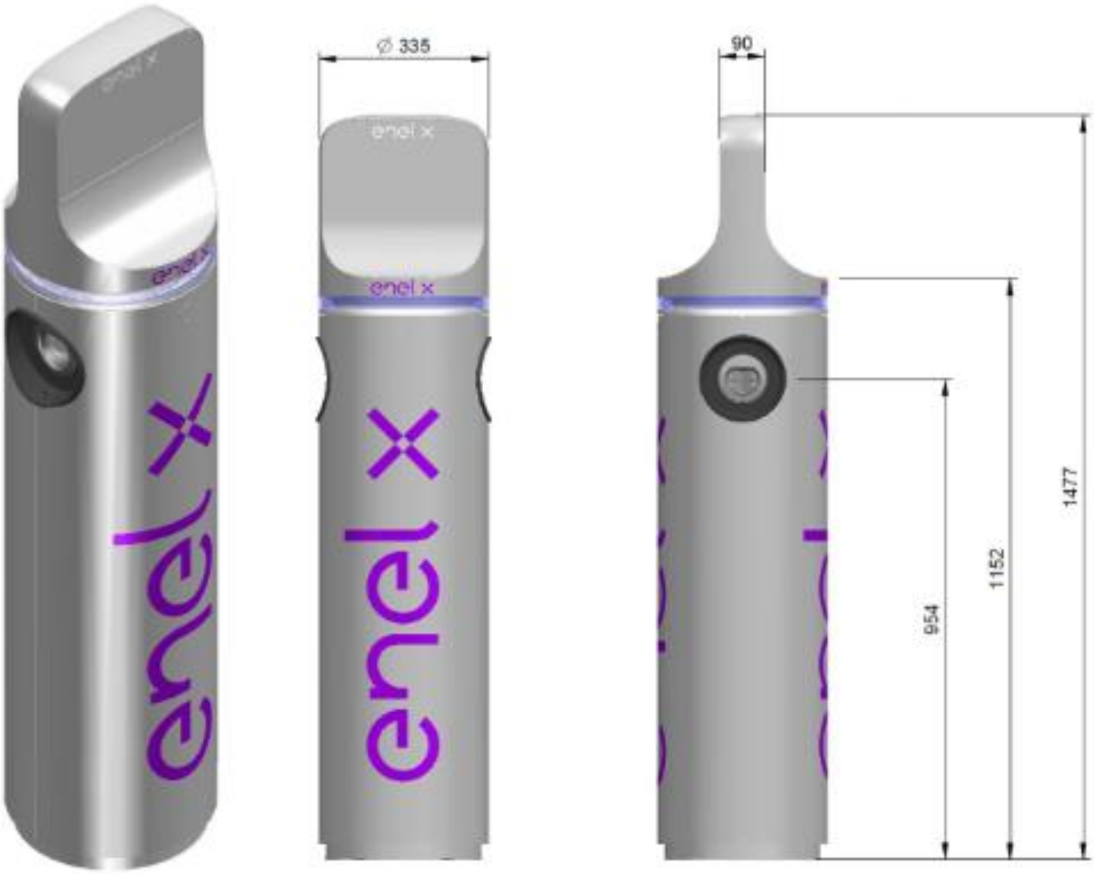


Figure 21. Version B main dimensions [mm]

5.3. Installation mode

5.3.1. Version A

Installation requirements

The version A must be installed by a qualified electrician according to the following specifications:

- Within range of the vehicle's charge port
- Units equipped with cellular connection: Within range of mobile cellular coverage. If reception is poor, an external antenna and cable extender with the following characteristics are recommended:
  - *External antenna: Omnidirectional, high gain antenna with coaxial connector*
  - *Cable extender: Low loss coaxial cable*

- Units equipped with Wi-Fi connection: Within range of the local Wi-Fi network (supporting IEEE 802.11b/g/n at 2.4 GHz)
- 150-160cm above the floor or ground
- A dedicated overcurrent protection device that includes both a Curve D MCB (miniature circuit breaker) and Type A RCD (Residual Current Device) with the characteristics shown in Table 8.

Table 8. Overcurrent protection device on each model of Version A

Version A models	Curve D MCB	Type A RCD
Version A 03 1-Phase 16A (up to 3 kW)	ICC: 6kA In: 25A Poles: 2	Id: 30mA In: 25A Poles: 2
Version A 07 1-Phase 32A (up to 7kW)	ICC: 15kA In: 40A Poles: 2	Id: 30mA In: 40A Poles: 2
Version A 22 3-Phase 32A (up to 22kW)	ICC: 15kA In: 40A Poles: 4	Id: 30mA In: 25A Poles: 2

- Power cables with the following characteristics (Table 9):
  - *Each cable must have an earth resistance of less than 150 Ω.*
  - *In the Table 9, "concealed" refers to wires that are routed inside the walls of the installation site.*
  - *The power cable specifications in the Table 9 are recommended for a normal installation. In some cases, such as when the cables must cover a large distance, a certified installer might use heavier wiring.*

Table 9. Power cable characteristics

Version A model	Concealed	Not concealed
Version A 03 1-Phase (up to 3 kW)	SWA 230 VAC 1-Phase 4mm^2 single-core cable for Phase/Neutral	4mm^2 cables (x3)

