D4.2 End-user requirements and building constraints - Italian demo

WP4, T4.1

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HAPPENING VERZUOLO

Technical references

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[1] PU = Public

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Versions

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Abbreviations and acronyms

Acronym	Description
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
BMS	Building Management System
DHW	Domestic hot water
EC	European Commission
ESCO	Energy Services Company
LPG	Liquefied petroleum gas
POD	Point of Delivery
PoE	Power over Ethernet
PV	Photovoltaics
WP	Work Package
WPL	Work Package Leader

Abstract of the HAPPENING project

Currently, **buildings are responsible for 40 % of the energy demand and 36% of the CO_2 emissions in Europe**. Decarbonisation of existing buildings plays a key role in order to reach the overall climate protection targets. However, current renovation rates lie in the order of 1%.

Heat pumps are a key technology in bringing renewable shares into heat supply of buildings; especially their combination with onsite renewable electricity production e.g. by PV allows to bring high renewable shares. Their current installation in existing multi-apartment buildings is however still marginal.

The proposed technological solution is based on decentralized heat pumps, in such a way that it results an easy-to-install solution for installers, low-intrusive for the occupants and easily adaptable to a large number of different building situations. This is flanked by developing near-zero planning, implementation and operation processes, in order to facilitate the work during the planning phase, ensure a high-quality installation and effective operation, and reduce the efforts and costs within the whole retrofitting project. The challenge of cost-competitiveness is addressed by developing new financial and business models. Bringing new players (such as financial experts) and financing models to the renovation market is expected to bring the needed paradigm change and boost investments in the residential retrofitting sector. Dissemination of measured performance and system characteristics from HAPPENING will be one of the key results of the project.

Through **3 demo sites (Spain, Italy and Austria)**, the project will demonstrate a highly versatile, scalable and replicable solution package for buildings energy system retrofitting allowing 70-75% of renewable energy fraction, 30-50% of PE and GHG savings, reduction of planning time by 50% and installation/operation time by 30% and payback time for ESCOs and investors of less than 8 years, compared to best available solution existing today.

1. Introduction

1.1 Objectives of the deliverable D4.2

The objective of Deliverable D4.2 is to provide the reader with a general view of the Italian pilot building of the HAPPENING project, located in Verzuolo, in the Piedmont region, in the North-West of the country.

The description will include a definition of the constructive characteristics of the building itself, in which the peculiar characteristics of this will be highlighted, as well as the properties of the geographical place in which it is located.

Of fundamental importance is the delineation of the systems currently present in the building, which will have to be replaced and / or readjusted for the purposes of the HAPPENING project and for the new systems to be installed, and the definition of the current energy parameters, such as the energy needs of the different apartments and the thermal equipment and the display of the current consumption of primary energy sources.

The contribution given by the users of the building will also be very significant, with their considerations and requests on the new systems.

In this way, an overview of the pre-intervention situation of the Verzuolo Demo site can be provided, which will be very useful for evaluating and explaining the reasons for the solutions studied in the HAPPENING project that will be adopted here.

1.2 Deliverable description

The deliverable D4.2 is structured in several chapters explaining the following key aspects related to the main characteristics of the actual status of the Demo Case building in Verzuolo:

- General Introduction of the Deliverable, contributions and connections with partners and Tasks of HAPPENING Project
- Description of the building, the place, the current systems installed and the present equipment
- Energy Demand of the building for electricity, heating and cooling in the present situation
- User requirement and desire on the building systems and equipment
- Conclusions
- Annexes

Descriptions contained in these chapters will lead to a detailed knowledge of the characteristics of the building and a basis on which to make considerations and develop the best solutions for the renovation according to what has been studied and implemented within HAPPENING, which must combine the achievement of the project targets, the characteristics of the building and the requests of the end users.

1.3 Contribution of partners

The main partner involved in everything at local level regarding the Verzuolo Demo case is TECNOZENITH.

TECNOZENITH company is in fact the company dealing with the management of the entire building in question, and it is the partner who will take care of the energy efficiency and renovation of the building with the solutions of the HAPPENING project. Having been in this role for years, having already carried out some renovations in previous years and currently having the ordinary and extraordinary maintenance of the systems in charge, TECNOZENITH has in-depth knowledge of everything regarding the generation, distribution and use of energy carriers for the condominium.

