HEART D6.5 – DC-HP units, thermal storage units and smart fan-coils for on-field demonstration - II

January 2020

HEART

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HISTORY OF CHANGES

Version	Date	Comments	Main Authors
0.1	09/12/2019	First draft, establishing document structure	G. Manfroi (STI)
0.2	13/01/2020	First version, incorporating input Heliotherm.	M. Bangheri (HELIO)
0.3	15/01/2020	Revision of first version	G. Manfroi (STI)
0.4	17/01/2020	Second version, incorporating input UL	Rok Koželj (UL)
0.5	24/01/2020	Quality review	C. Del Pero (POLIMI), F. Leonforte (POLIMI)
1.0	30/01/2020	Final version addressing all further comments	G. Manfroi (STI)

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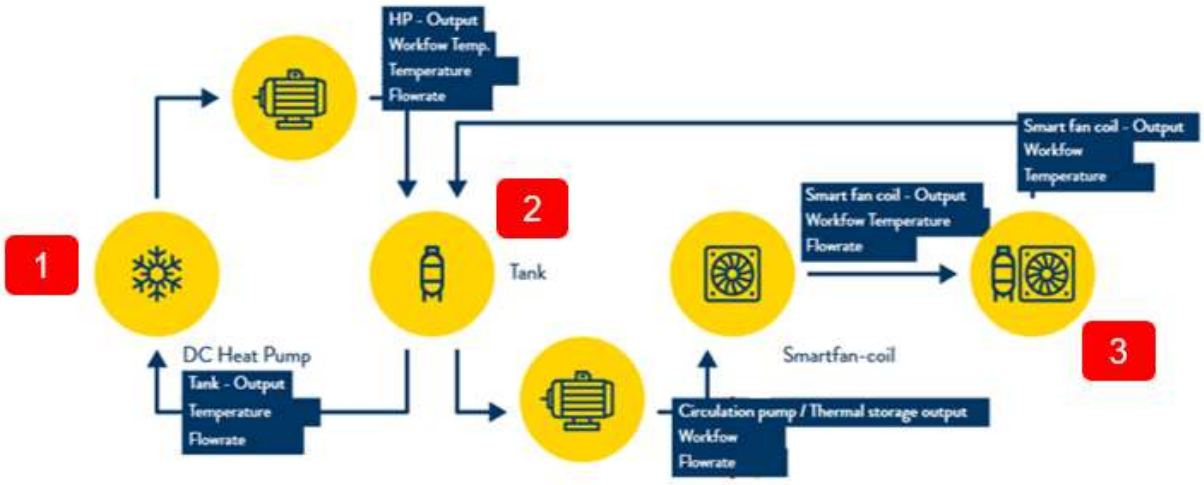
EXECUTIVE SUMMARY