	$4mm^2$ single core "green/yellow" cable for Earth	
Version A 07 1-Phase (up to 7 kW)	SWA 230 VAC 1-Phase $6mm^2$ single-core cable for Phase/Neutral $6mm^2$ single core "green/yellow" cable for Earth	$6mm^2$ cables (x3)
Version A 22 3-Phase (up to 22 kW)	SWA 400 VAC 3-Phase $6mm^2$ single-core cable for Phase/Neutral $6mm^2$ single core "green/yellow" cable for Earth	$6mm^2$ cables (x5)

5.3.2. Version B

Pole pre-disposition (Fig. 22)

1. Once the pole has been removed from its packaging, and placed vertically on the pavement, taking care not to damage it, it must be prepared for installation. With the key, open the front and back doors making sure to temporarily place them vertically and on a suitable surface, avoiding balancing them precariously.

Figure 22. Version B front panel pre-dispositioning

2. Unscrew the front Panel and set it to one side, together with its 10 screws. It should be noted that this step has not to be done with screwdriver.
3. Unscrew the "lexan" protection of the terminal block, placing it with the 2 screws in a safe place.

Positioning the Pole in situ

1. Remove the central cover of the cap and insert it on the clamps in the direction indicated by inserting the power cable in the central hole.

2. Place the pole on the clamp studs in the direction indicated by “FRONT” paying attention to the cable “part”.
3. Position the pole on the 4 studs of the Clamps.
4. Fix it to the base with the screws provided. The tightening torque is 18.4 ft/lb.

Ground power wiring

1. Unscrew only on one side the metal cable tie of the terminal block. Prepare the power cable.
2. After having prepared the power cable and the main ground (eyelet cable lugs for M8 screw) operate the connection with the terminal block.
3. Use a socket wrench, **at least 1.6’’ long,** of 0.5’’ to tighten the bolts at best, applying a minimum torque of 4.4 ft/lb.

Concluding Operations

- Cross-check all Switches (Magneto-Thermal and Differential - Single phase and/or three phase).
- Reassemble the transparent “lexan” protection.
- Reassemble the terminal block protection.
- Reassemble the front Door.
- Place the 2 doors in their slots and lock them.
- Manage key storage according to established procedures.

After closing it, remove any film that has remained glued onto the Top, Side, Front and Back.

Final Operations

Once operations are completed:

- Verify the correct fastening and locking of the Apparatus.
- Verify the “working state” of the Apparatus.
- Retrieve all the equipment and store it away carefully.
- Retrieve any waste produced.
- Leaving the “environment” just as you found it.

5.4. Operation mode

5.4.1. Version A

Before setting up the Version A, it is important to determine which mode you want to use it in. Version A has 2 modes: Connect & Charge mode and Unlock To Charge mode.

Connect & Charge mode

- This mode does not require any authentication to start or stop a charge. In this mode, it is not possible to set up delayed recharges.
- To start a charge, simply connect the Version A to your vehicle.
- To stop a charge, send a stop command (from the App or your vehicle) and then disconnect your vehicle. Version A is set to operate in Connect & Charge mode when first started.
- However, it is recommended to perform the steps to Connect & Charge online in order to remotely manage recharging, configure Version A settings and other parameters.

Unlock-To-Charge mode

- This mode is suggested when the Version A is installed in a private area.
- This mode is suggested when the Version A is installed in areas with public access.
- In Unlock-To-Charge mode, the Version A recharges only after it has recognised an authorised user. Recharges are then started and stopped using an authorised profile on the JuicePass App, or an RFID card associated with the Version A.
- This mode also allows you to set up delayed refills.

5.4.2. Version B

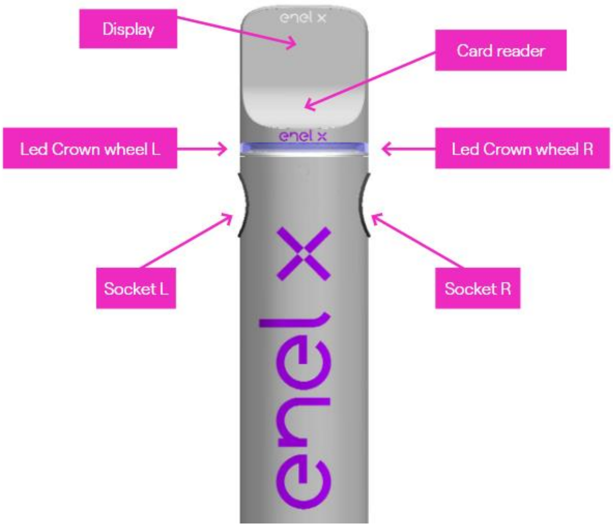


Figure 23. Detail of Version B

The two L and R sockets (Fig. 23) are managed by the Version B Control System simultaneously; namely it is possible to charge two electric vehicles at the same time.

