Low valued energy sources UPgrading for buildings and industry uses

LowUP relevant environment 1

Deliverable D4.8

Lead Beneficiary: ACCIONA
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Silvio Vitali-Nari[1] / Carlos Ramos Rodríguez[1]

[1] *ACCIONA*

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About LowUP

LowUp – Low valued energy sources UPgrading for buildings and industry uses – is developing efficient alternatives to supply heating and cooling for building and industries, based on the use of renewable free energy and heat recovery from non-valuated residual energy sources that are currently wasted. As a result, these technologies will contribute to reducing significantly CO_2 emissions and primary energy consumption, and increasing the energy efficiency in buildings.

Led by the Spanish firm ACCIONA, the LowUp project gathers 13 partners (3 large companies, 3 research and technology organisations and 7 SMEs) from 7 European countries. During 48 months, the consortium will develop efficient alternatives to supply heating and cooling for buildings and industries based on renewable free energy as well as non-valuated wasted thermal sources:

- 3 technologies will be developed and demonstrated: one heating and one cooling system for buildings, and one heat recovery system for industrial processes.
- The systems will be demonstrated at 4 demo sites: A Pilot Office building in Seville (Acciona Construction, Spain), a Waste Water Treatment plant in Madrid (Canal de Isabel II & Acciona Water), a Pulp and Paper mill in Setubal (Portugal, The Navigator Company) and a Student Hall in Badajoz (Spain, University of Extremadura)

For more information visit: www.lowup-h2020.eu

Coordinator contact
Rafael C. Socorro Hernández
Acciona Construcción
Avda de Europa, 18, 28108 Alcobendas (Madrid, Spain)
email: rafaelclaret.socorro.hernandez@acciona.com

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Executive Summary

The aim of this deliverable is describing all the activities necessary for executing the proper implementation of LowUP concepts at emulated test-site scale in relevant environment 1 (building level), the thermal lab of ACCIONA in Seville and the students' residence in Badajoz (Rucab), upgrading the already installed technologies and minimizing the investment for the execution.

Seville demo site is actually used for characterizing novel & traditional thermal equipment (solar, boiler, chiller, cooling towers, etc…) and experimenting advanced integration concepts, in order to assess their viability before implementation in the real market. Seville test site was adapted in terms of space around the warehouse, for equipment installation, and in terms of building refurbishment, according to local laws and normative for energy efficiency with the objective of a fruitful installation of Heat and Cool-Low UP.

On the other hand, the students' residence (Rucab) in Badajoz was modified according to the integration with waste heat recovery system (Ecowec), developed by Wasenco; energy recovered is monitored and transferred remotely to Seville pilot plant for emulated operation. Monitored data are gathered and logged into a remote server for their use in Seville demo, where they will be emulated thank to existing heat generators.

Keywords

Installation Plan, space conditioning, building environment, residential demo building

1 Introduction

During this third phase of the project, the goal was installation, integration and start-up at a relevant environment of all 3 LowUP concepts. This deliverable is focused on Heat-LowUP and Cool-LowUP concepts.

According to results from previous tasks (mainly within WP2), Heat-LowUP and Cool-LowUP prototypes, previously individually fully tested, have been implemented at their final sites; most of them were integrated with existing settings of ACCIONA pilot plat in Seville, while remaining were integrated in Rucab (Badajoz), for remote emulation in Seville plant.

In D4.1 deliverable was developed an installation plan for Seville demo site. In this deliverable is explained how that's plan was followed to carry out the adaptation of spaces around the office/warehouse to install and integrate the main system and its start-up. It explains how it was the area of the thermal lab of ACCIONA in Seville at the beginning of the project and how the works were adapting different space to integrate all the technologies in the same lab. It showed the status when all equipment was started up before testing.

Finally, it explains each part of the installation Heat LowUP (Solar field, Stratified tank, Wasenco Emulator and radiant floor), Cool LowUP (AHU, chiller, cooling tower, PCM tank and chilled beams), and supervisory system (SCADA).

On the other hand, it´s explained the process of adaptation in students residence located in Badajoz (Rucab), what it´s modified according to integration plan with the sewage energy recovery system developed by WASENCO. This installation was monitored in the same site and managing by the main computer in Seville.

2 Implementation of equipment at Seville demo

All the works described in the following sections took place it in order to conditioning ACCIONA settings of Seville; with the purpose to provide a relevant environment for testing Heat/Cool LowUP concepts, a real demo building has been refurbished for the project.

The activity required modification of an existing warehouse, transformed into an office building, and external spaces for hosting all components required for the two LowUP concepts, taking into consideration space requirements and existing installations.

The demo building is located in an industrial area, next to a dismissed thermal lab where ACCIONA owned a research facility consisting of a tri-generation plant and an HVAC test site.

This lab disposed of renewable-based generation-transformation-dissipation systems, integrated with proprietary supervision system for real-time monitoring and control, which were used for operation, simulation and emulation of heating & cooling technologies; during last year the lab has been gradually dismissed, nevertheless some technologies that were still on-site, have been "recycled" and integrated with LowUP concepts.

Figure 1. Aerial view Seville demo before LowUP with available spaces

There is plenty of space (in green) in the surroundings of the office demo building (here still warehouse, in light blue) where the LowUP individual systems could find a place for being installed, as it is shown in the previous illustration.

The layouts of the Heat/Cool LowUP, defined during the design phase, are as follows (for further information, please refer to D4.1):

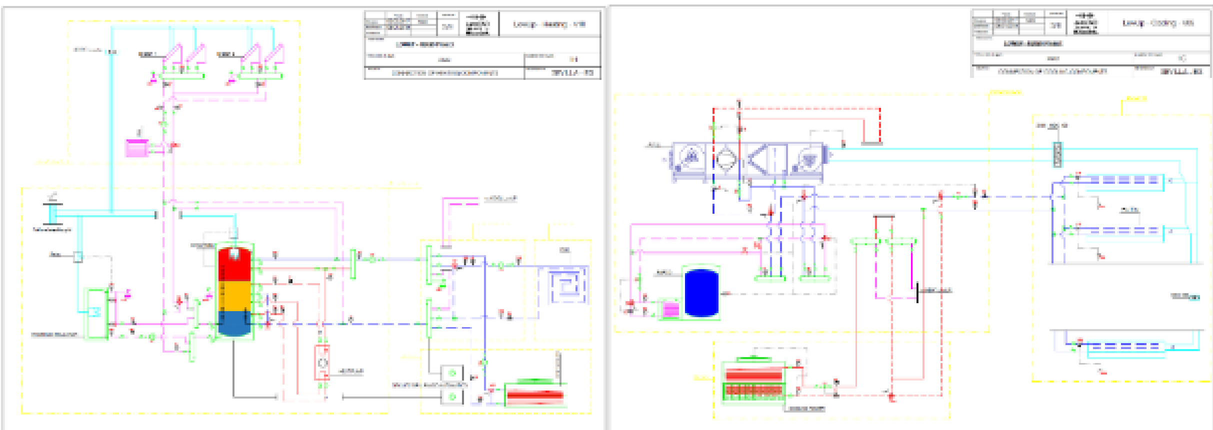

Figure 2. Layout of the Heat (left) and Cool (right) LowUP

In red, blue and pink are represented water piping; in green, the equipment and in yellow the areas of installation.

2.1 Interested areas for conditioning of entire site

Spaces have been selected considering the requirement of space, proximity to demo building, connection with existing technologies, and accessibility for installation and maintenance.

The chosen location for each equipment is presented in the following sketch.

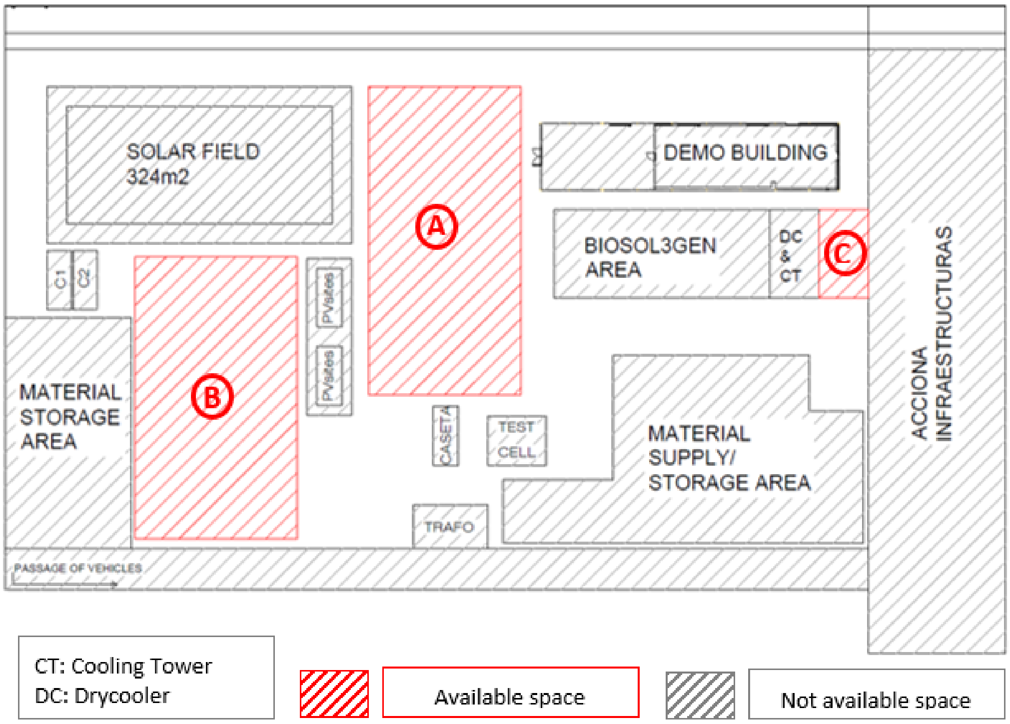

Figure 3. Location and distribution of the installations

The “A” space was designated for the following components:

- ✓ Secondary cabinet for control and power supply
- ✓ Stratified tank from Entropy
- ✓ Wasenco emulator
- ✓ Back-up Heat Pump
- ✓ Auxiliaries of circulation (pumps, valves, vessels, piping, sensors, ….)

The “B” space was designated for the following components:

- ✓ PVT panels
- ✓ SMA PV inverter
- ✓ ENDEF cabinet for control and electrical protection.
- ✓ Weather station
- ✓ Auxiliaries of circulation (pumps, valves, vessels, piping, sensors, ….)

The “C” space was designated for the following components:

- ✓ Primary cabinet for control and power supply
- ✓ Borealis Chiller/AHU
- ✓ PCM storage tank
- ✓ Dry cooler for load emulation
- ✓ Cooling tower
- ✓ Auxiliaries of circulation (pumps, valves, vessels, piping, sensors, ….)

The Demo Building was designated for the following components:

- ✓ Chilled beams
- ✓ Radiant floor
- ✓ Central control room for SCADA and DataBase

2.2 Building retrofitting

The demo building selected for the retrofitting was an existing establishment used as a warehouse for materials of construction. The initial state of this building is shown in the following figures:

Figure 4: Warehouse before being retrofitted

The building, after the retrofitting, has been changed to administrative/office use, fulfilling the requirements of LowUP project. The refurbishment required adaptation to local normative, in terms of construction-comfort-safety-energy efficiency for hosting people executing engineering activities.