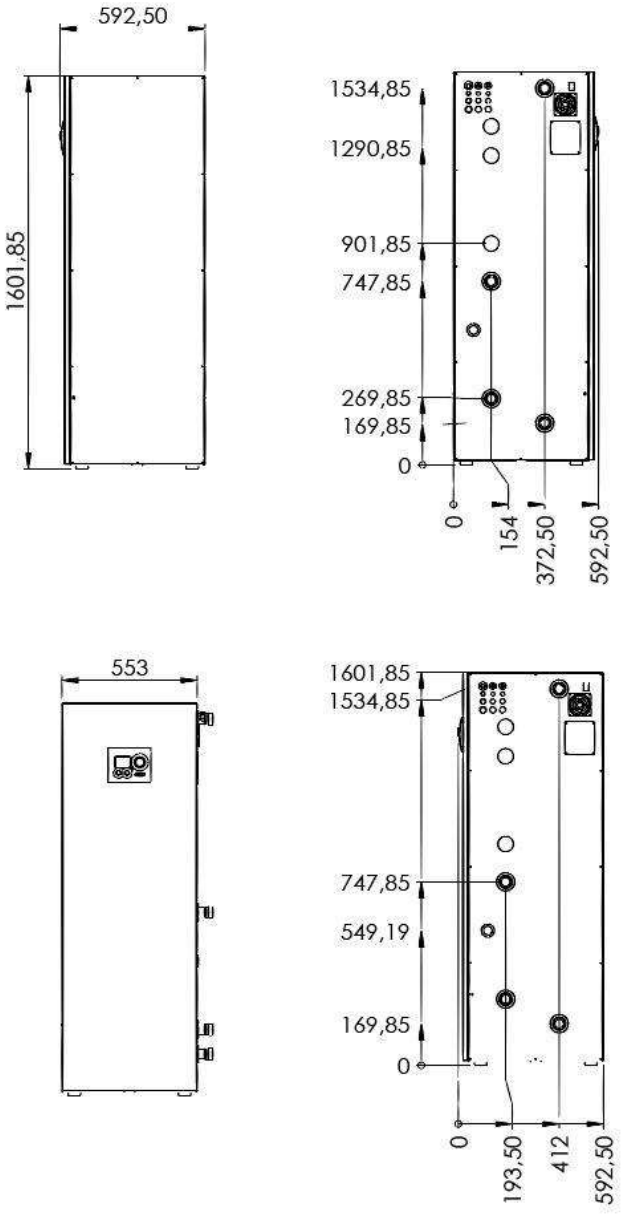
This document represents the update of the Deliverable 6.4 about the development of the DC-HP, thermal storage and smart fan-coils units.
More in detail, the present deliverable is intended to outline the main subcomponents belonging to the heating/cooling system designed for on-field demonstration. The development of such components are completed and, some of them (the heat pumps and the storage tanks), have been be delivered in Bagnolo in Piano (Italy) (as shown in the figure below). The Smart Fan-Coil will be delivered according to the timing of the retrofit works, with the aim to ensure a proper logistic management of the building site and an effective coordination of the various working phases. In detail, the renovation of the HVAC system of the first demo case consists in the replacement of the existing gas boiler and radiators with a DC-heat pump coupled with smart fan coil un its and PCM storage tanks. In particular, HELIO developed a centralized DC heat pump which will provide heat/cold at moderate temperature to the smart fancoils installed in each flat (manufactured by STI). The heat pump, already delivered in Bagnolo, can store heat inside the centralized storage tanks. Smart fancoils will exploit this moderate temperature as a source or a sink during heating or cooling working modes. Domestic Hot Water (DHW) is produced inside each dwelling through a dedicated unit (smart domestic hot water producer) that incorporates a decentralized water storage of 80 litres. As shown in the following figure, the main components belonging to the thermal system are:

1. the high efficiency Direct Current (DC) electric heat pump unit;
2. the modular thermal storage system;
3. the smart fan-coils.



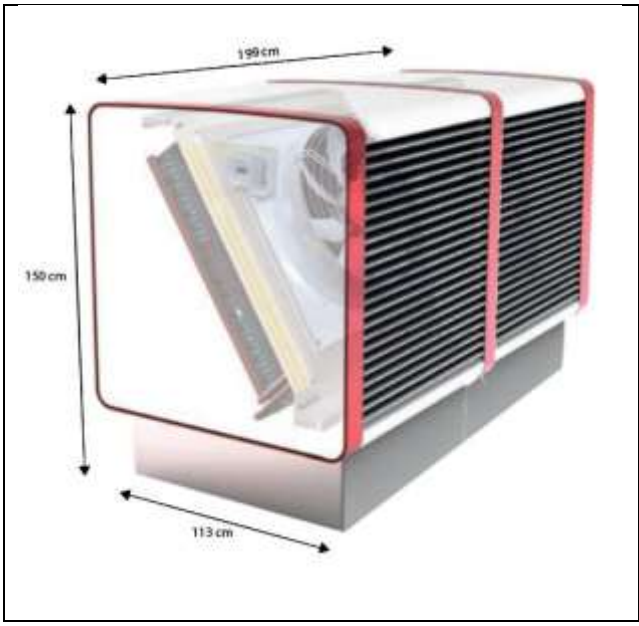
1. DC HEAT PUMP

The air to water DC-Heat pump developed within HEART project exchanges heat with the ambient, by using the temperature of the surrounding air to evaporate the liquid refrigerant in the outdoor evaporator unit. The heat pumps manufactured for the installation in the first demo case (2 units) consist of an outdoor unit (air heat exchanger) and of an indoor unit (condenser, compressor, control board and all meaningful components). The main technical drawings of the components under manufacturing are reported below.