Charging process

The display initially looks like Fig. 24 assuming there are no other charging processes in progress:

Figure 24. Initial display

First, the users must identify themselves via RFID card or suitable APP. Bring the RFID card close to the reader and wait for it to be accepted. as soon as it is accepted, the display in Fig. 25 will appear briefly:

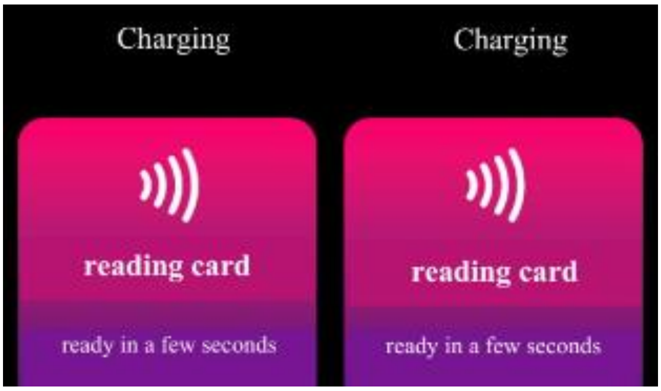


Figure 25. Display when it is readied to read RFID card

If the RFID card is accepted by the system, Fig. 26 will be seen:

Figure 26. Display when RFID card is accepted

When the display shows the Fig. 26, the user is required to insert the plug of the charging cable into the chosen socket, within 90 seconds (timeout). When 30 seconds are left, the screen shows a numerical countdown. For example, when a Plug is placed in the R side, the display would show the Fig. 27. As soon as the charging session begins on the side where the plug is inserted, the dispensed energy in kWh will appear on the screen.

Figure 27. Display when R side socket is plugged in

If, during the start of the charging session, a second (valid) RFID card is presented to the reader (or by using the appropriate APP) in sequence, the screen shows as Fig. 28.

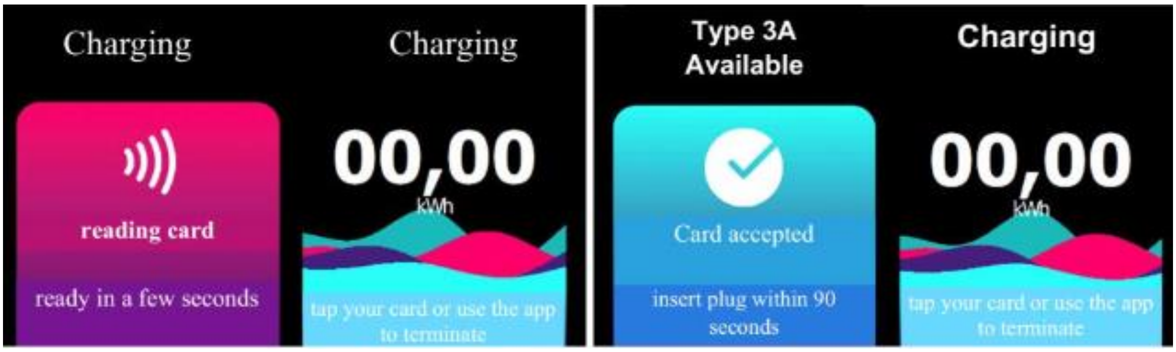


Figure 28. Display when second RFID card is accepted

At this point the plug of the charging cable should be inserted into the L side socket (last available) within 90 seconds (timeout), only for the L side one will see the screen with the plug appearing/disappearing (Fig. 29).

Figure 29. Display when L side socket is ready to be plugged in

As soon as the charging session starts on the display (on the L side, where the plug is inserted) the supplied energy in kWh will appear (Fig. 30).

Figure 30. Display when charging session starts – L side display

Assuming that the supply from the R side ends when nearing your card to the RFID reader (or by using a suitable APP), the screen shows in sequence: The system stops supplying power from the side corresponding to the RFID Card used and summarizes the energy supplied during the charging process. One must now pull out the R side plug (Fig. 31).

Figure 31. Display when the session ends

The R side Socket is available again for the following charging session (Fig. 32).

Figure 32. Display when the charging in the R side socket ends and the socket is available again

Finally, assuming that the supply on the L side is also completed when nearing the card to the RFID Reader, it shows the screen (Fig. 33) in sequence:

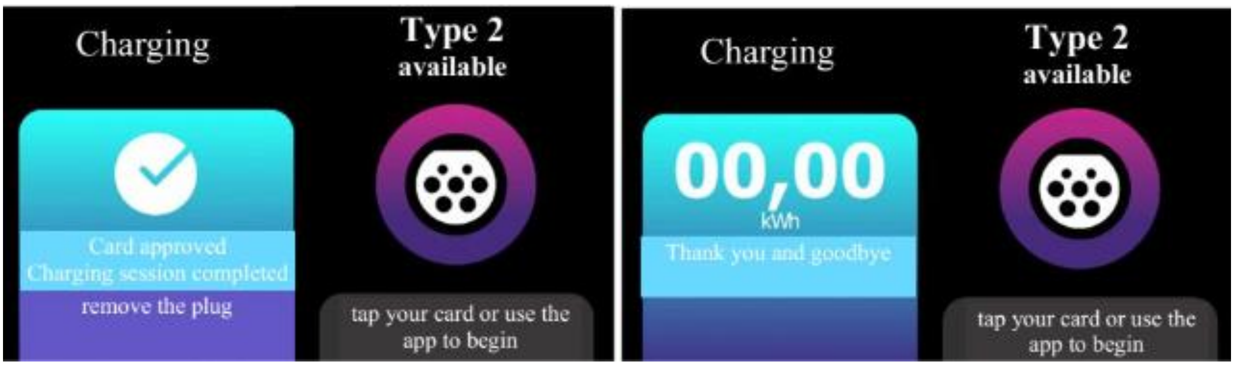


Figure 33. Display when the charging at L side ends

The system stops supplying power from the side corresponding to the utilized card and summarizes the energy supplied during the charging session. One must now extract the L side plug.