In addition, TECNOZENITH headquarter is located a few kilometres away from the Verzuolo building, so it can guarantee an accurate view of the progress of the work, when the HAPPENING solutions will be implemented, and maintenance or punctual interventions in case of alarms or problems reported on the site.

Within the project, many other partners will be involved and will provide different contributions for the Italian Demo Case.

EURAC is, within HAPPENING, the lead partner for the entire project management and communications relating to the Verzuolo building. The choice was agreed for the experience of this Italian research institute not only about the in-depth research knowledge on renewable sources and HVAC systems, but also for the experience in several European projects. EURAC leads the "Italian Demo Case management group" in which, in addition to them and TECNOZENITH, there is the partner INNOVA.

1.4 Relation with other activities in the project

The definition of Verzuolo Demo Site is closely related to almost all the other activities present within HAPPENING: in fact, the pilot buildings represent the test of the proper functioning and correct implementation of what was designed, studied and produced throughout the project. In the works that will be carried out inside the building, making up Work Package 4, technologies and machinery developed by the partners within the WP2 will be introduced, within the "Industrialisation of HAPPENING Technologies".

The data will be generated by the building, before and after the intervention, will be sent from the site used and studied in the first instance in WP3, which deals with performance monitoring, but also by WP5, to validate the data with respect to the provisions of the EPC contracts, and the results obtained will be included in the Exploitation (WP6) and Dissemination (WP7) activities.

All the activities described above will always be managed within the project by the coordination activity of WP1.

2. Demo building description

The Italian Demo Case building for the HAPPENING project is in the municipality of Verzuolo, in the Piedmont region, in northern Italy, located in the historic centre of the town, in a hilly position, along the road that leads to the ancient medieval castle.

The historic building underwent a series of deep interventions in the years 2008-2009 that changed its structure and appearance. The interventions concerned not only the building part, but also the electrical, plumbing, and sanitary systems: from an uninhabitable structure, the works made it possible to obtain a building containing 10 dwellings and a commercial activity on the ground floor we can see today.

Figure 2.1: North facade of Verzuolo building before and after 2008 interventions

Figure 2.2: South facade of Verzuolo building before and after 2008 interventions

Renovated to be the site of a holiday home, in addition to the commercial activity on the ground floor, the apartments are now rented with a lease. The systems each apartment is equipped with are centralized and controlled by a BMS system. In the following paragraphs all the geographical structural, and thermal equipment characteristics of the Italian Demo Case will be explained in detail.

2.1 Location description

Verzuolo is a small town of about 6000 inhabitants, located at the mouth of the Varaita Valley, in the province of Cuneo, Piedmont region, in the north-west of Italy.

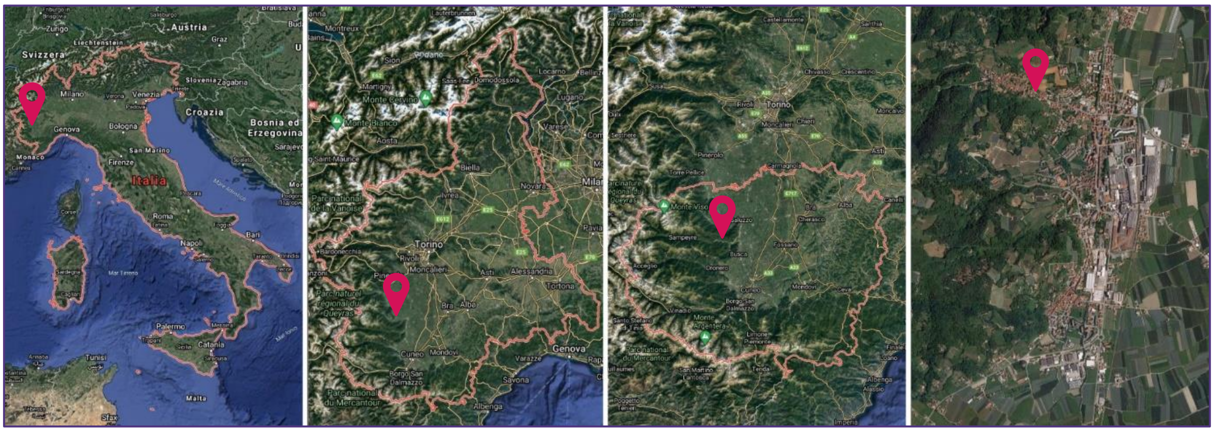


Figure 2.3: Location of the building (from left to right) in Italy, Piedmont Region, Cuneo Province and Verzuolo

Although its territory was already inhabited both during the Bronze Age, as evidenced by the findings of engraved stones dating back to this period, and in the Roman age, Verzuolo had a great development during the medieval period and the modern age with the construction of the structures on its hill, during the dominion of the Marquisate of Saluzzo and the Duchy of Savoy, a period in which, among others, the first nucleus of the building today Demo Site was built.