After the acceptance by local authorities of the legal project for refurbishing the building, the works started with the adaptation of all envelope components, considering requirements of bearing structure, natural light, insulation and protection against fire.

The first step to start the works it was removing the old roof and installing the new roof.

Figure 5. Removing the old roof and fire treatment for roof bearing structure.

At the same time, all external walls were adapted and refurbished, improving the insulation and opening windows.

Figure 6. Works in the building envelope.

Once external parts were finished, the inner part of the building has been adapted in order to reach minimum insulation requested by RITE (local normative in terms of building efficiency).

For this rock wool panels were imbedded in the internal side of external walls, as shown in following images.

Figure 7. Insulation of the walls.

In following images, the status of the building after the refurbishment, including the new roof in a sandwich panel, two internal partitions (office and storage) and finishing of internal walls; the picture is taken before the introduction of LowUp technologies.

Figure 8. Inside the office/warehouse after retrofitting.

Figure 9. East wall and north gate of the office/warehouse after retrofitting.

2.3 External spaces conditioning

The main changes, necessary to transform external unconditioned spaces into suitable places for installation of LowUP technologies, required minor activities with respect to building refurbishment; it was required only the space necessary to place equipment and auxiliaries, considering a minimum of protection from the weather.

2.3.1 External space "A"

Next pictures show the open space "A" at the beginning of the project, when only uncompacted soil was present, without any kind of use.

Figure 10. Space designated for HEAT LowUP components.

This installation, due to weight of the components (mainly stratified tank of 6.500 litres), required a solid and level ground, to prevent from collapsing. Therefore, a foundation slab was built. The dimensions enable placing the rest of the systems that integrate the Heat-LowUP installation.

The characteristics of this foundation are:

- Material: reinforced concrete slab
- Dimensions: 5 x 7 x 0,2 m.

Figure 11. Foundation for stratified thermal storage installation

2.3.2 External space "B"

Next pictures show the open space "B" at the beginning of the project when only compacted soil was present, without any kind of use but transit for vehicles.

Figure 12. Space designated for the solar field.

A concrete slab was required as bearing, levelling and anchoring structure for PVT panels, in order to provide a reliable space where to perform the installation and where to fix the panels against the wind.

The characteristics of this foundation are:

- Material: reinforced concrete slab
- Dimensions: 25 x 6 x 0,2 m.

Figure 13. Foundation slab for PVT system.

2.3.3 External space "C"

Next pictures show the open space "C" at the beginning of the project, when only structural concrete slabs were present, without any kind of use but passage for persons.

Figure 14. Space designated for chiller, PCM tank and AHU.

The C space was already suitable for bearing the weight of all equipment; it only required the levelling of the ground surface, and this was achieved spreading gravel inside a bordered perimeter.

The result was a "gravel slab" of 10 cm, as it can see in the next image.

Figure 15. Gravel´s floor in "C" space

2.4 Heat-LowUP and Cool-LowUP installation

The design process of these installations can be found in D4.1 deliverable, while this section will reflect all works executed to implement Heat/Cool LowUP installations physically.

2.4.1 *Equipment installed in space "A"*

In the scheme below, the components of HEAT LowUP, installed in this space, are represented with colours while in grey the remaining components.

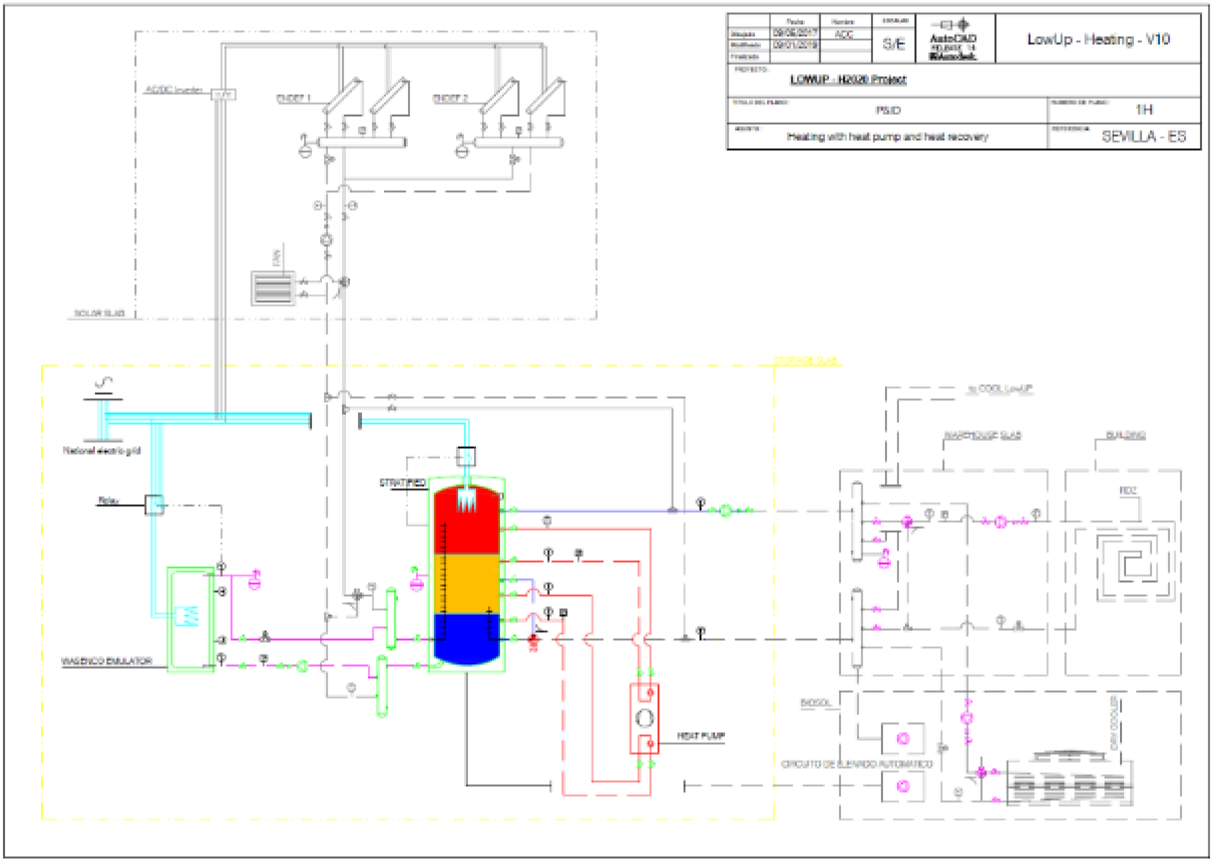

Figure 16. Equipment at space "A"

In following pictures, the details of the stratified tank during installation and finished; connections with heat pump, solar field, emulation tank and thermal load are in PPR piping, while insulation is made with armaflex. The tank has been insulated with 12 cm of foam in a pre-manufactured coat.

The tank disposes of 3 electric resistances in the upper part, while 12 sensors are distributed along the height to monitor the level of stratification.

Figure 17. Stratified tank with connections

Emulation tank came with preassembled insulation from factory and electric resistance for the generation of fictitious loads; energy meters integrate view panel and temperature sensors.

Figure 18. Emulator tank and its pumps and flow rate meter

Electric cabinets have been designed to host equipment from tertiary partners like Entropy, including power supply, connections for sensors, space for controllers, switches for Ethernet communication, ventilation for heat rejection, etc.…

Figure 19. Secondary cabinet and PLCs

The water-to-water back-up heat pump is directly connected with the stratified tank: the evaporator with the bottom while the condenser with the upper part, as shown in the following images.

Figure 20. Heat pump and piping connections

In the following images, it is shown the insulation for the different connections between equipment, considering expansion vessels, valves, supports and circulating devices.

Figure 21. Pipes with insulation and connections

In the following image, connection of the solar field and emulation tank with stratification column of the stratification storage tank.

Figure 22. Pipes with insulation

In the following image, the connections FROM and TO the stratification tank with the circulating device.

Figure 23. Circulation pumps for the stratified tank (P3)

In the following image, the connections FROM and TO the emulation tank with the circulating device.

Figure 24. The pump of emulation tank (P2)

In the following image, the detail of the sensors installed over piping.

Figure 25. Sensors distributed in the installation

In the following image, the global view of space “A” finalized, with all elements installed and rain protection.

Figure 26. General view of space "A"

2.4.2 Equipment installed in space “B”

In the scheme below the components of HEAT LowUP, installed in this space, are represented with colours while in grey the remaining components. This space is totally dedicated to the solar field loop.

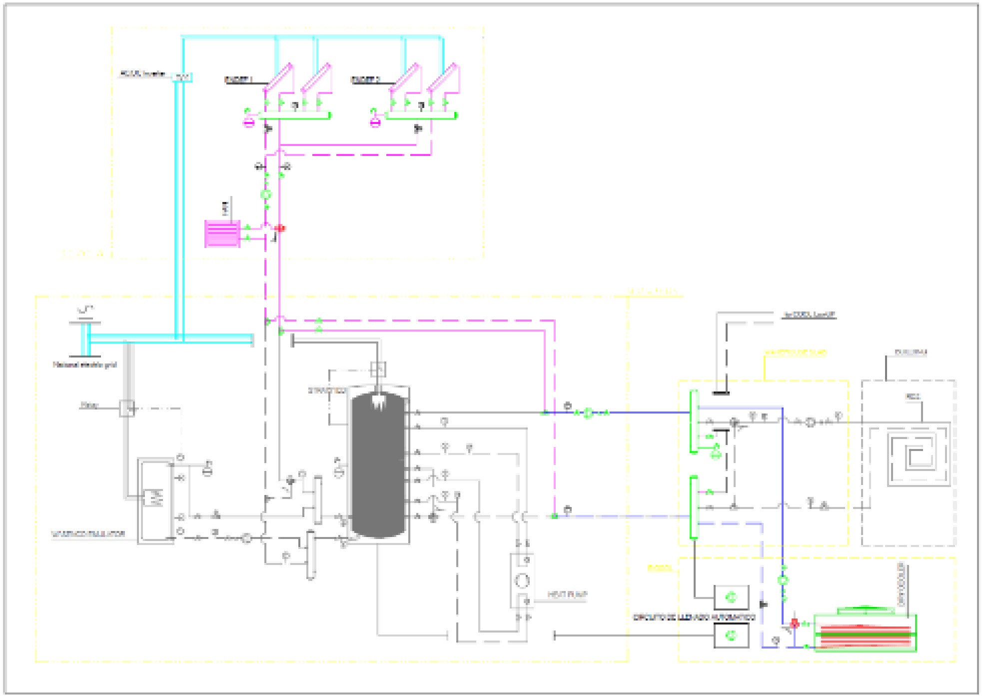

Figure 27. Equipment at space “B”

In the following image, the front side of the solar field installed on the slab.

Figure 28. PVT Solar Field.