According to the designed features, the internal unit of the heat pump has been manufactured and tested in a climatic chamber. Components were delivered in Bagnolo according to the timeline of the retrofit works.

It has a heating capacity of 20kW and all components can easily be connected and disconnected for installation, maintenance and repair.
Each inside heat pump unit will be connected on site, through a brine circuit, with an air heat exchanger (outdoor unit) which is tailored and assembled according the demo case study needs.



Special prototype lamellas have been tested on the case of the external unit. In particular, the shape and material of the lamellas has been optimized in order to reduce the possible noise issues.

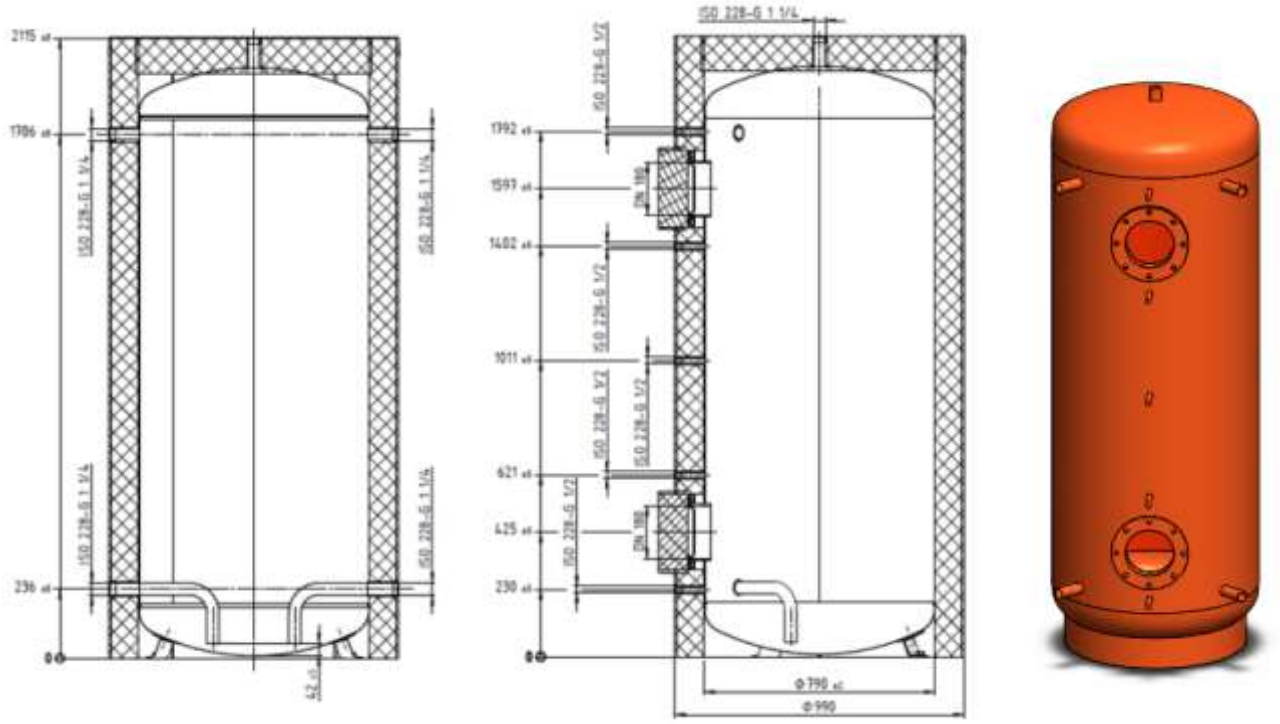
The comparison between the old and the new component is shown below.