Subsequently, the population grew mainly in the plain area, today the most inhabited portion of the territory, where agriculture is flourishing, in particular the cultivation of fruit such as peaches, apples, kiwis and apricots.

In 1905 one of the largest paper mills in Italy was opened here. For its construction, in the municipal area, one of the first national hydroelectric plants was installed in the previous years, which allowed Verzuolo to be the first municipality in Italy to have the electric public lighting, in 1882.

Figure 2.4: Areal View of Verzuolo (left) and the castle on the hill (right)

The climate of Verzuolo is temperate, characterized by hot and humid summers and rigid winters, in which the minimum temperature often drops below 0 ° C. According to the Köppen-Geiger climate classification, Verzuolo falls within the Cfa range.

Precipitation occurs all year round, but with prevalence in the spring and autumn season, while snowfalls are frequent in winter.

The following charts show some information about climate and temperature of Verzuolo.

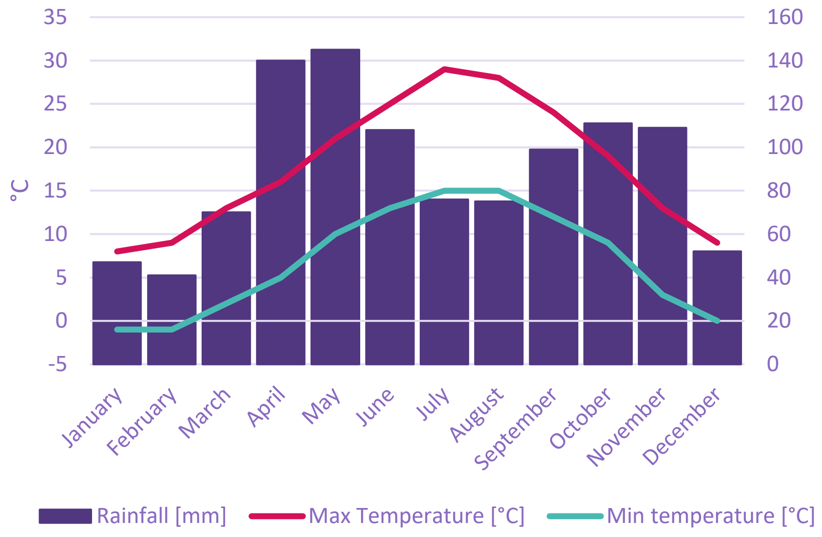


Figure 2.5:Average Monthly Values of temperatures and rainfall in Verzuolo

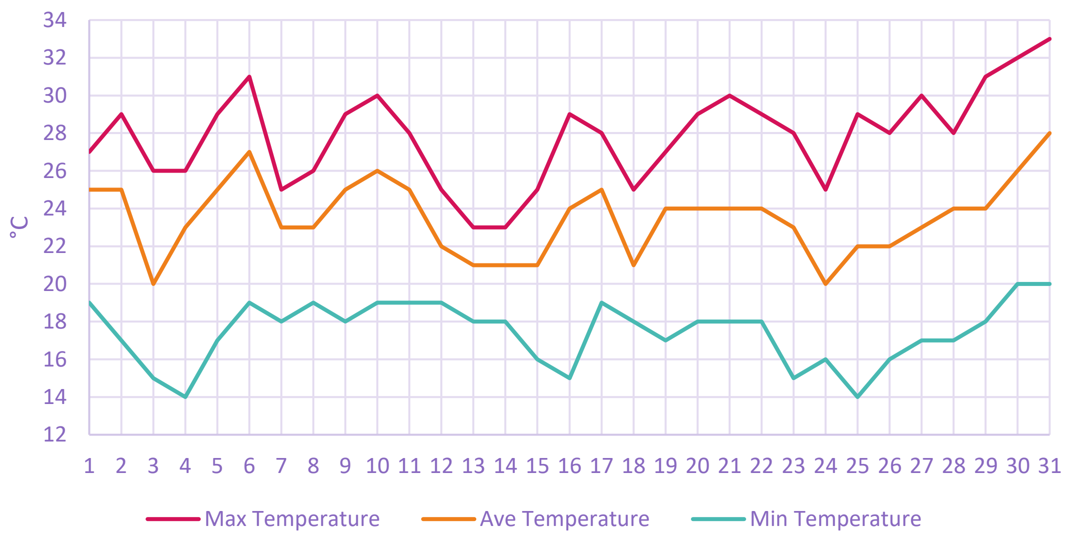


Figure 2.6: Daily Temperature in July 2020 in Verzuolo

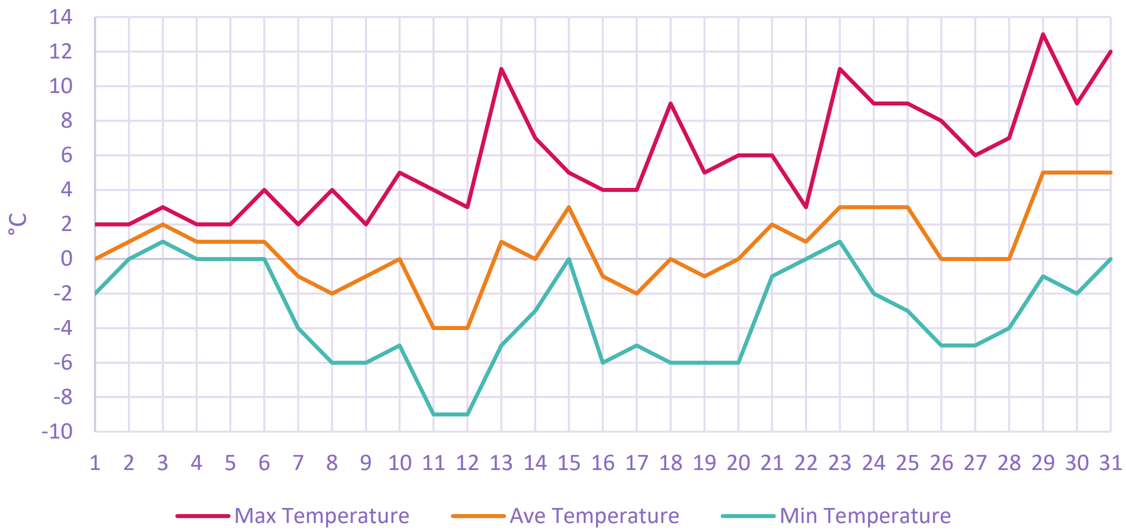


Figure 2.7: Daily Temperature in January 2021 in Verzuolo

As can be seen from the graphs, there is a high seasonal thermal variability, with a considerable difference between the average temperatures of the warmer months and those of the winter period.

The buildings in the area must be equipped with a robust heating system that can operate properly even with very rigid external conditions: the design temperature of the heating systems settles at -8°C.

Summer cooling systems are not yet the majority in Verzuolo residential buildings, where only heating systems are present. However, the benefits of air conditioning in homes are undoubted, from the point of view of indoor thermal comfort, due to the high temperatures, reached especially in the months of July and August.

The microclimate is also different within the municipal area, mainly due to the wide altitude range of the territory, from 367 meters above sea level to 1165 meters above sea level, with the hilly area characterized by cooler temperatures in summer, greater windiness, more snow but fewer days of frost in winter. Particularly, the street on which our building overlooks is characterized by a strong and persistent wind, which lashes the north wall of the building.

The Degrees Day amounted to 2834, which included the municipality in band E according to the Climatic classification of Italian municipalities introduced by law in 1993: this means that the warming period of Verzuolo goes from October 15 to April 15 of the following year, for a maximum of 14 hours per day, which can be extended in exceptional cases by the mayor of the town.

2.2 Building description

The building under study for the HAPPENING project is located in Verzuolo, along the road that connects the current main street, on the plain, to the fortress, passing through the district called "La Villa ", consisting of the historical buildings located on the first hill.