In the following image, the backside of the solar field installed on the slab.

Figure 29. Backface of the PVT panel (Collector and expansion tank)

In the following image, the electric cabinet for Endef, including power supply, weather station, proprietary monitoring/control system, connections for sensors, switched for Ethernet communication, etc.

Figure 30. Solar field cabinet with the meteorological station

In the following image, the details of hydraulic connections, temperature sensors and manual valves.

Figure 31. Temperature sensor distributed in the solar field

In the following image, the air purge system distributed over the solar field on top points of the piping.

Figure 32. Bleeder distributed in the solar field

In the following image, the front side of the solar field pump station with circulation piping for supply and return.

Figure 33. Supply and return water pipes from the solar field to stratified tank

In the following image, the backside of the solar field pump station with regulation devices like 3ways valves and pump, monitoring devices like sensor and flow counters, and hydraulic elements like a safety valve, gauges and manual valves.

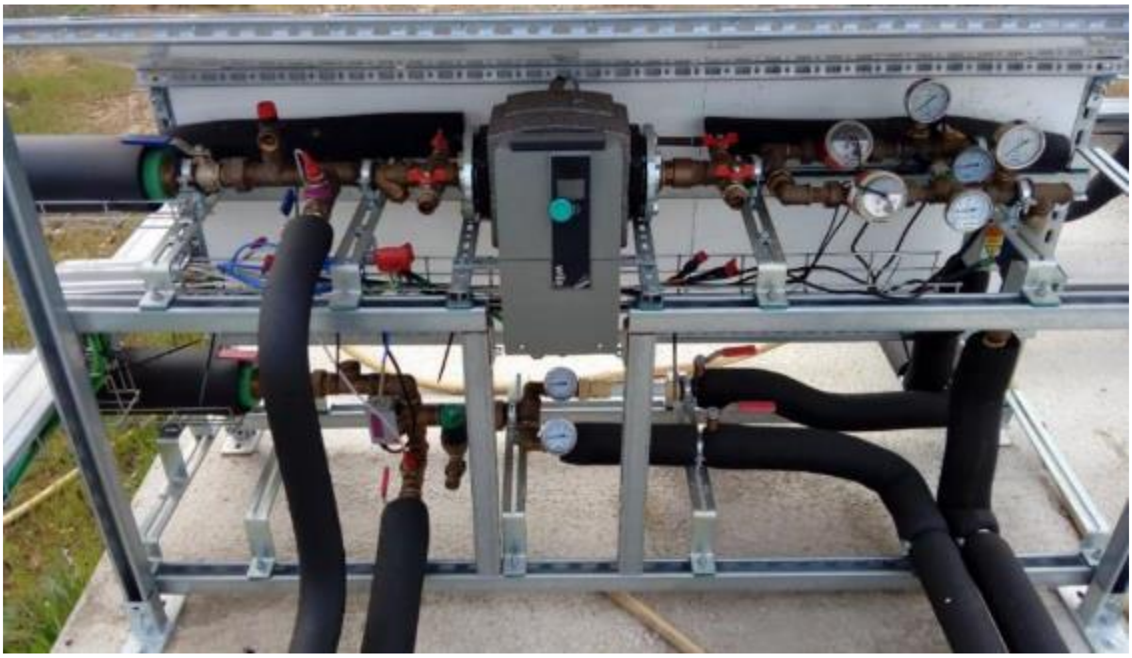

Figure 34. Solar pump (P1) and monitoring equipment

In the following image, the front and backside of the emergency heat rejection system, in parallel with stratification tank.

Figure 35. Dry cooler of the PVT system

In the following image, the two channels solar AC/DC inverter coupled with PVT panels, installed on the back of the Endef cabinet.

Figure 36. PV inverter

2.4.3 Equipment installed in space "C"

In the scheme below the components of COOL LowUP, installed in this space, are represented with colours while in grey the remaining components.

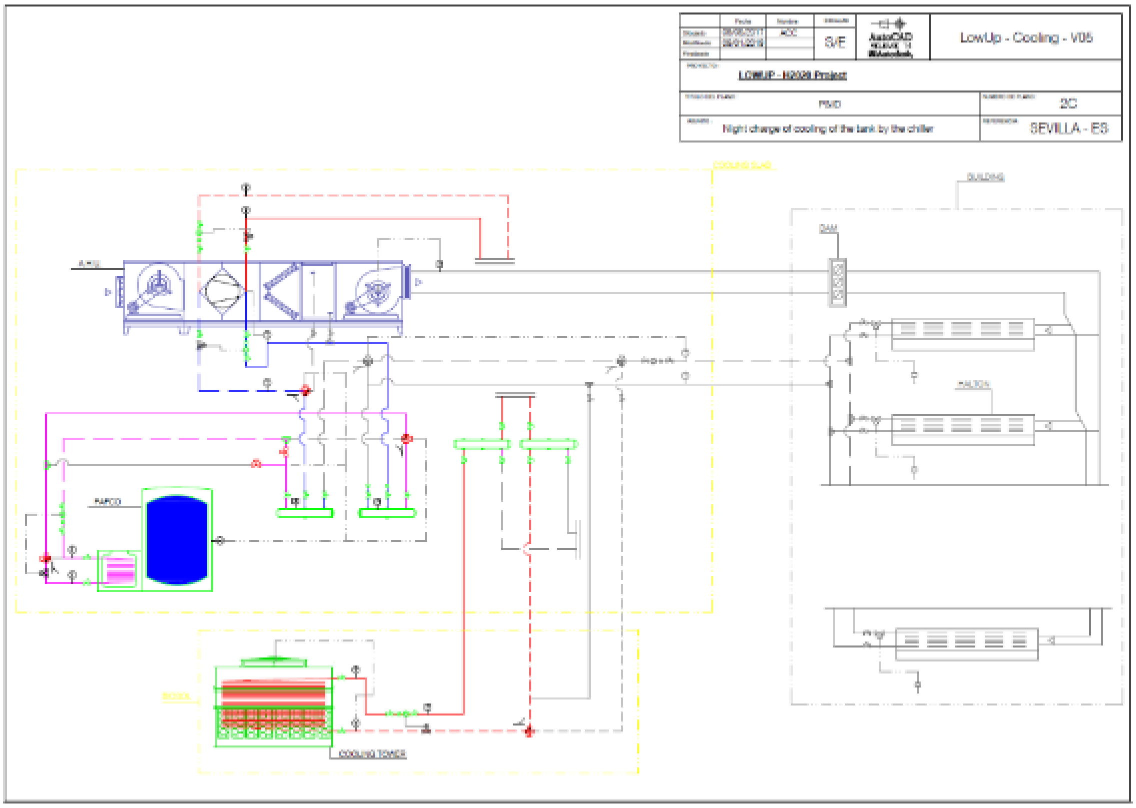

Figure 37. Equipment at space "C"

In the following image, the PCM storage tank of Fafco with all hydraulic components for connection and integration with COOL LowUP.

Figure 38. PCM tank with own hydraulics

In the following image, the existing equipment recovered by Acciona thermal lab and integrated with HEAT (dry cooler) and COOL (wet cooling tower) LowUP.

Figure 39. Dry cooler for emulation (left) and wet cooling tower for dissipation (right)

In the following image, the chiller/AHU of Borealis used to produce primary air and cooling.

Figure 40. Borealis chiller with own hydraulics

In the following image, the air ducts for primary air from AHU to the building, including return in the meeting room of the office building.

Figure 41. Supply and return duct of the AHU

In the following image, the details of hydraulic connections of the chiller with manifolds and building, including all circulating devices and monitoring system.

Figure 42. Details of hydraulic connections

In the following image, the control cabinets for Fafco and the primary cabinet for the control of all devices of COOL LowUP, including switches, controllers, electric protections, etc.

Figure 43. Fafco control cabinet and primary control cabinet

In the following image, the finalized installation of COOL LowUP, including chiller/AHU, PCM storage tank and wet cooling tower.

Figure 44. General view from cooling equipment

2.4.4 Equipment installed at Demo Building

In the scheme below the components of HEAT LowUP, installed inside/around the building, are represented with colours while in grey the remaining components.

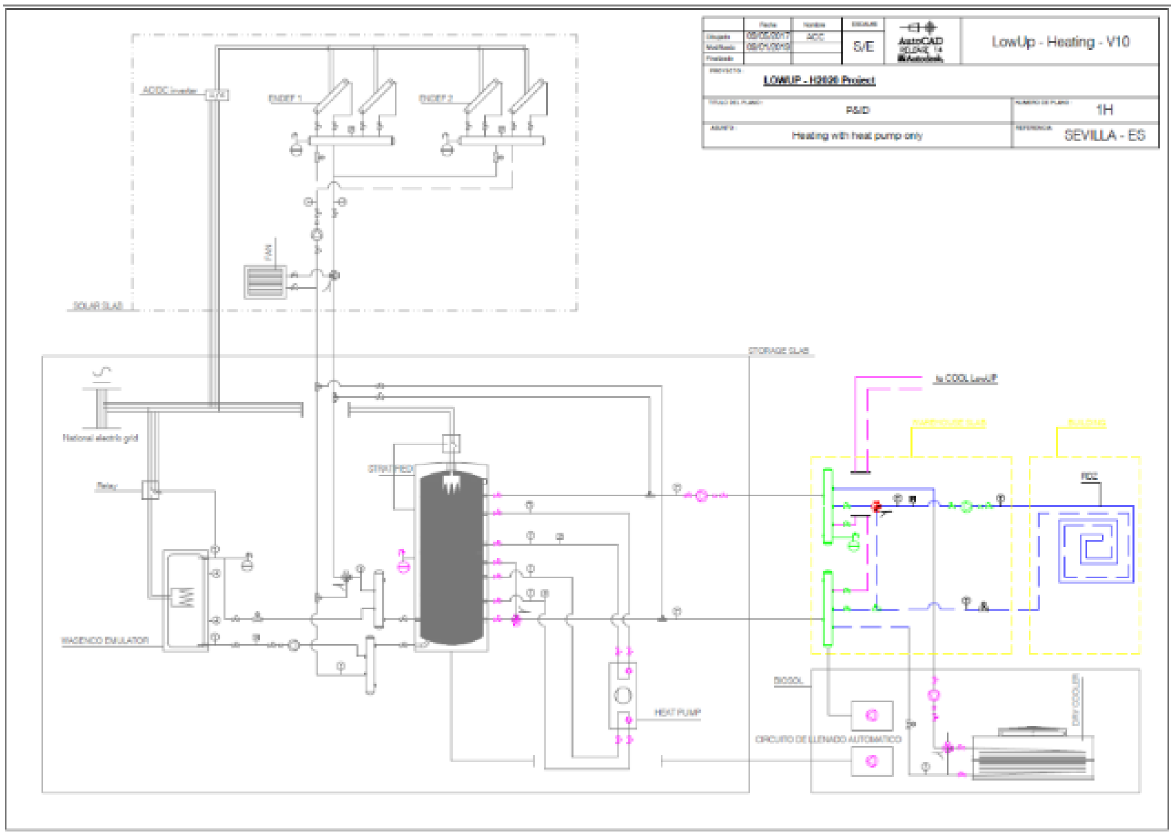

Figure 45. Schema of the equipment in the Demo Building

In the following image, the different stages of installation of the radiant floor, with insulation, pipes and radiant slabs, before the installation of ceramic tiles

Figure 46. Radiant floor during installation

In the following image, the different phases of the installation of radiant floor distribution manifolds and connection with radiant pipes, before and after installation of ceramic tiles.