The main activities in the past months were related to the assembling and re-assembling component parts, testing the operation of each item of the heat pump, as well as the fine-tuning of the whole system and developing a de-icing cycle control. The development of the house's control system has also been a crucial part this past season. Functional tests in heating and cooling mode have been carried out successfully. The picture of the developed heat pump that will be installed in the first demo case study is shown below.

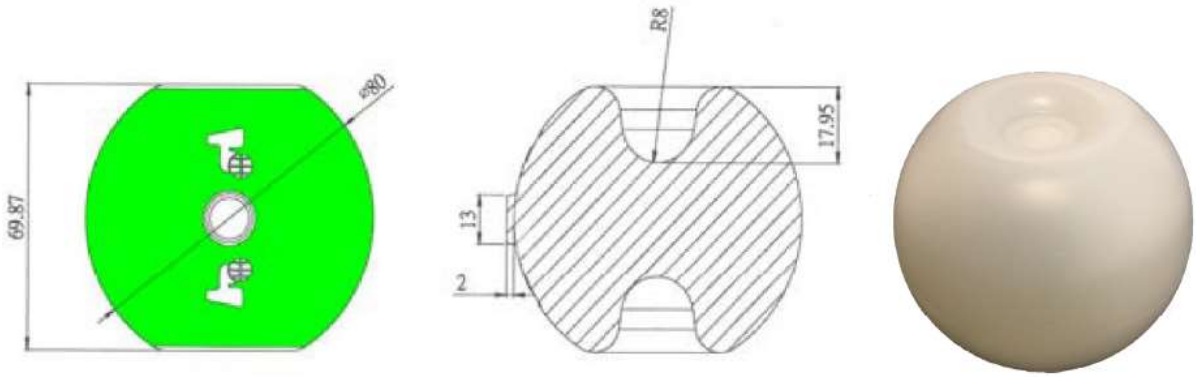
2. THERMAL STORAGE

Thermal storage units developed for the Italian case study consist of 3 tanks; each one has 1 m^3 of total volume which is filled with water and PCM modules. In particular, the first application will be carried out with 30% of PCM modules while the rest of energy will be stored in sensible heat in water, which also has a role of heat transfer medium. Thermal storage tanks will be connected in series and will operate as a thermal battery to shift thermal load to times when demand takes place.

The technical drawing of the manufactured component is shown below.



The PCM modules have been bought from an external company by HELIO. The PCM is salt mixture with 342 kJ/l of latent heat. The shape of modules is designed to start solidification/melting of PCM from outer and inner side of the module.



Energy stored in thermal storage with 30% of PCM is 117 kWh at ΔT of 20 K based on case study configuration. Operating temperature range is between 60°C to 5°C. Minimum temperature difference (inlet and outlet) of fully charged storage is 16°C. The useful temperature range to exploit the potential of latent heat is from 35°C to 16°C.

PCM modules will be integrated in thermal storage tanks at the building site because of their great weight, which would increase the difficulty of storage tank placement in the technical room and its installation. Furthermore, PCM modules would also bounce in the tank during the transport what increases the chance of damage.

Bellow picture of adjusted tanks manufactured by Heliotherm and PCM modules.

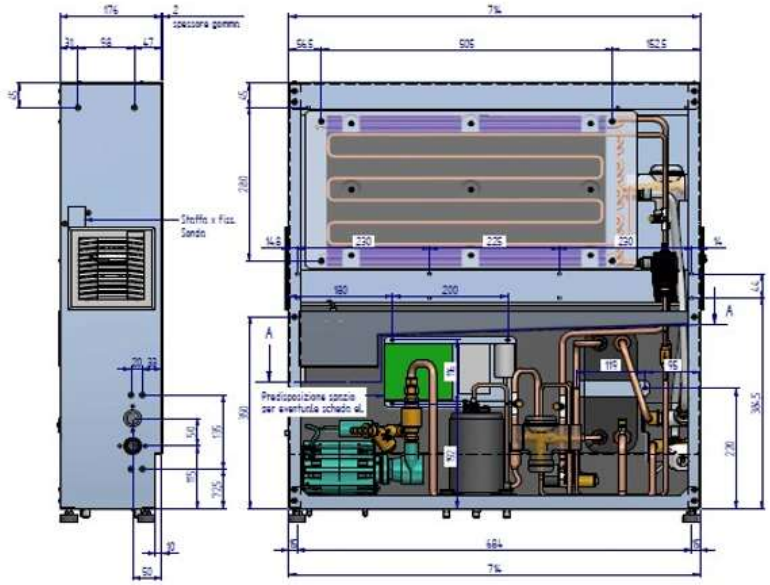
The thermal storage tanks has been tested under various conditions adjusted to case study, where it has been found that lower temperature difference is needed as it was expected at the beginning. Thermal storage tanks are currently delivered on site of the Italian study case will be installed according to the timeline of the retrofit works.