Figure 2.8: North (left) and south (right) façade of Verzuolo building

The neighbourhood in which it is located is residential, in which, among the various oldest buildings, there are also some recently built single-family houses.

In particular, this building overlooks the street directly, with the north wall that delimits the street on which it is located, while the vent is located in an internal courtyard, which is accessed by a driveway passing under an arch.

The north wall, facing the street, therefore has, as regards the apartments, only windows, while on the ground floor there is the access for the commercial activity present here, a restaurant.

Exactly the ground floor occupied by the restaurant represents the first foundation of the Demo Case building: this portion, as it is still visible, was built at the end of the 16th century, during the expansion of the city on the hill. Like all buildings of this era, the structure is made up of thick lime and river stone side walls, with vaulted ceilings.

Figure 2.9: Interior of the restaurant on the ground floor

In the interiors it is still possible to appreciate this type of workmanship. During the renovation of the building, mentioned in the previous chapter, it was not possible to make profound changes to the ground floor, as it has a historical character and the possible interventions are regulated. As it was not possible from a regulatory point of view to adapt for energy efficiency, a conservative restoration was instead carried out, with the laying of a new flooring, suitable fixtures and recovery of the vaults in exposed river stone, which in addition to assuming a historical character have objectively an excellent impact on the aesthetics of the ambient.

The ground floor, as a commercial activity, is however not the subject of the study of the HAPPENING project, which will continue to be supplied by the current heating systems even after the implementation of the solutions developed here, thanks also to the already present separation between the distribution systems of the ground floor and of the dwellings.

On the other hand, the first and second floors had a different historical development: if the originally building was on a single floor, as happened in many structures in this area and of that period, the Demo Case building was also extended several times in height, according to the needs of new premises, on several occasions, in different periods, without a precise and defined conception or design of the building and with the use of different materials and construction methods.

The result of these extensions, visible until the 2008 interventions on the building, were reflected in a jumble of various modestly sized rooms side by side, without a precise constructive logic and without safe and efficient electrical and heating systems.

In 2005, the building was uninhabited and in poor condition.

In 2006, the deep restructuring works of the entire building began, which led to a radical transformation, changing its appearance especially in the part facing the internal courtyard while enhancing the historical character, above all the ground floor mentioned above and the north façade, on the road side.

Figure 2.10: Installation of systems during 2008 renovations

The interventions carried out in this period are summarized here:

- Excavation and creation of new reinforced concrete foundations towards the inner courtyard, with the function of structural reinforcement.
- On the ground floor, expansion of the spaces serving the commercial premises, creation of a new space to be used as a common boiler room and creation of an aired cavity to prevent humidity problems in the premises.
- On the first and second floor, complete dismantling of the internal and external walls facing south, with complete restoration of those, realizations of the new internal partitions that delimit today's apartments, new slabs in reinforced concrete and construction on the second floor of a mezzanine in metal structure to expand the interior spaces.

- Replacement of all external windows and doors.
- Complete refurbishment of the roof and its raising, with metal structure in IPE 180 beams, covered in wood for a better aesthetic effect.
- Installation of new centralized electrical, heating and domestic hot water production systems, as described in the following chapter.
- Recovery and restoration of the rooms on the ground floor to be used as restaurant rooms.
- Creation of the current 10 dwellings, with internal partitions, systems and finishes to make them habitable.
- Complete renovation of the internal courtyard with blocks.

From an energy point of view, the renovation considered the constraints in force in 2006, the year of the request for the building permit: the building therefore complies with the Italian requirements imposed by that period.

To improve thermal insulation, the new south exterior walls were built with a double layer of brick and 10 cm of mineral insulation interposed, as well as the new exposed roof, in a metal structure with a wooden finish, was insulated by interposing 10 cm of mineral insulation. The windows installed are airtight and have double glazing.

On the other hand, no intervention was made on the north facade towards the street except for the replacement of the windows, due to the landscape and historical constraints imposed by municipal regulations, so the original solid brick masonry remained.

The building we see today, and which represents the Italian demo case for the HAPPENING project is therefore the result of all these interventions mentioned above.

Figure 2.11: Interior of various dwellings after works has just been completed

There are 10 apartments, including 5 two-room apartments on the first floor and 5 three-room apartments (2 bedrooms plus the mezzanine used as a sleeping area) on the second floor. They are characterized by modest dimensions, between 32 and 42 square meters and all oriented according to the north-south direction.