Figure 47. Manifolds of the radiant floor

In the following image, the different phases of the installation of chilled beams, from anchorages to piping and air ducts. Ceramic tiles are already installed, and a meeting room has just been finished.

Figure 48. Chilled Beams during installation

In the following image, the details of installation of air ducts in the meeting room and in the open space of the office.

Figure 49. Details of air duct connections

In the following image, the global of the connections between radiant flor, emulation load and stratification tank just on the external backside of the building.

Figure 50. Radiant floor collector and piping connections

In the following image, the details of actuation and circulating devices for the radian floor.

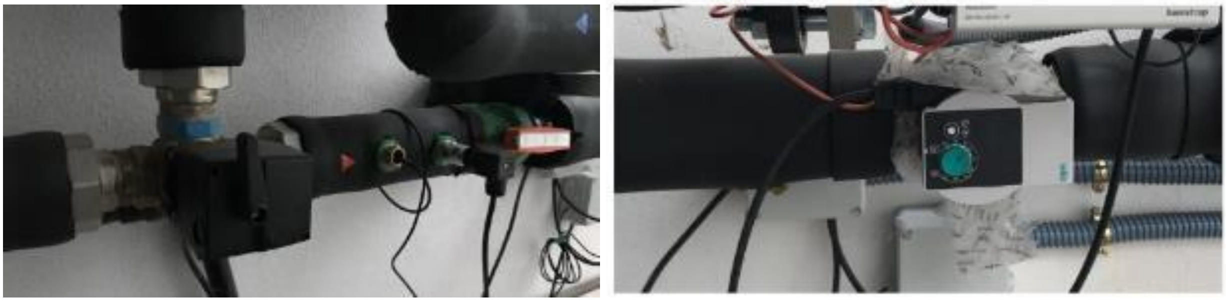

Figure 51. Radiant floor´s three-way valve and radiant floor pump (P4)

In the following image, the details of monitoring devices for the radian floor.

Figure 52. Flow rate meter and temperature and pressure sensor in the radiant floor system

In the following image, the global view of the office with all HEAT and COOL LowUP devices installed in the building, with occupation from engineering personnel.

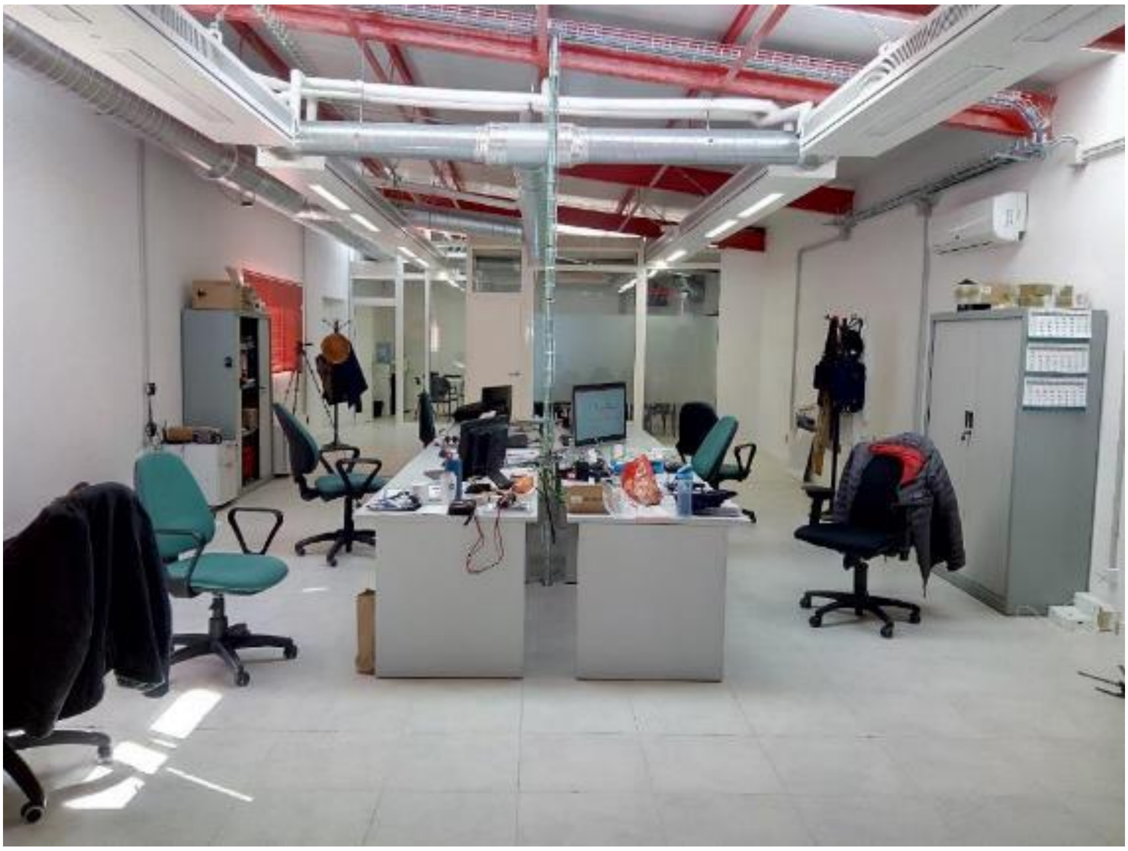

Figure 53. The final status of office/warehouse after retrofitting.

The control of individual devices is integrated with a just only one system that it´s monitoring, controlling, managing and logging data proceeding by all equipment.

The system is composed of a DataBase, with a dedicated server, and a SCADA, with a dedicated server. The SCADA is connected via Ethernet to all plc of the demo and to the DataBase, where the automatic control algorithm is hosted.

Figure 54. SCADA and Database´s PC inside of Demo building

In this section, SCADA is presented in all its interface windows, in order to describe all functionalities. By clicking each section (Heat LowUP and Cool LowUP), it is possible accessing to different parts of the installation.

Following figures show a schematic view of Heat/Cool LowUP, where end-user is able to navigate in order to achieve detailed information about the status, operation and history of each component.

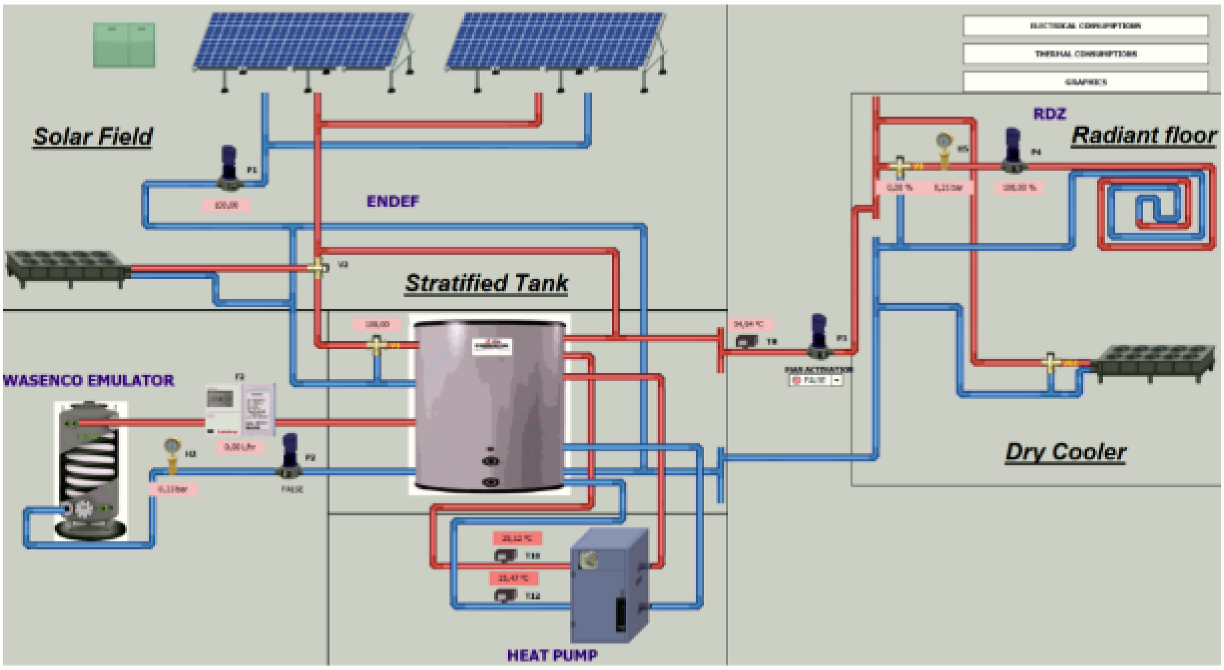

Figure 55. SCADA´s general view of Heat LowUP

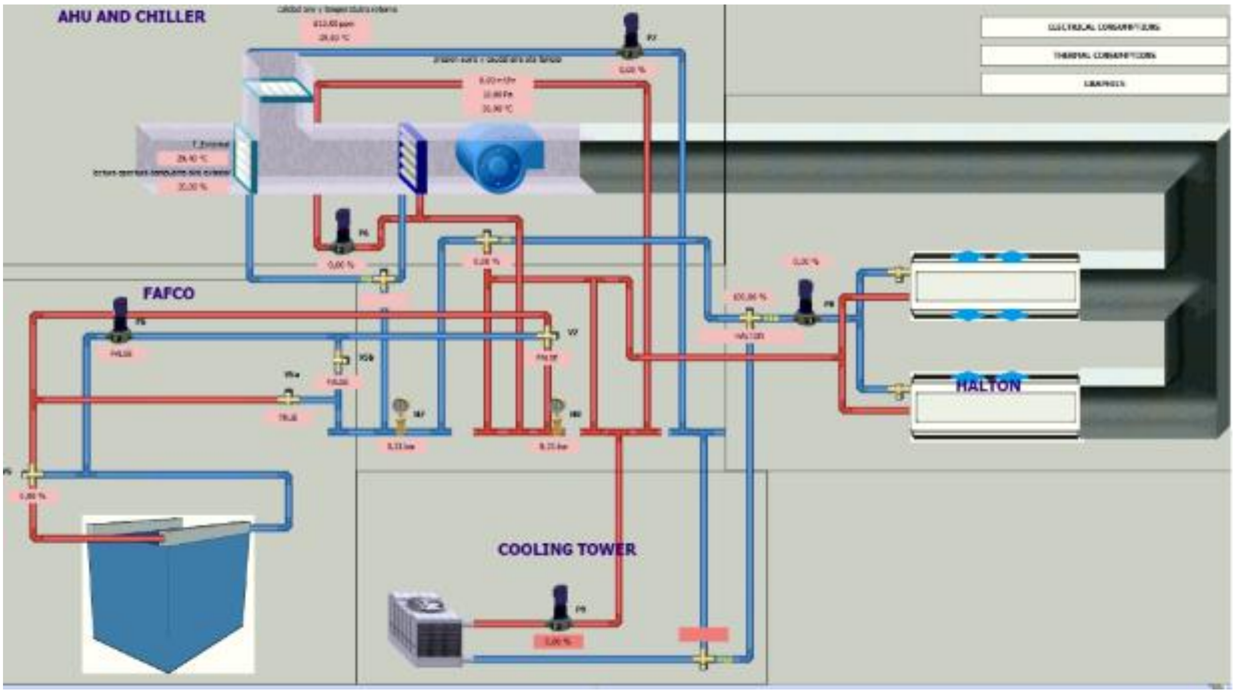

Figure 56. SCADA´s general view Cool LowUP

General information can be expanded clicking on each system, thanks to the distributed control system implemented at the level of HEAT and COOL LowUP concepts; all sensors and equipment data are accessible, depending on the level of precision required for analysis.