Hereafter a picture of the delivered heat pumps and storage tanks in the first demo case is reported.

3. SMART FAN COIL

The component developed for the on-field installation is in an individual self-contained water-source heat pump unit, connected to the closed water loop system. The unit comprises a hermetically sealed refrigeration circuit with refrigerant-to-air and refrigerant-to-water heat exchangers. Therefore, each heat exchanger acts either as an evaporator or condenser. The airside heat exchanger adds or removes heat from the room by passing air over the indoor coil, whilst the waterside heat exchanger either adds or extracts heat from the water loop. Of course, if the supply temperature from the water loop is enough, the unit can work as a traditional fan-coil unit thanks to the 3 intake fans installed above the heat exchanger.

The scheme of the unit, in which all the subcomponents are listed and sized, is reported hereafter.



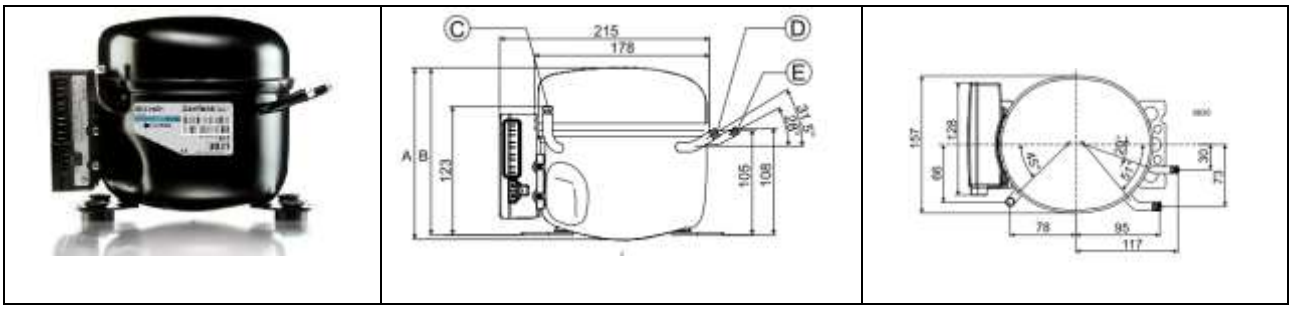
The unit is built with 2 main circuits:

1. the first one, filled with refrigerant gas, is connected to the DC compressor. It allows to exchange energy with the building water loop that is connected with the main heat pump;

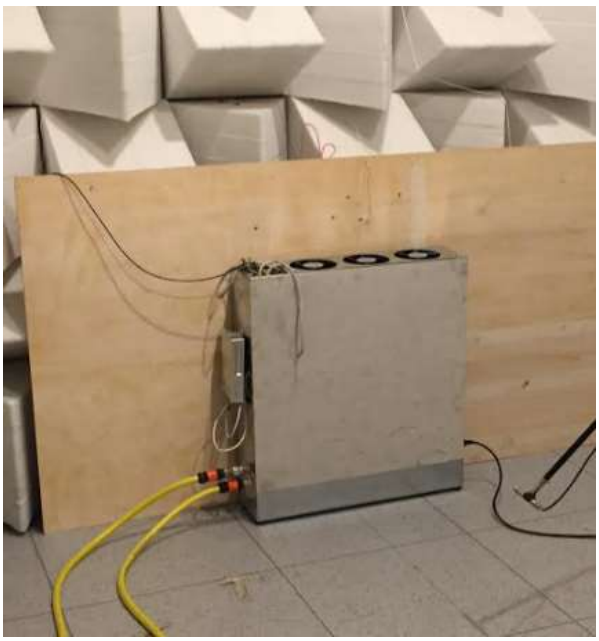
2. the second one consists in a water loop coil which allow to the unit to work as a traditional fan coil (without the contribution of the compressor);