Access is from the south, from the internal condominium courtyard, towards which the 10 entrance doors that allow access to the kitchen overlook: the apartments on the second floor can be reached via an external staircase and balcony. The two-room apartments have a kitchen to the south and a bedroom to the north, while the three-room apartments have a kitchen to the south, a living room to the north and a sleeping area on the mezzanine. The bathroom is always located between the two non-mezzanine rooms.

2.2.1 Current hydraulic and electric system

The renovations of the years 2006-2008 did not really affect the geometry of the building spaces and the envelope, but they also allowed the creation of new electrical systems, and air conditioning of all the rooms of the building.

The choice of a centralized system was pondered by evaluating the fact that it was more easily maintained, would have allowed a reduction in consumption and energy waste and would have been better adapted to the post-renovation situation of the building, which was designed at that time like a holiday home, with a large turnover of people inside the lodgings, who had to find working systems that were easy to use. In addition, for the heating and DHW production system, the encumbrance of the boiler in the already small apartments was avoided.

The various systems are described below, as they have been designed and installed.

2.2.1.1 Hydraulic System

The centralized hydraulic system of the Verzuolo building has its heart in the boiler room: here, in fact, the gas piping and the water supply pipe arrive, each one from their own meter. The heat generator consists of a condensing natural gas boiler with 80 kW of nominal power. It is powered by the gas arriving in the boiler room, which reaches by passing through the protection and safety devices, such as solenoid valve, shut-off valves and filter.

The boiler has the dual function of providing hot water for heating and to produce domestic hot water. Its operation is regulated by BMS, so the start takes place based on the winter calendar, with time setting as regards the heating, and on the basis of the temperature of the boiler, as regards the production of domestic hot water. All the devices required by law are present on the boiler flow, such as safety valve, maximum temperature thermostat, block pressure switch and minimum pressure switch.

As regards the heating circuits, a pump with inverter makes the water circulating in the two circuits: the utilities of the dwellings, and the restaurant and the adjoining kitchen (out of scope for this project). Each circuit is also equipped with shut-off valves, calibration valves, temperature probes and expansion vessels. Each circuit feeds its associated fan coils.

As regards DHW production, a dedicated circulating pump is installed on the supply boiler manifold: when the BMS system detects that the 500-liter boiler used for DHW production drops below the set point, a command is sent to the pump and the boiler in order to restore the desired temperature in the buffer tank. The hot water produced through a coil reaches all the apartments, together with cold water from the freshwater pipe.

The last pump present in the boiler room is the sanitary water recirculation pump: to always guarantee hot water is quickly supplied to all users, the hot water is continuously recirculated thanks to a small pump placed here, connecting the top of the DHW circuit to the inlet in the buffer tank.

Figure 2.12: Interior of the boiler room

In reality, in the boiler room also a chiller is present: this one, installed with the purpose to keep the rooms cool during summer, using the same fan coils and pipes (already properly insulated to prevent condensation). It has never been used yet, so as not to increase the management costs of the tenants, who would have suffered an increase in costs for air conditioning. It will therefore be decommissioned during the HAPPENING project.

In dwellings the emitters are fan coils. These ones are installed horizontally, in the false-ceiling of the corridor in first-floor dwellings (one for the kitchen, one for the bedroom), while in the three-rooms apartments we find wall-mounted fan coils, located in the kitchen, living room and bedroom.

Each fan coil is controlled by BMS through the temperature sensor of the room, and it is hydraulically connected to the manifolds (supply and return) of each dwelling. The drainage pipes are also connected, because of the original predisposition to use them also for cooling purpose.

2.2.1.2 Electric System

The building's electrical system consists of a single Point of Delivery (POD) by the electricity supplier, which therefore has a single meter. The type of supply has a nominal voltage of 400 V and the power used is 50 kW.

In fact, this meter serves all 10 apartments, common services and the central heating system. Restaurant has its own electrical connections, with a three-phase line dedicated: here there is the electrical panel feeding all the services of the rooms on the ground floor and the kitchen, this one with its own dedicated electrical panel, derived from the first.

There is a centralized electrical panel downstream of the dwellings' energy distributor meter, which contains the switches with the line outlets to the different users of the building, including dedicated circuit breaker protection switch for each dwelling.