6. Battery pack

6.1. General description

The BESS (Battery Energy Storage System) is composed of three parts: the battery pack, the enclosure and the BMS (Battery Management System).
The battery pack comprises 144 repurposed LEV40 cells connected in series to form a high-voltage battery with a nominal voltage of 540V. While the nominal capacity of these cells is 40Ah, it is anticipated to be around 30Ah, considering the cells are recycled from EV cars.
The enclosure, designed for outdoor use in the garden, is a metallic cabinet with an IP55 rating. It is to ensure safety and comply with insurance requirements.
The BMS is a system supplied from a company named REC. This system has a Master/Slave configuration. This system is meant to read the data of the cells and communicate with the MIMO. The BMS reads current, voltage, and temperature of each cell and manage the charging and discharging accordingly.
The cabinet will feature nine sliding shelves, with each shelf accommodating a BMS slave responsible for managing 16 cells (the top shelf will additionally house the Master BMS). To maintain optimal operating conditions and ensure safety, the cabinet will be equipped with a heater and a fan, preventing the battery pack inside from exceeding temperature limits imposed for safe operation.

6.2. System/ component design

Enclosure

The components of the battery pack are to be contained within an off the shelf Electrical/Server cabinet designed to receive 19” (19 inch) “Racks/Trays” (trays) stacked vertically. The Housing can be sourced in many formats intended for various operating environments such as indoor, outdoor, harsh environment, etc. The housings can also be sourced with various features such as fire resistance or suppression, automatic thermal and environmental control, or other various operational or safety features.
The use of this type of housing allows for variance in customer preference and requirement as well as forming the basis for a scalable and modular solution which can be expanded without affecting the core functional architecture of the pack system.
An overview on the enclosure (Fig. 34) as well as the main features are reported below.

Figure 34. Overview of battery pack enclosure

- Material
  Housing frame: Stainless Steel 1.4301 (AISI 304)
  Flat parts and plinths: Aluminum, AlMg3
  Rain roof: Aluminum
- Dimensions [mm]: 2,145 x 800 x 800 (L x W x H)
- Protection class: IP55

Battery cells

The cells are divided into groups of 16 cells that are governed by a dedicated BMS. The BMS has various communication I/O (input/output) points for stand-alone or integrated operation. The series connected cell groups will have at each end of their DC V connection path a dedicated Positive and Negative DC V connection terminal (DC Traction Terminals) for connection of external hardware or Slabs (Battery Tray Modules) to form a higher voltage pack (Figs. 35-36).

Figure 35. Battery cell **Figure 36.** 8 battery cells in series

The main features are as follows:

- Dimensions [mm]: 170 x 35 x 100 (L x W x H)
- Weight: 1.65 Kg

BMS (Battery Management System)

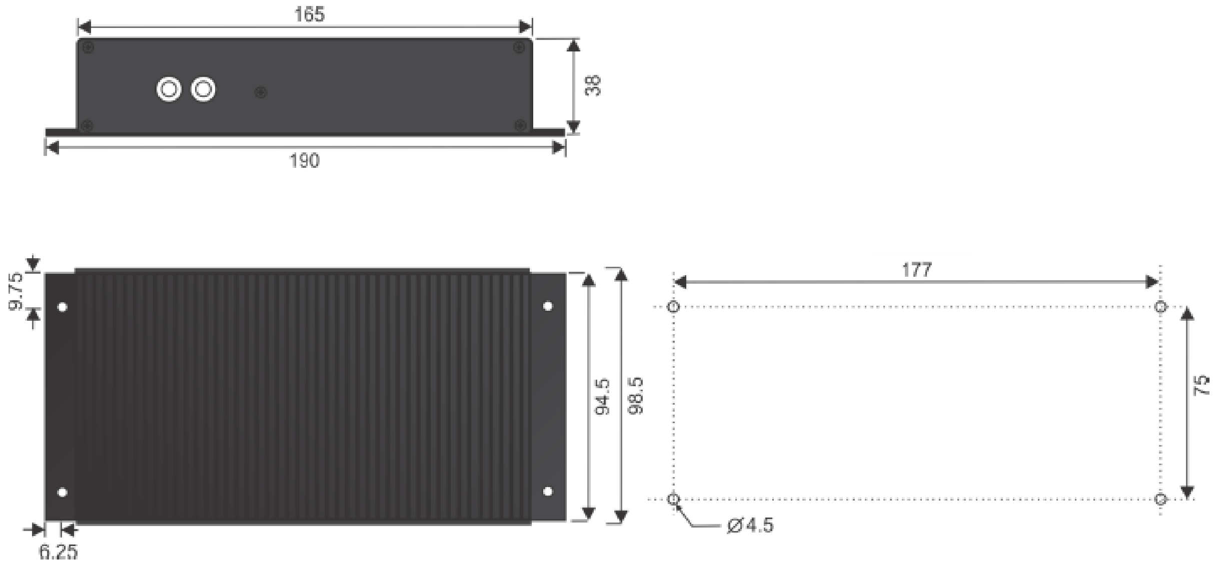


Figure 37. Slave BMS unit dimensions [mm]