SCADA for Heat LowUP:

In this window is presented five-section composing Heat LowUP: Solar field, emulation tank, Stratified Tank, Heat pump and Radiant floor.

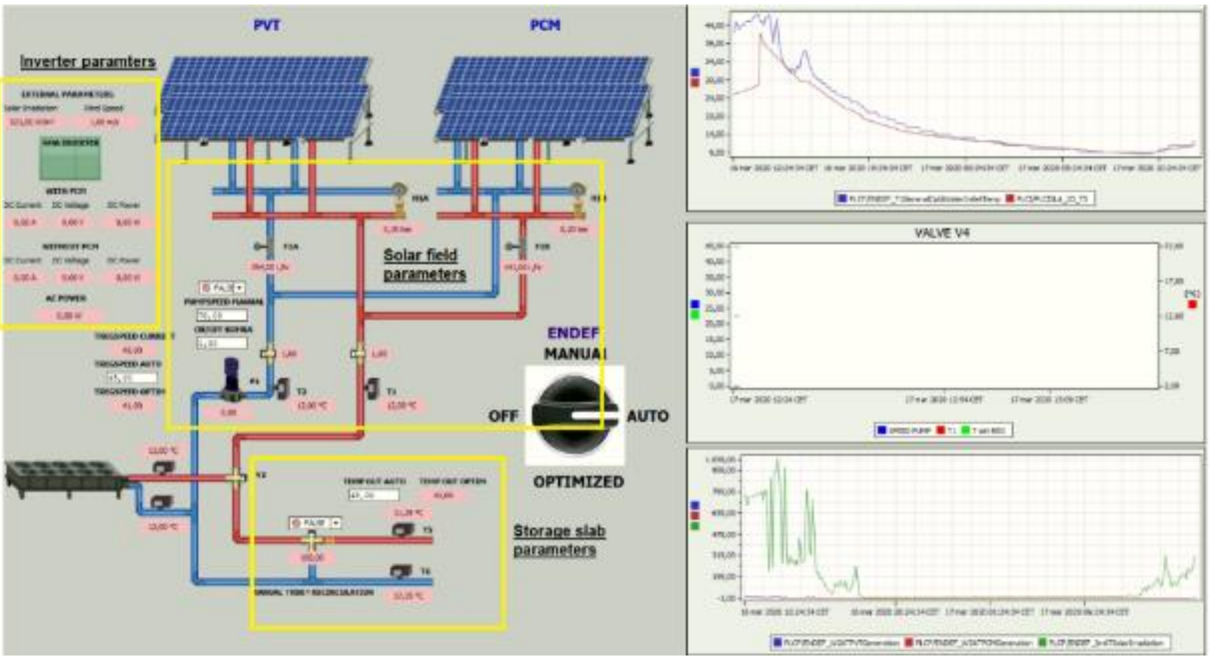

Figure 57. Solar field loop

The screen is divided in graphics on the right (temperatures, three-valve actuation and Solar irradiation), while in the left part are shown inverter parameters; in the centre are represented the most important parameters of the solar field. In the yellow bottom box, the connection of the solar field with the stratified tank.

The system is prepared with a switch that enables changing between different operation mode: OFF, MANUAL, AUTO and OPTIMIZED.

Solar field´s pump can be operated in different operation modes: fixed speed or speed controlled to achieve a setpoint temperature.

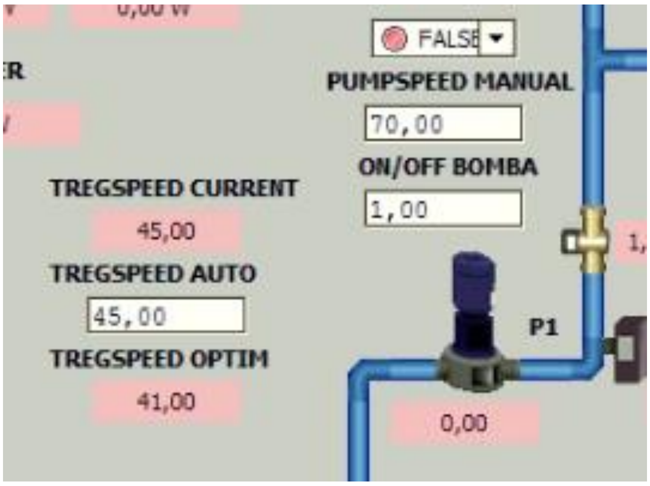

Figure 58. Input parameters solar field pump

In emulation tank section, it is possible to access to following:

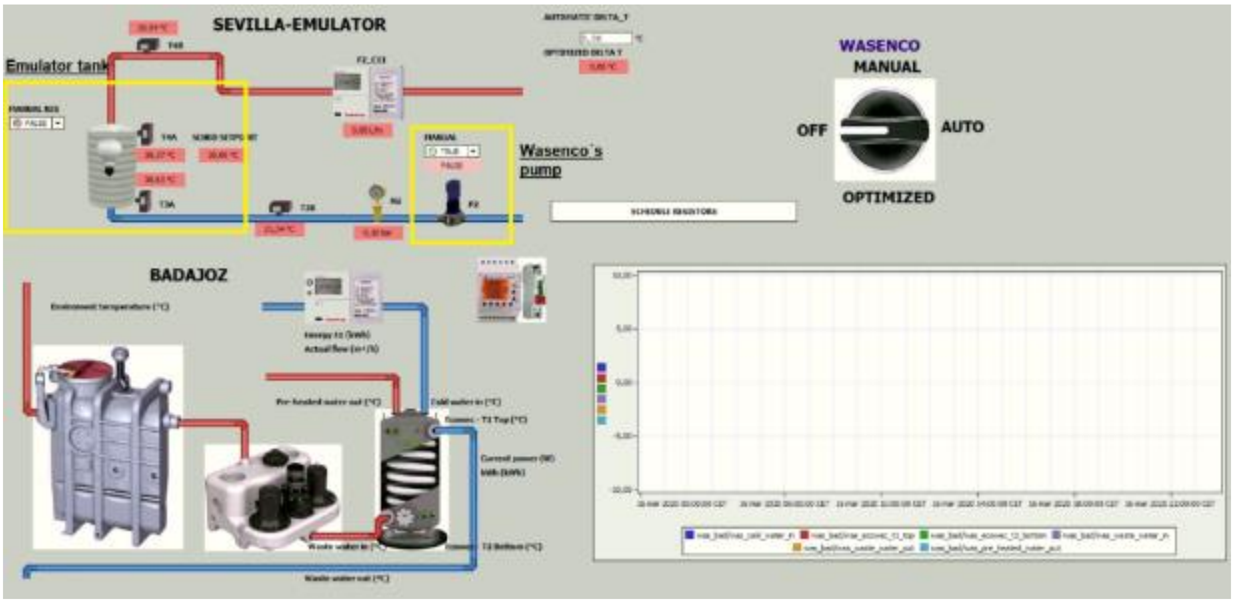

Figure 59. Emulation tank loop

Through this window, electric resistance and pump state can be controlled, monitoring in real-time all different sensors.

In the next figure, it is possible monitoring all temperatures sensor inside of the stratified tank.

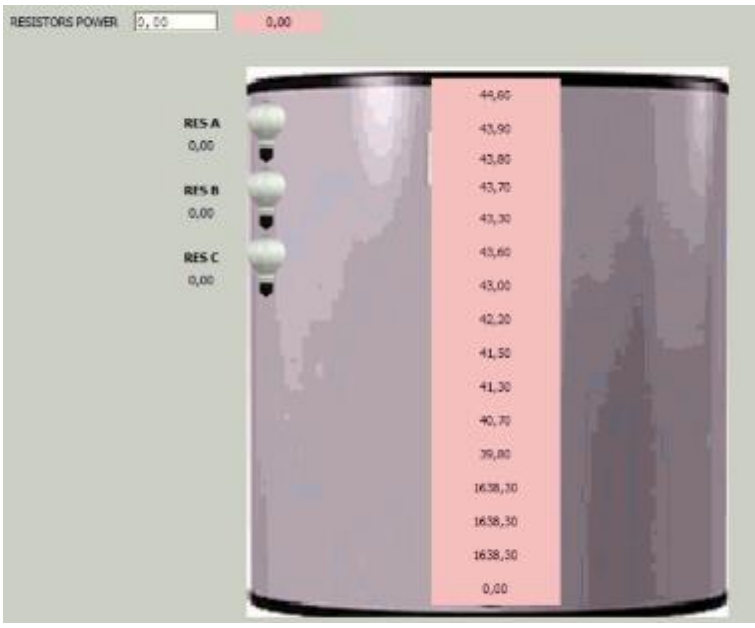

Figure 60. Stratified tank

Next window shows parameters monitored in the heat pump loop.

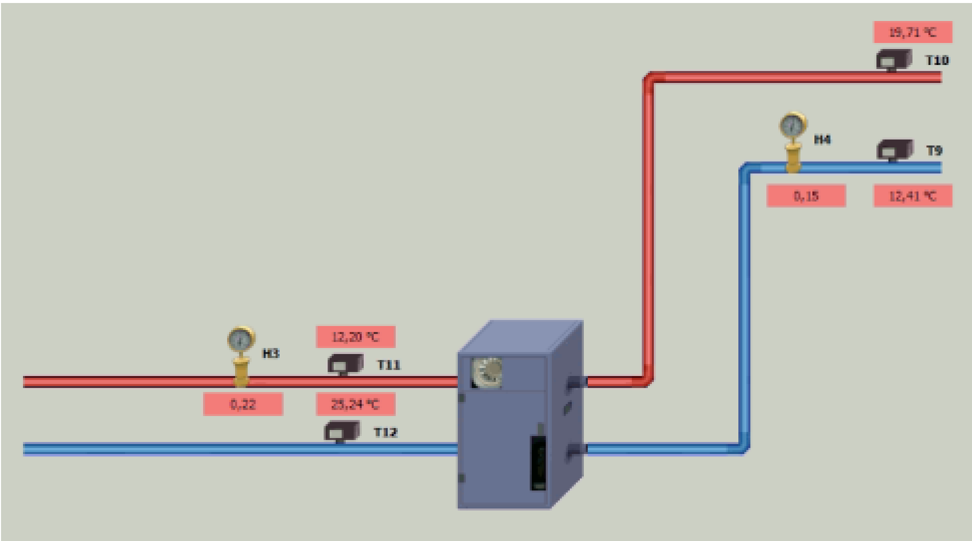

Figure 61. Heat pump´s windows

In radiant floor window, the temperature inside the room can be controlled with operation mode and the state of the pump.