Inside the boiler room there is also a switchboard for the electric power supply, with three-phase arrival, of all the equipment for the operation of the heating and domestic hot water production systems present there.

Each apartment then has its own dedicated electrical panel, located in the hallway, with disconnectors, contactors, and protection switches. In dwellings, there are dedicated electrical lines for the power of each fan coil, of the kitchen equipment, sockets, and lighting and for the extraction fan inside the blind bathrooms.

Every electrical panel present in the building (dwellings, restaurant, kitchen, boiler room) is also equipped with a controller of the BMS system. This system, described in detail in chapter 2.2.2, was originally installed in 2008, with a BMS control system from Trend, a UK company dealing in automation and control field. Today, after a quick revamping work, Swiss Control System (SCS) controllers are present, integrating sensors and acting on devices: the operation of gas boiler and pumps in the boiler room, as well as the start and stop of fan coils and the extraction fans from bathroom for dwellings and restaurant is completely automated by BMS.

SCS controllers also interface the electric meters present: to know and share electrical consumption of different dwellings and restaurant electric meters were installed in all dwellings and restaurant electrical panels; by connecting them with BMS system it is possible to visualize these parameters remotely.

To make the BMS system remotely reachable and to assure more services to tenants, a data network was installed already during 2008 works on this building. The data line connected to internet arrives in the boiler room, where a firewall and a central switch are present.

From there, the network reaches each dwelling thanks to UTP cables: here, inside the electric box, another PoE (Power over Ethernet) switch is present, not only to centralize BMS system, but also to provide internet via different RJ45 sockets located in the apartment and to power and supply network for the access point of the dwellings and guarantee Wi-Fi to tenants.

2.2.2 Existing equipment

In this chapter, a better identification and description of the different appliances and devices present in the building will be done, not only to understand better the situation ante HAPPENING interventions, but also to identify and understand if some of them can be included or reused with the new solutions developed in the project and to be installed in Verzuolo Demo Case building.

For a better understanding of these paragraphs, please refer to Annexes 2, 3, 4 and 5, at the end of the document, showing the plans and layout of the current system.

2.2.2.1 Condensing Gas Boiler

The gas boiler, installed in 2008 in the boiler room on the ground floor to produce DHW and for heating, is of the wall-mounted condensing type, branded "Ecoflam", model "Blumax 80".

Figure 2.13:_ Gas Boiler installed in Verzuolo

The main characteristics of it are listed in the table below:

Ecoflam Blumax 80	M.U.	Value
Nominal Thermal Power (80°C/60°C)	kW	78.2
Minimum Thermal Power (80°C/60°C)	kW	19.5
Efficiency respect to nominal power (80°C/60°C)	%	97.7
Efficiency respect to nominal power (50°C/30°C)	%	103.4
Max operating temperature	°C	90
Max fumes temperature	°C	64
Max fumes flow	kg/h	121
Max operating pressure	bar	4
Boiler water content	l	10
Pressure drop on water circuit	mbar	270
NOx emission	mg/kWh	<60
CO_2 emission at nominal power	% vol	9.1 ±0.2
Power consumption	W	120
Power supply	V-Hz	230-50
Supply Gas pressure	mbar	20
Weight	kg	102
Protection class	--	IP40

Table 2.1: Main characteristics of the "Ecoflam Blumax" gas boiler

This gas boiler is now the only heat generator of the whole building. HAPPENING project will provide for this building heat pumps and micro heat pumps for heating, cooling and DHW purpose. However, the restaurant and the kitchen will continue to have to be heated through the existing system, so the boiler will continue to operate for this purpose.

Furthermore, it can be seen as an integration also for apartments, but only as a back-up, in the event of malfunction or failure of the installed heat pumps, in order to be able to guarantee heating and domestic hot water supply to users.

2.2.2.2 Circulating pumps

Three pumps are present in the building: one for the heating circuit, one for the DHW production in the hot water storage tank and the recirculation one. All the pumps are of "DABPumps" brand, with different models.

Figure 2.14: Pumps of heating (left) and DHW (right) circuits

Since the system will be completely reformed and modified by the new devices that will be installed, new circulators will also be installed, all with on-board inverters, in order to guarantee the correct flow rate with low energy consumption. It will be possible to evaluate whether the current pumps, especially the one already equipped now with an inverter, can be reused, for example on the restaurant circuit.