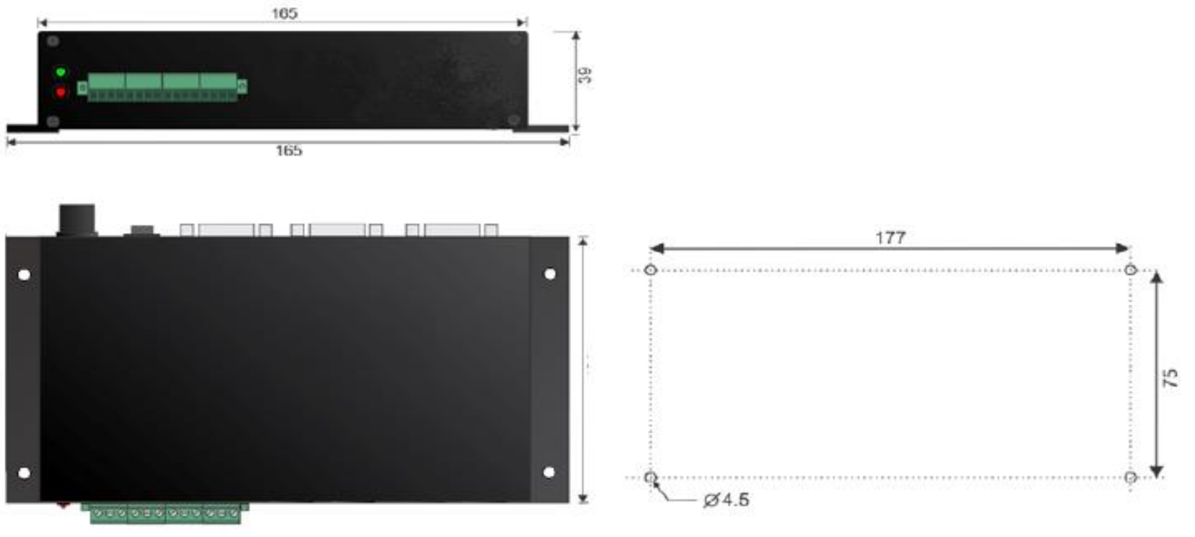


Figure 38. Master BMS unit dimensions [mm]

The proposed battery system for this phase of the RE-SKIN project comprises nine "Slab Batteries" connected in series within the 19” Rack Housing, collectively forming the "System Cell Bank" (SCB). An integral component, the 10th "Control Slab," would govern both the SCB and additional embedded or integral systems within the pack.

The placement of the Control Slab within the system stack (either at the bottom or top) is contingent upon factors such as the planned installation location and orientation of the pack housing. This decision also considers existing or planned customer/project stakeholder hardware configurations, such as cable routing out the top or bottom of the housing.

The Control Slab serves as the primary housing for the Master Battery Management System (BMS) and other necessary control systems/hardware. The Master BMS plays a pivotal role in monitoring and governing the functionality and coordination of the 9 Slab Batteries during operation. Additionally, it has the capability to control other systems or hardware within the pack to ensure optimal operation and performance, including functions such as temperature or climatic control, electrical isolation/emergency shutdown, and more (Figs. 37-38).

Beyond its role in internal pack operations, the Master BMS serves as the communication interface point for external systems, such as the "MIMO," facilitating communication between external systems and the internal and embedded systems of the Battery Pack.

6.3. Installation mode

Currently, the Battery Pack System is designed to be positioned at a minimum distance of 1 meter from any structure or dwelling, aligning with evolving regulatory and insurance standards related to lithium-ion systems. The potential adjustment to allow the battery pack within 1 meter of structures or dwellings is contingent upon further clarification and definition from regulatory bodies and certifying organizations. This adjustment aims to enhance the effectiveness of mitigative development efforts, pending comprehensive guidelines from relevant authorities.

The Battery Pack itself will be housed in an outdoor electrical cabinet featuring Ingress Protection (IP) rated cable glands or entry points, facilitating the connection of the Main DC Traction Cables and any Communication Cables. It's essential to emphasize that all connections or servicing of the pack must be undertaken exclusively by trained, certified, and approved technicians. Under no circumstances should the end user or any third party directly interact with the interior of the battery pack, emphasizing the critical importance of professional expertise in managing and maintaining the system.

6.4. Operation mode

The system will be delivered ready to operate in conjunction with the MIMO. Little or no interaction from the customer is required for ongoing operation. If an error occurs, the system will take necessary actions, such as shutdown or isolation, and the MIMO will receive a notification. The customer can monitor performance statistics and error messages, similar to other battery management systems on the market thru the MIMO interface and not directly thru the battery. In case the issue persists, the customer is advised to contact the registered service provider for troubleshooting, following the steps outlined in the user manual. Importantly, the customer, end user, or any third party should never interact with the interior or internal components of the battery pack under any circumstances.
Any interaction by uncertified or unregistered personnel should be conducted exclusively through the battery management app, user control screen (if available), or a specifically designated communication port (if provided).