On the other hand, outside/inside temperature, pressure and flow rate can be monitored. In the bottom of the window of some sensors of the radiant floor system are shown graphically during time.

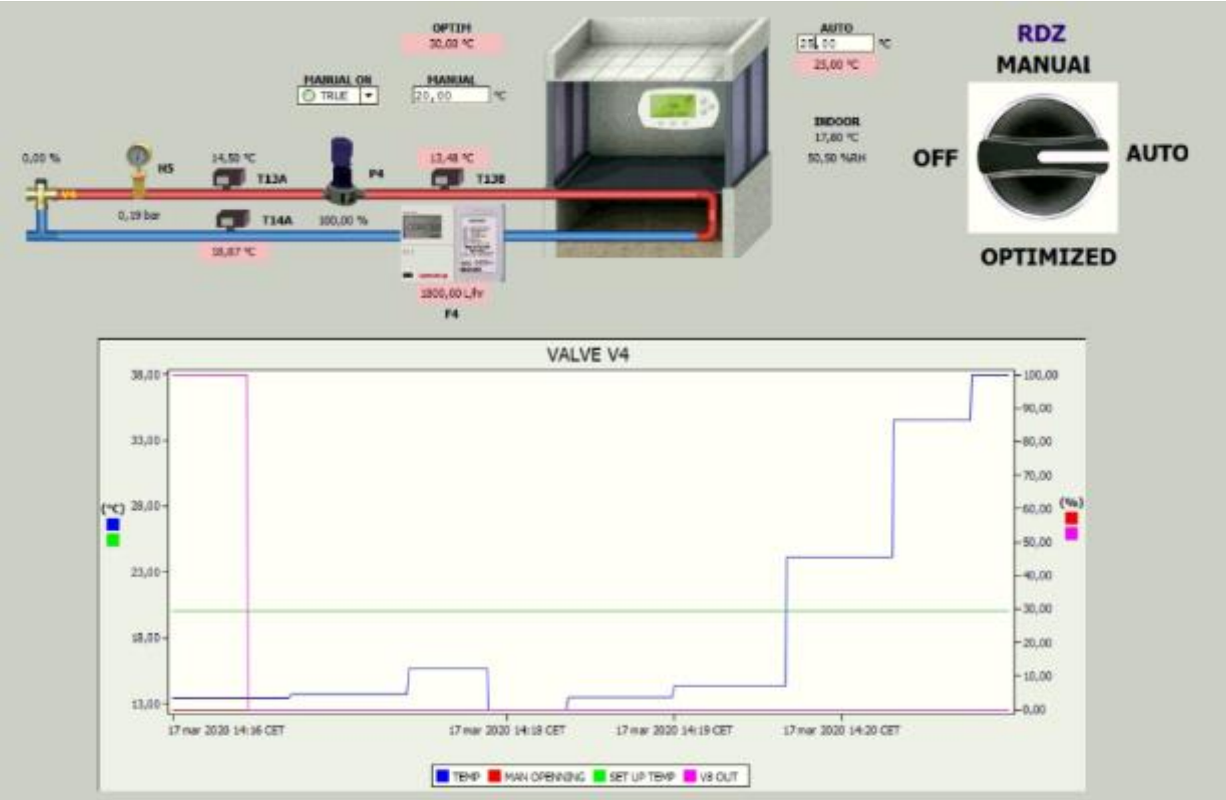

Figure 62. Radiant floor

SCADA´s Cool LowUP:

In this window are presented all four sections composing Cool LowUP: AHU/Chiller, PCM tank, Cooling tower and Chilled beams.

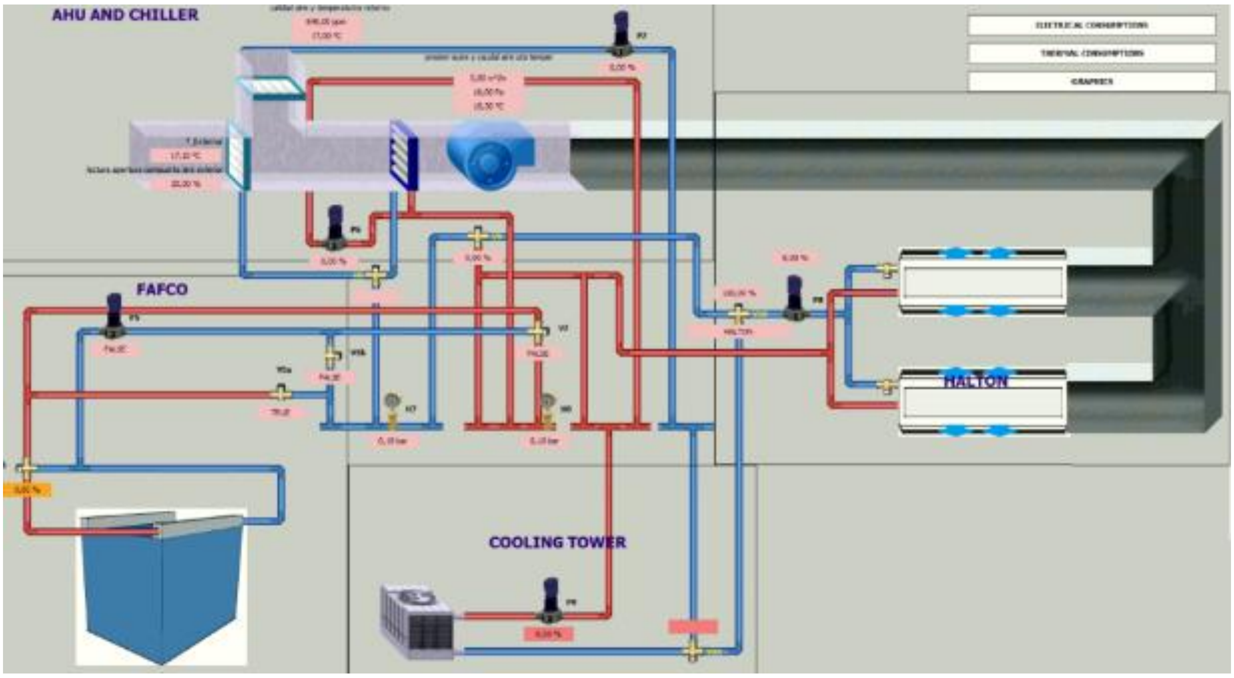

Figure 63. Cool LowUP

It has the same usability principles of HEAT LowUP, by which clicking over each section is possible to access to main parameters/controllers of that specific sub-system.

Next image presents AHU and Chiller in their connection with cooling tower and chilled beams.

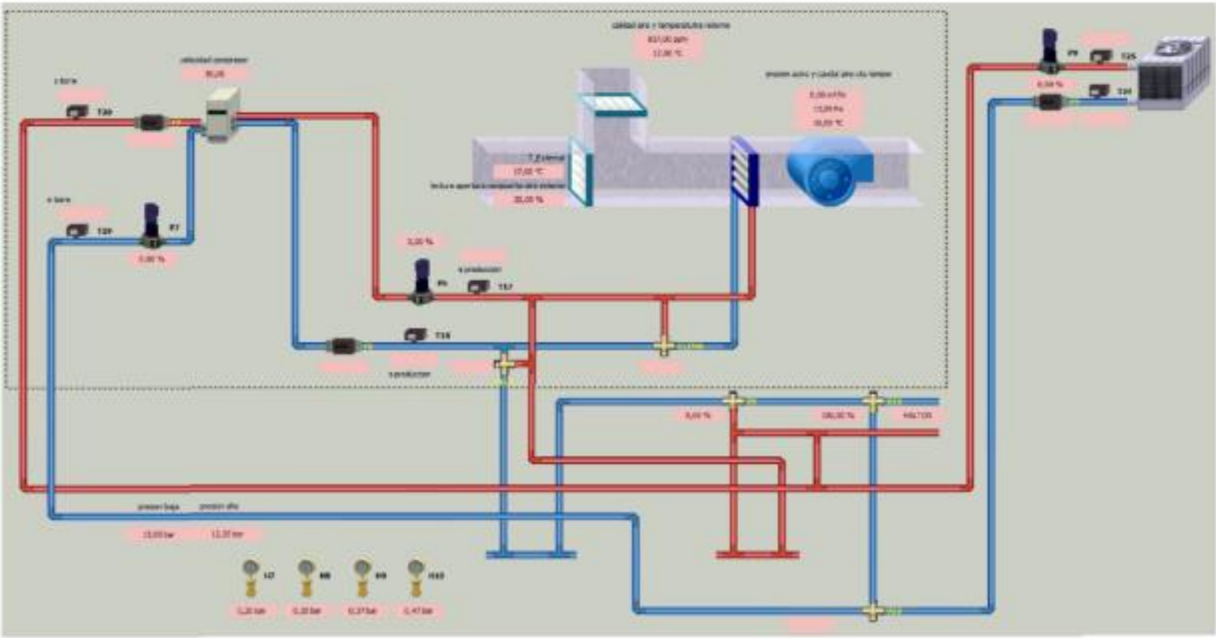

Figure 64. AHU/Chiller

There are represented internal temperature and pressure sensor, outside temperature, inside pipe´s temperature and pressure sensor, opening/closing level of the three-way valve, etc.

Changing section to FAFCO (PCM Tank), it opens a window like the next image.

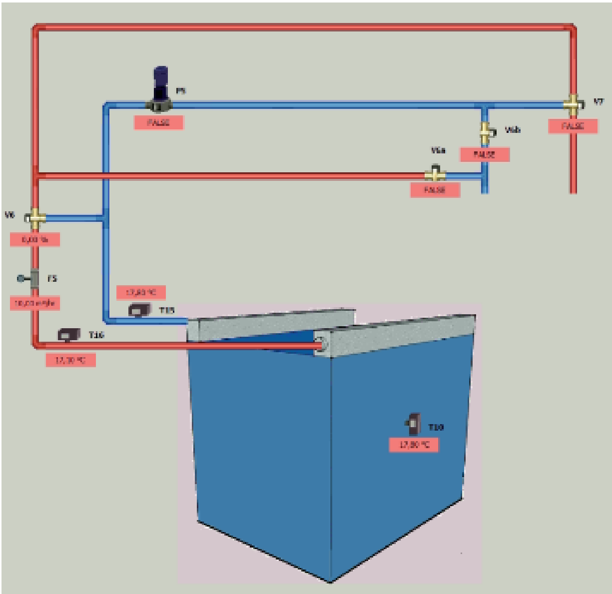

Figure 65.FAFCO subsystem

Clicking on the Halton section, it is possible to accesses to Halton´s all monitored parameter from this system, beam by beam.