Below the 2 mentioned coils there is a small tank that collects the condensation water, which is pumped in the main water loop circuit of the building, avoiding the need to provide a drain to each fan coil. The Smart fan-coil is also equipped with 3 intake fans which further increase the heat exchange between the coils and the air.

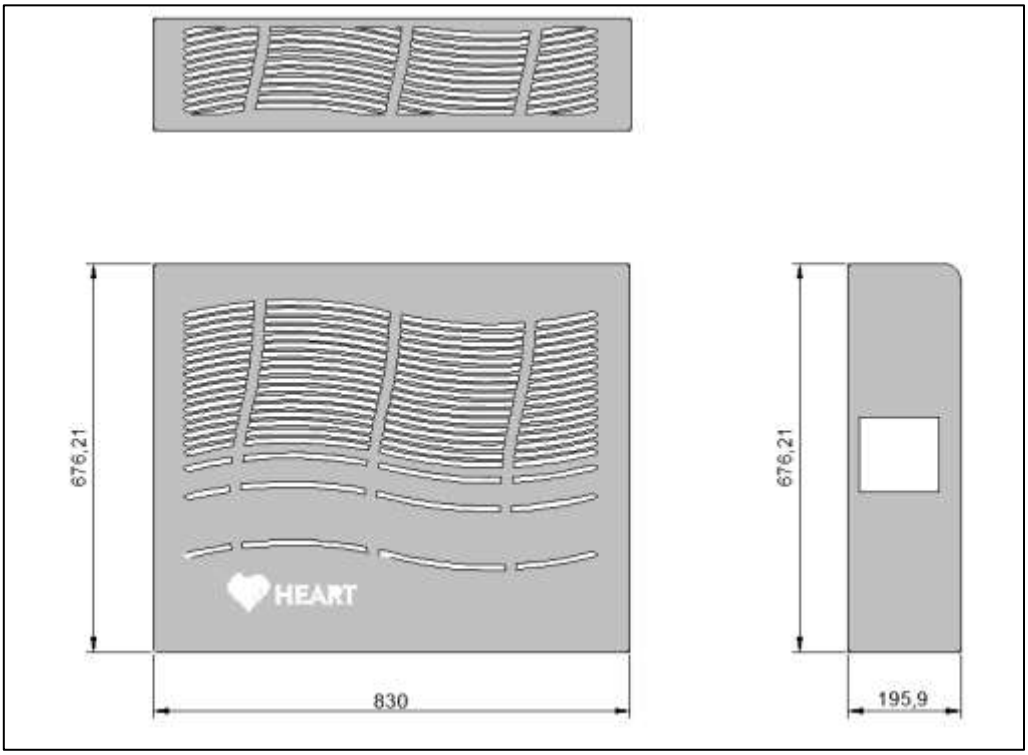
To allow the DC power supply, a commercial variable-speed DC compressor (BD350 Danfoss) was selected as the best option and integrated in the fan-coil; it is designed to operate at a nominal voltage of 48V DC. The technical drawings of such subcomponent are reported below.



Finally, some pictures of one of the manufactured products are shown below; they are related to the testing phase.



Finally, the cover of the smart fan coil has been designed in order to increase the appealing of the component as shown in the following figure.



All units to be installed in the Italian demo site will be delivered progressively with the retrofit of the various dwellings, starting from the version intended for heating/cooling. Units for DHW production is currently under construction (as shown in the following picture) and will be delivered in the last stage of the retrofit, always according to the GANTT of works.