7. Smart Control System (SCS)

7.1. General description

The Smart Control System (SCS) is a central component in the building, orchestrating communication with other components to provide local storage and visualization services. Additionally, the SCS communicates with the RE-SKIN cloud infrastructure to send notifications, data streams, and other required events. Moreover, in accordance with the Edge Computing paradigm, the SCS may also run simple data processing pipelines if it is more efficient to do so compared to running them in the cloud, depending on the scenario.
The SCS stands out from other components discussed in this document. This distinction arises because the SCS is primarily composed of software services. While there is a hardware component responsible for fulfilling computing and memory requirements, it is secondary to the software. The devices mentioned here represent one of many possibilities. While they are a recommended configuration, it's essential to note that they are not the sole available option.

Due to its focus on software instead of hardware, the structure of the subsections differs slightly from other sections in this document:

- The **system/component design** subsection presents the primary design decisions and architecture of the SCS. It also presents the technology stack.
- The **installation** subsection details the specific configuration of hardware devices that constitute the building blocks of the SCS.
- The **operation** subsection, while comparatively brief, concentrates on the conditions and recommendations for the SCS's stable operation.

7.2. System/ component design

The SCS is a set of software services made for securely storing data streams from different building components, like DC Heat Pump, for long term. In addition, the SCS includes services that facilitate user-friendly visualization and exploration of the datasets it contains. It also provides processing services to implement data pipelines based on these datasets.

Figure 39 presents a diagram of the high-level architecture of the SCS. It also illustrates the primary interactions with the RE-SKIN platform's cloud services and the collaborative methodology employed between the SCS and the cloud development teams.

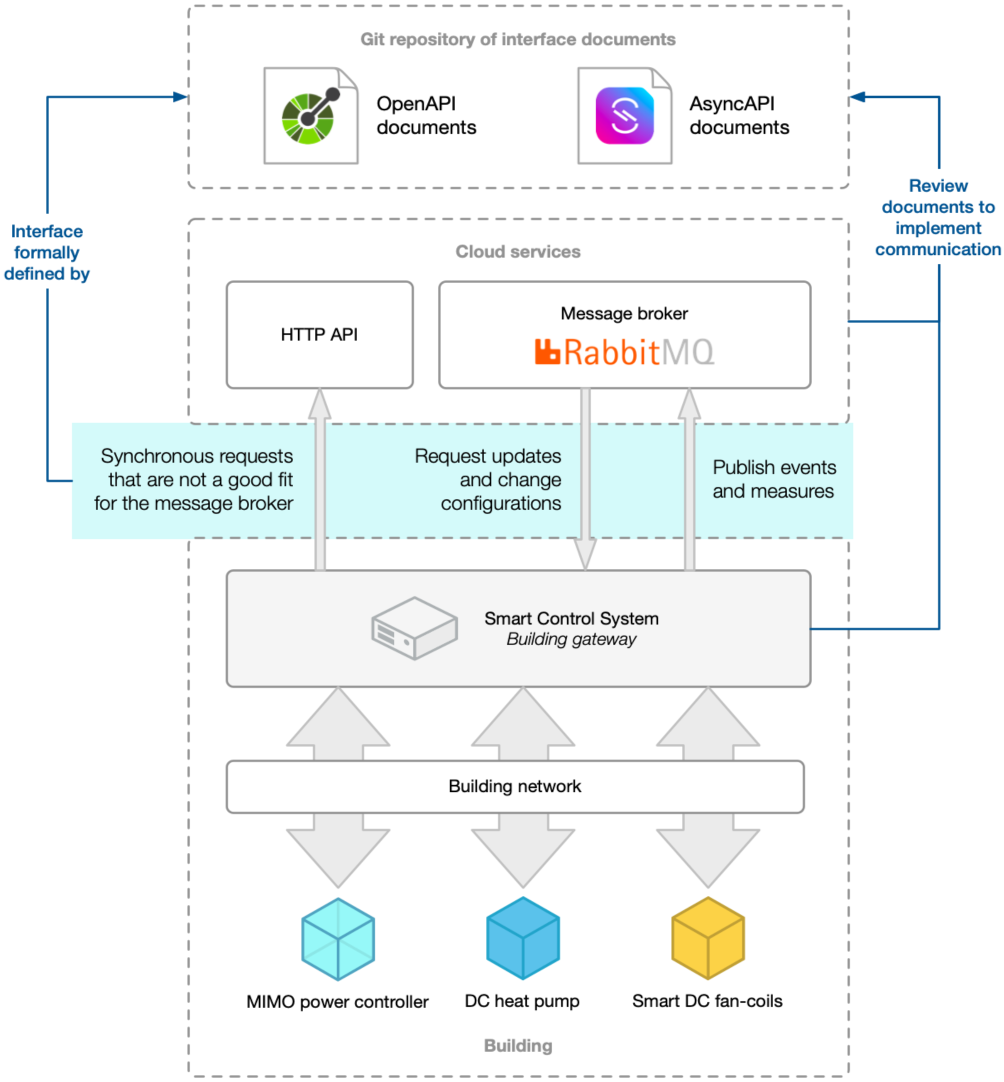


Figure 39. Architecture of the SCS including interactions with cloud services

The SCS collects data streams from various building components, such as DC Heat Pump and the MIMO Power Controller, via the internal building network. This communication relies on the Modbus TCP protocol and takes place over a physical, wired Ethernet network. While some components may use a push-based approach, where the component initiates communication to the SCS, others may use a pull-based approach (often referred to as polling), where the SCS initiates the communication. In any case, all components must comply with the interface of the SCS API.