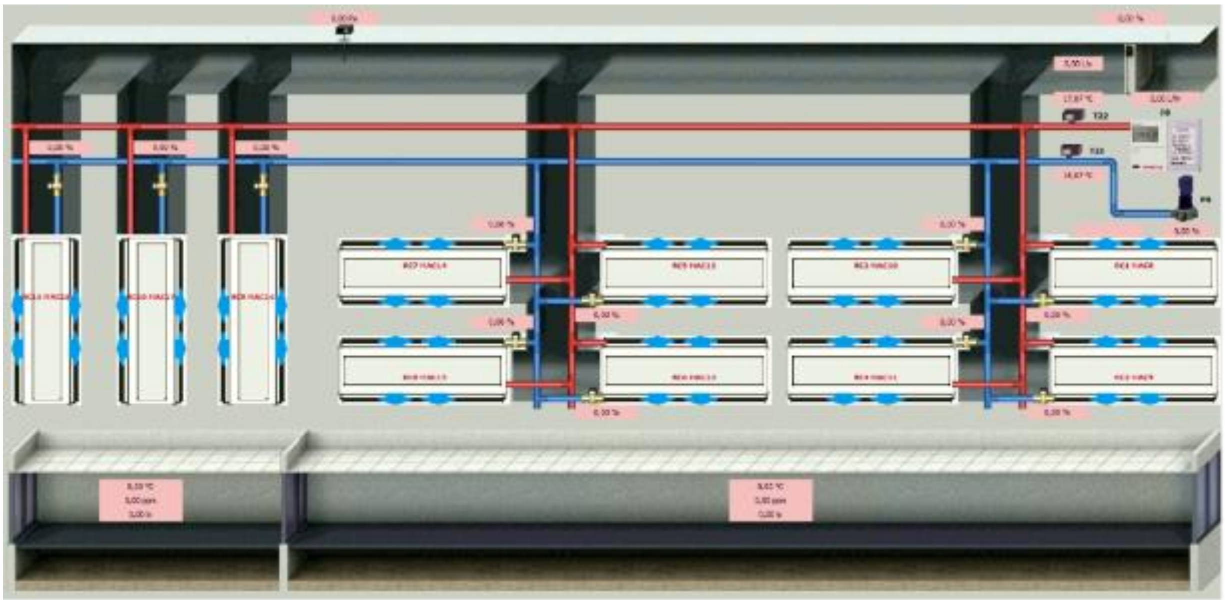

Figure 66. Halton subsystem

In the top right of the Cooling panel, it possible to find three buttons which give more information about COOL LowUP.

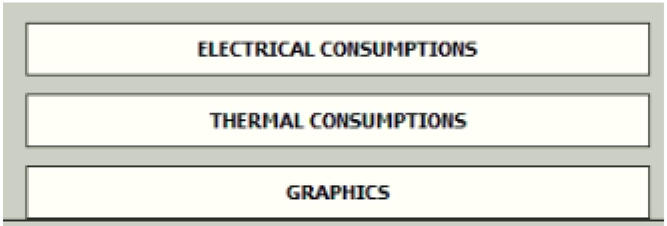

Figure 67. Buttons´ parameters in the cooling panel

Each button accesses to a different window like the next ones. Following image refers to electric consumption.

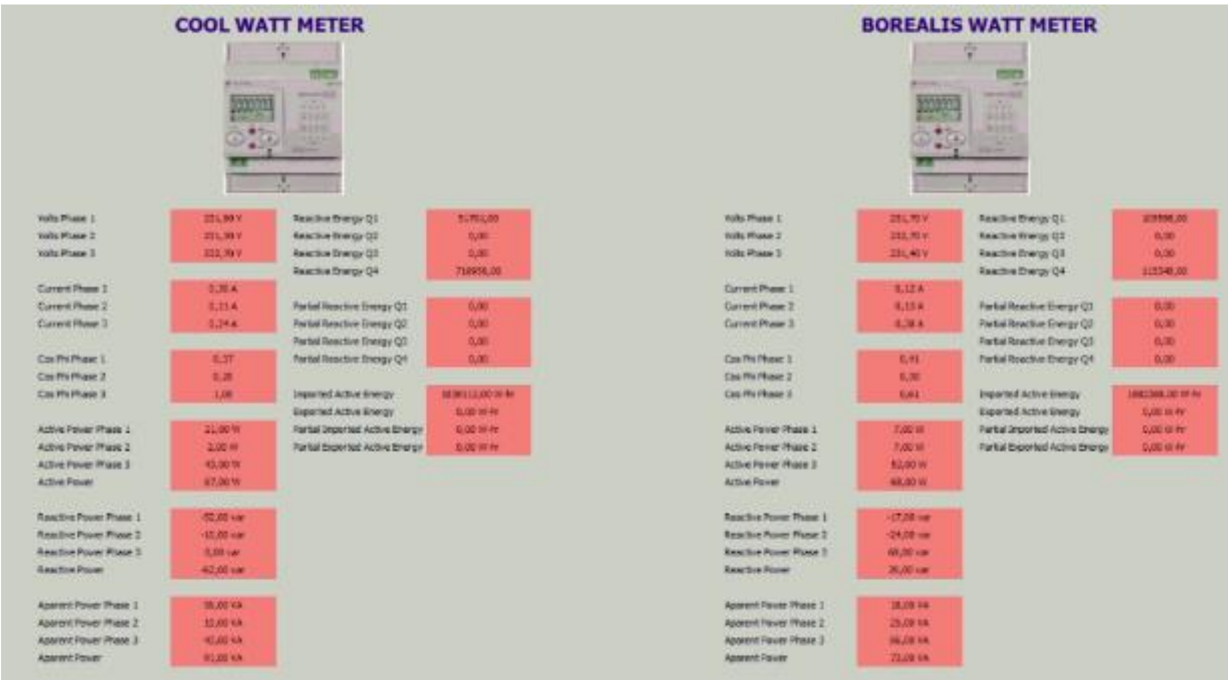

Figure 68. Electrical consumptions in COOL LowUP

Following image refers to energy meters over water piping.

Figure 69. Thermal consumptions in cooling LowUP

Following image refers graphs during the time of main cooling parameters.

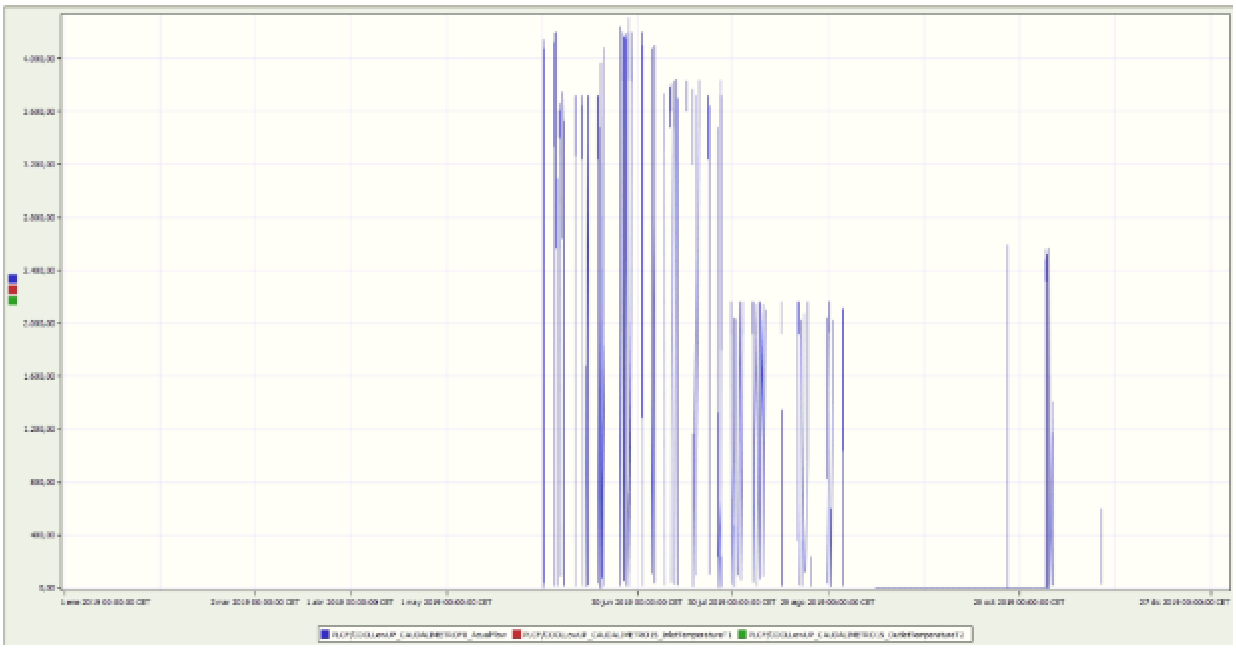

Figure 70. Graphics of cooling parameters

3 Implementation of equipment at Rucab demo

The Hybrid Waste Heat Recovery (HWHR) system planned in the scope of the LowUP project, is aimed for recovering the heat of liquid or semiliquid effluents, with the special feature of not presenting the disadvantage of clogging or dirtiness such as other convectional heat exchangers.

Within this scenario, the aim was to find a facility with certain heat energy consumption and mainly with a high number of working hours. The potential candidates were the tertiary sector, due to the energy demand and the frequency of the exploitation of the energy recovery system.

The university residence of Rucab at Badajoz presents an interesting profile of energy waste during the year and during the day because of the use of the kitchen for students. The residence presents two different heat sinks: industrial dishwashers and wastewater from pots.

The activity required modification of the existing structure of a collection of wastewaters and of heating of sanitary hot water, integrating the HWHR system in parallel with respect to present installations.

3.1 Description of RUCAB building before system integration

The residence selected is located in Badajoz, RUCAB, and it has accommodation for 204 students offering services such as canteen, laundry service, and heating system.

Figure 71. Aerial view Rucab demo (Badajoz)

In the following image, the detail of the building from the entrance.

Figure 72: Students residence located in Badajoz (Spain)

The installation plan for this system is explained in D4.1, so only the works for conditioning the Rucab building are presented in this deliverable. In the next image, the layout for the integration of the system.