The SCS has adequate computing resources for both the long-term storage of datasets and the execution of its processing pipelines. However, it also transfers a subset of the local data to the cloud services to facilitate the functionality of the RE-SKIN cloud platform. There are two primary interfaces between the cloud and the SCS: an HTTP API for synchronous requests and a message broker for asynchronous communications and event-based messaging in scenarios where the HTTP API is unsuitable. These two interfaces are formally defined using the OpenAPI and AsyncAPI specifications. The former is designed for describing HTTP APIs, while the latter is for describing event-based asynchronous APIs.

The specific technology stack is not finalized at the time of writing and may be subject to change as the project evolves to adapt to unforeseen events, such as significant modifications in other components. Nonetheless, there is a preliminary proposal that could fulfill all the current requirements of the SCS. This technology stack is described in detail in Table 10.

Table 10. Technology stack of the SCS

Technology	Role	Brief description
ThingsBoard	IoT platform that centralizes communications in the SCS	ThingsBoard is an IoT platform that enables the SCS to abstract from the complexities of a system comprising multiple devices. It provides a set of software gateways that support various transport protocols, including Modbus TCP and OPC UA. This creates a uniform layer, thus streamlining operations. Furthermore, it eases the administration of devices and the management of the data streams they generate.
Timescale	Time-series database for data collected by the SCS	Timescale is a database engine that is engineered on top of PostgreSQL, a highly reliable and proven relational database. Its primary focus is to facilitate the efficient storage and retrieval of time-series data. One of the most significant advantages of Timescale is its seamless integration with PostgreSQL. This integration allows Timescale to provide all the guarantees and tools inherent to PostgreSQL while also scaling effectively to handle large volumes of time-series datasets. In the context of the SCS, Timescale acts as the database backend of ThingsBoard.
Grafana	Visualization tool for users inside the building network	Grafana is a web application that enables users to build modern visualizations using a variety of dashboard components, including line charts, pie charts, tables, and geographical maps. It integrates seamlessly with Timescale, providing all the necessary functionalities out-of-the-box to create comprehensive dashboards tailored to the specific requirements and preferences of the scenario and the end user.

RabbitMQ	Messaging broker	RabbitMQ is a highly flexible message broker that implements the AMQP protocol. It allows developers to configure the messaging application to implement various patterns, such as topic-based publish-subscribe and task queues. RabbitMQ supports a flexible configuration to define different levels of persistence, high availability, and quality of service. Additionally, it supports the popular MQTT protocol using a plugin.

7.3. Installation mode

The most important hardware component of the SCS is its hardware platform—that is, the device that provides the computing, memory, storage, and network capabilities required by the software services of the SCS. Figure 40 shows the rear view of the physical enclosure of this hardware platform. The main specifications of SCS hardware platform are shown in Table 11.

Figure 40. Rear view of the SCS hardware platform

Table 11. Main specifications of the SCS hardware platform

Technology	Role
CPU	Intel Core i5-1145GRE
Memory	8GB
Storage	128GB (2.5” SSD)
USB	USB 3.2 Gen 2 x 3 USB 2.0 x 1

Network	GbE x 2 (interface #1 up to 2.5Gbps, interface #2 up to 1Gbps)
Display	HDMI 2.0 x 1 /DP 1.4 x 1 eDP x 1, 4K at 60hz panel
Power	12V
Operation temperature	0ºC – 60ºC
Weight	2.3Kg
Dimensions	278mm x 269mm x 149mm

Figure 41 displays a picture of the cellular router. This router offers all the expected functionalities, including support for 4G, 3G, and Wi-Fi, along with a plethora of other features such as support for multiple VPN protocols, security mechanisms, APIs for programmatic management, and extended temperature and humidity tolerances.

Figure 41. Back view of the cellular router

Together, the hardware platform and the cellular router constitute the backbone of the SCS from a hardware perspective. The diagram in Fig. 42 presents a high-level view of how the individual hardware devices that make up the SCS are interconnected. Please note that there are other hardware devices shown in the diagram that has not been detailed previously. This is because their specifications are more flexible and could evolve as the project progresses.

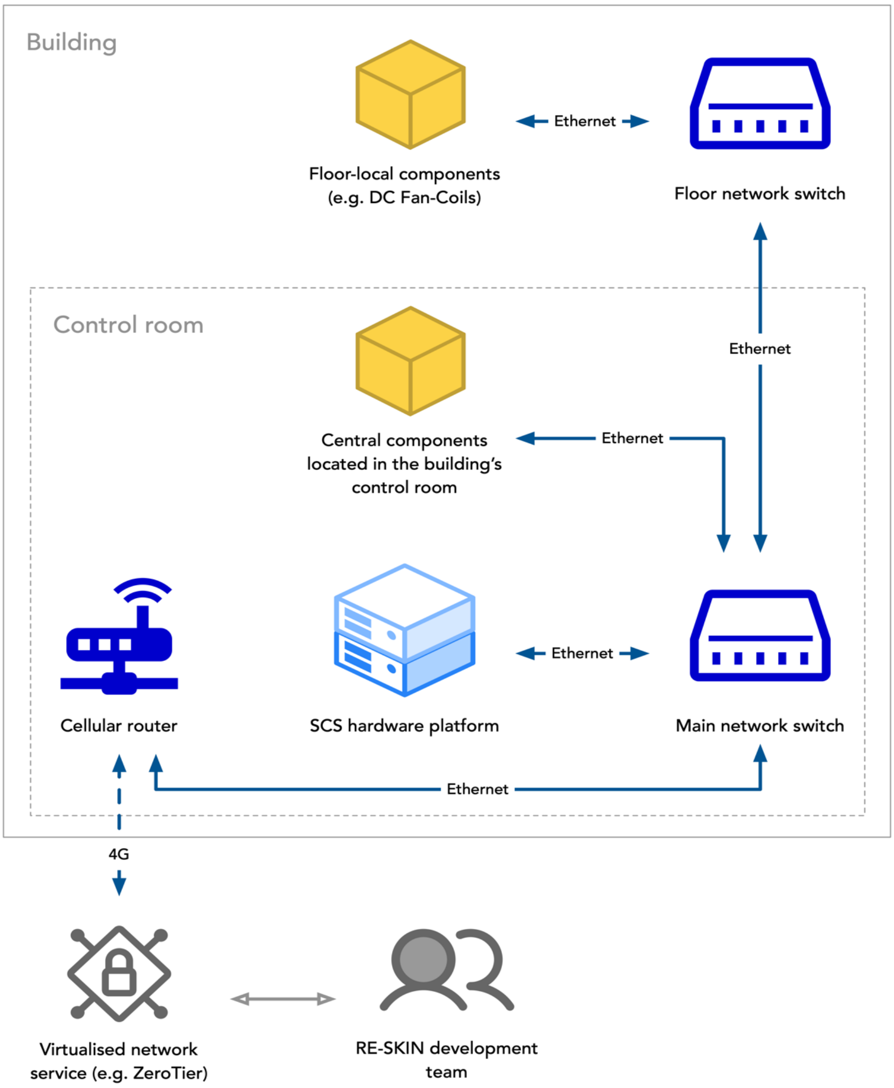


Figure 42. Installation diagram of the SCS

Physical network Installation

Although the installation of the wired network is not specifically part of the scope of the SCS, nor is its deployment and operation the responsibility of the RE-SKIN partner in charge of developing the SCS, it is essential to the SCS. A reliable building network is critical to ensure adequate communication between the SCS and the building components, a fundamental requirement for the smooth operation of the RE-SKIN toolkit.

For this reason, a wired Ethernet connection is preferred as the first choice, while a stable wireless connection may be an alternative option. Ethernet is undoubtedly the recommended option due to its reliability, speed, and low latency. It provides a stable connection with high bandwidth, guaranteeing coverage and quality of transmissions throughout the building. It should be highlighted that the installation of a wired Ethernet network will likely involve a significant project; however, the benefits outweigh the costs when stability is a primary requirement, as in the case of RE-SKIN.

Ethernet wires should be of category 6 (Cat6) or category 7 (Cat7) with STP or SFTP shielding. Cat7 cable is better at protecting against possible degradation caused by crosstalk and EMI. Since Cat6 and Cat7 cables have a maximum cable segment run length of 100 meters, if the distance is greater than that, a signal repeater (switch) in the middle is a must. If the cable is going to be secured to the exterior of a building, it is recommended to use an exterior-grade Ethernet cable that's UV resistant and coated with PVC or LLDPE.

In cases where using an Ethernet wired connection is not possible, Wi-Fi is the second-best option, preferably using the latest technologies such as Wi-Fi 6 or mesh to ensure the best coverage possible. Nevertheless, the use of Ethernet and Wi-Fi is not mutually exclusive, making it possible to use them in the same network, which means that some devices may communicate with the SCS via an Ethernet cable and others via Wi-Fi.

7.4. Operation mode

This section contains a list that briefly provides the recommendations and requirements of the SCS to ensure its continued and stable operation:

- It is critical that wired Ethernet connections are available in most cases, except where there are insurmountable barriers, or the cost is excessively high. Although Wi-Fi is a mature, proven, and stable technology, the components of the RE-SKIN toolkit demand the most stringent availability and stability guarantees, which can only be provided by a wired Ethernet network.
- Special attention should be paid to the installation of the cellular router to ensure that 4G coverage is acceptable and sufficient to support stable connections to the Internet. Raw bandwidth is not the most important feature in this case; stability and latency are much more important.
- The cellular router, SCS hardware platform, and network switches should not be in tight spaces with insufficient ventilation, especially if next to other devices that are in continuous operation. Moreover, they should be securely installed while remaining accessible for maintenance and day-to-day operations. For example, devices should not be left on tables unless undergoing active maintenance or for a specific purpose.

- Relying exclusively on the 4G connection for access to the Internet carries an increased risk of unavailability. Having the 4G connection act as a fallback, while there's also a cabled connection with a local ISP, would be the most optimal solution in terms of Internet connectivity.
- The RE-SKIN development team should have administrator access to configure and monitor this cabled Internet connection. Moreover, it’s recommended to replace the ISP-provided network router, which is usually a budget device, with a more capable network router that is more appropriate for the role.