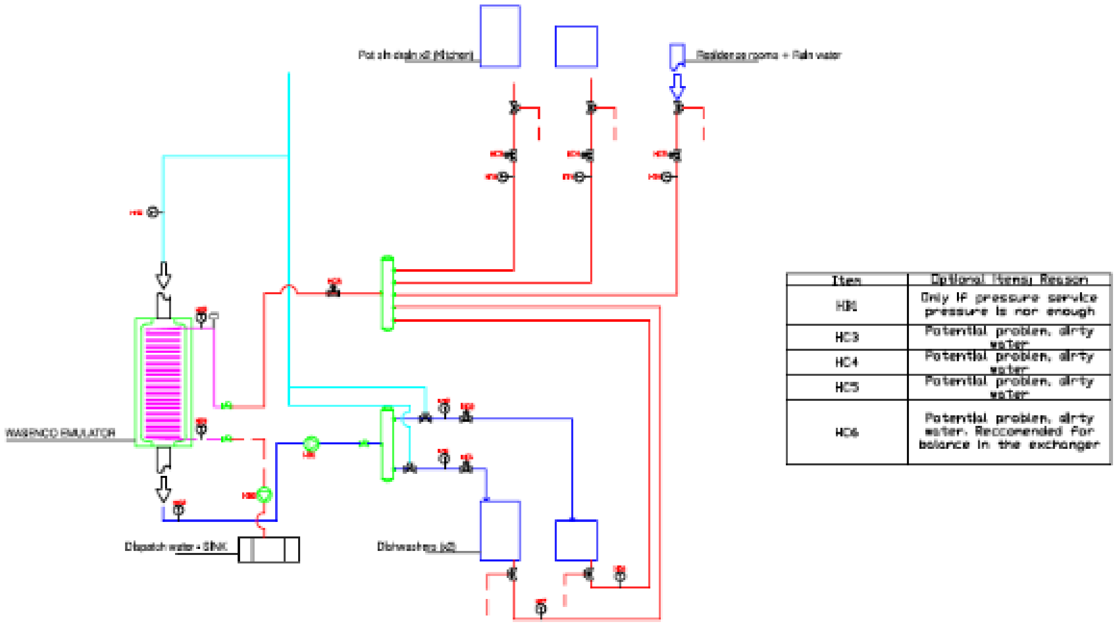

Figure 73. P&ID Scheme design for a thermal recovery

The HWHR presents the next items:

- Pumping system. Two pumps in parallel for liquid push up, suitable for admitting water with a certain level of dirtiness, integrated with the plastic structure for an increased life cycle.
- Degrease tank. To separate grease from effluent, in order to avoid fouling because of grease solidification due to low temperature.
- The HWHR tank. The system is based on three circuits without mass transfer: the circuit of dirty water; the circuit of sanitary water; the circuit of heat storage, not flowing, just filled during the starting-up process.
- The control/monitoring system. It is composed of a PLC for pump control, an embedded pc for data storage and 3G for remote communication.

Next drawing shows a kitchen plan, where appears the different sources of waste heat considered in this installation:

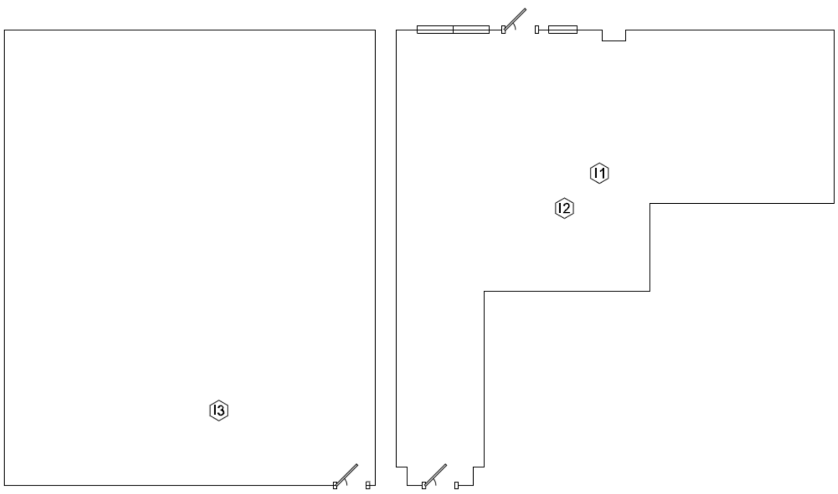

Figure 74. Kitchen plan and heat sources location

Item 1 and 2: Sink 1 and 2 from the kitchen.

Item 3: Dispatched water line from the dishwashers.

Figure 75: Dishwashers in the kitchen

The system required the placement under the ground floor, below the level of the kitchen, with necessary changes of the pipes to main greywater collector; on the other hand, cold water line required to be intercepted and deviated to HWHR.

In the following image, the lines of waste and clean water present on the underground floor.

Figure 76: Current state of pipe system: grey waters (left) and clean water (right)

3.2 Rucab adaptation to HWHR system

Once selected the emplacement, the old connections and pipes required to be adapted for installing the Wasenco system. When the actuation was designed, the new pipes were thought as a by-pass concept of the old pipes, making easy to by-pass the new system in case of problem, with the choice of returning to the previous state of the installation.

In the following picture is represented as a sketch of the connections.

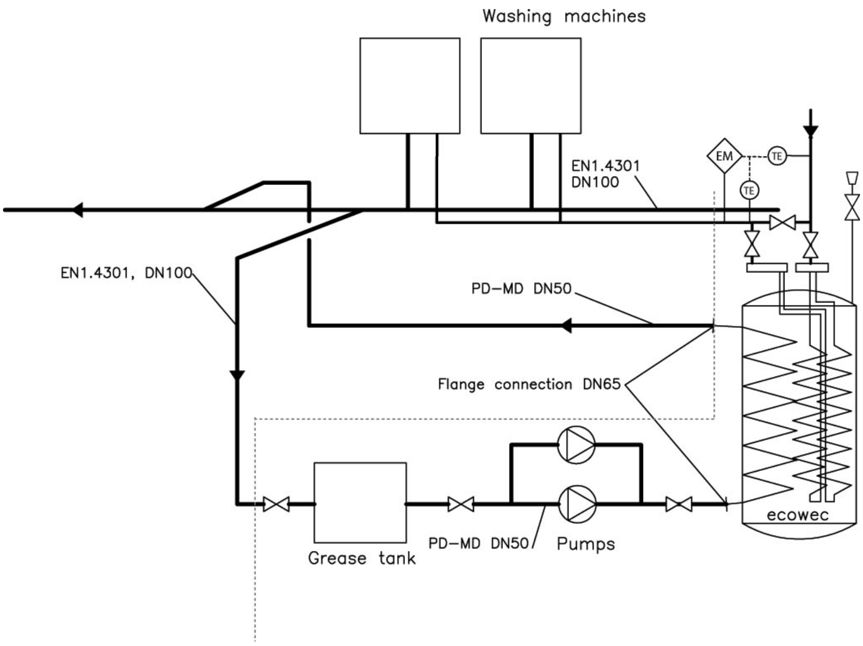

Figure 77. The connection between Wasenco and Rucab

The preliminary works, for pipes adaptation, required modification of existing lines, introducing "T" and valves in order to create parallel new lines able to deviate fluid to HWHR, using a by-pass concept.

In the following image, the details of the works of pipes adaptation.

Figure 78. Replaced pipes (left), new pipes connections of the kitchen sinks (centre) and Item 3: Dishwasher 1 and 2 (right)

Figure 79. New pipelines to HWHR for grey and clean waters

Figure 80. Details of new pipelines to HWHR for grey waters

The valves and pipes were selected according to the Wasenco´ specifications, for offering the easiest way to assembly the items.

On the other hand, in order to speed up the installation process, the system was previously pre-assembled at Wasenco settings, and then shipped to Spain.

The preassembly was done in Finland as it´s showed in the next figure.

Figure 81. Wasenco preassembly in Finland

Items were packaged and delivered to Badajoz, in 4 pallets, for a final assembly on the location.

Figure 82. Package delivered to Rucab (left) and unpackaged items (right)

3.2.1 Installation and start-up

Schematically, the water coming from dishwashers and from kitchen drains reaches the degreasing tank; it is subsequently pumped to the heat exchanger, in order to recover heat and store it, before being directed to the sewage collector.

The cold, clean water is heated up through the storage tank and then delivered to the dishwashers as preheated water. The goal is reducing the energy used by dishwashers to heat up process water.

The installation, apart from hydraulics, pumping station and degreasing tank, consists of electrical supply panel, control and monitoring panel, and pump control panel (all these placed in the laundry room).

Figure 83. Working in laundry pipes (left) and connections to HWHR tank (right)

In the following image, the details of temperature sensors for greywater.

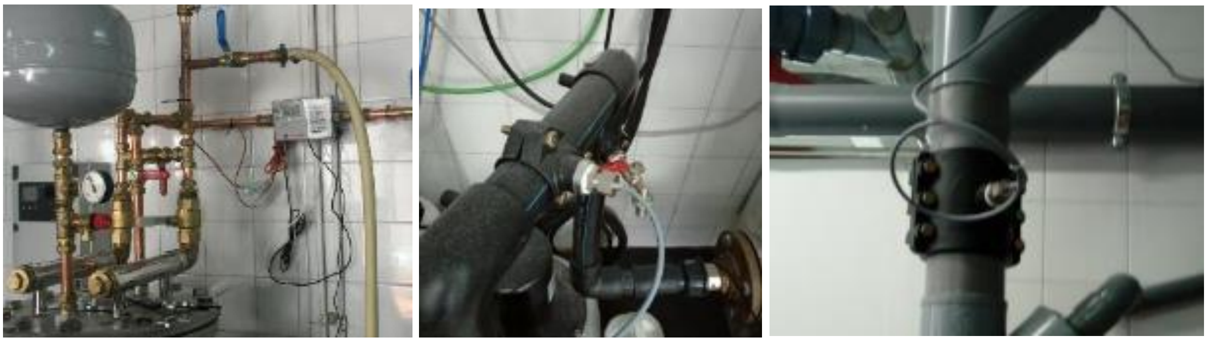

Figure 84. Pumping group connections

Figure 85. Coldwater inlet from the network (left) and pre-heated cold-water inlet (right)

Figure 86. System details for connections

The system control and monitoring computer is located in the laundry room. This cabinet has the following elements inside:

- An embedded industrial PC for collecting and sending the installation information
- A router in charge of sending the communications via a mobile network.
- A switch in charge of collecting communications from each element of the installation.
- A network analyzer for readings electrical variables of the system.

Figure 87. Cabinet of control and monitoring power supply (left) and power supply cabinet (right)

In the next image, the view of the dishwashers used as a heat sink and the water connections.

Figure 88. Dishwashers object of intervention

Figure 89. General view of the system in Rucab

In the next figure, each element of the installation is identified.

Figure 90. Inlet of grey waters

Figure 91. Heat recovery system

4 Conclusion

This deliverable gives a full description of the sites where Cool and Heat LowUP technologies are installed and ready to be tested: the thermal lab of ACCIONA in Seville and the student residence of Badajoz (Rucab). The demo site in Seville finally hosts the Cool-LowUP and Heat-LowUP installations, while the demo site in Badajoz hosts and operates the Waste Heat Recovery System.

All the equipment has been described in detail, explaining the main features and requirements of each one. Regarding these requirements, some previous works to adapt the demo sites have been proposed. These works are mainly: building refurbishment, ground conditioning, systems integration and previous engineering studies.

All demos, composed of one or more concepts, can be controlled from remote thank to level of automation implemented at a different level: technology, sub-system, system and concept.

The monitoring system is completed, and all relevant parameters are correctly logged in the DBB for future analysis.

Basic control strategies are implemented in order to achieve specific targets for each system and so being able to realize future tests of characterization.

All technologies have been commissioned and partially started-up, waiting for the introduction of an intelligent algorithm for operation optimization.

5 Bibliography

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