2.2.2.3 DHW Boiler

The water heater for the production of domestic hot water is a tank of 500 litres of capacity with 2 coils, located in front of the gas boiler, which provides the technical hot water for DHW production. This hot water storage tank is of the "Fiorini Industries" brand, model "Smart2 500"

It is equipped with a highly rigid polyurethane foam as insulation, external PVC coating, a magnesium anode for protection against galvanic currents and an inspection flange for access during maintenance.

The main characteristics of the tank installed in Verzuolo are listed in the following table:

Fiorini Industries Smart2-500	M.U.	Value
Capacity	l	500
Max temperature of storage	°C	95
Max operating pressure of storage	bar	10
Max temperature on primary circuit	°C	110
Max operating pressure on primary circuit	bar	16
Energy label	--	C
Dimensions	cmxcmxcm	75x75x204
Weight	kg	215
Connections	inches	1"
DHW Flow rate for T_{DHW}= 45°C, T_{TAP}=10°C – T_{IN}=70°C/80°C/90°C	l/h	638/860/1007
Thermal power for T_{DHW}= 45°C, T_{TAP}=10°C – T_{IN}=70°C/80°C/90°C	kW	26/35/41
DHW Flow rate for T_{DHW}= 60°C, T_{TAP}=10°C – T_{IN}=70°C/80°C/90°C	l/h	309/481/584
Thermal power for T_{DHW}= 60°C, T_{TAP}=10°C – T_{IN}=70°C/80°C/90°C	kW	18/28/34
Heat exchanger surface	m^2	1.1+2

Fiorini Industries Smart2-500	M.U.	Value
Nominal flow on primary circuit	mc/h	3

Table 2.2: Main characteristics of the "Fiorini Industries Smart2-500" buffer tank

The set point temperature in which tank operate is set by BMS system: when the temperature drops below the set point conditions (with a dead band) the controller makes the gas boiler and the DHW pump start.

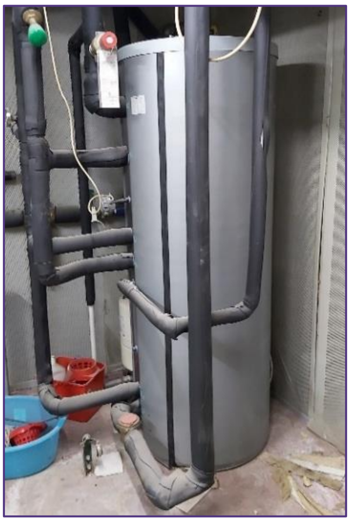


Figure 2.15: DHW Boiler

When HAPPENING solution will be implemented, domestic hot water production will be done by heat pump: this tank will not operate more, but it is possible to leave it inside the room, if there will be enough space, to act as back-up of the DHW system in case of failure of heat pumps, in order to guarantee supply for tenants.

2.2.2.4 Fan Coils

Each of the dwelling is equipped with a fan coil in each of the main rooms: two in the apartments on the first floor, three in the ones on the second floor.

The choice of fan coils as emitters, when renovations were done, have different reasons.

First, this kind of terminals ensures a rapid achievement of the desired set point temperature, thanks to the fan that moves and heats the air in the rooms quickly: we must not forget that the apartments were conceived with the function of a holiday home, so the accommodations could remain vacant for certain periods and then booked with little advance, so it was necessary to ensure fast and efficient heating.

Figure 2.16: Fan coils installed in the false ceiling (left) and on the floor wall (right) in Verzuolo

Second, the fan coils can be easily interfaced with a BMS system, as is the case for this building, managed by the housing controller via contactors. In this way the system is easily automated and activated / deactivated according to the temperature set point detected by the probes in the rooms. Unlike radiators, which are the most used terminals currently in Italian residential buildings, automatic control can take place more easily: in fact, valves electrically controlled by BMS can be installed in radiators, but with very different actuation and inertia times.

Finally, the fan coils also make it possible to cool the rooms: in the case of Verzuolo they were already set up for this function, for example by using suitable insulation for this purpose for the hydraulic connections.

The fan coils installed in this building are branded "Ecoflam" model "Brezza BI/BF 202", with different powers. Model “Brezza BI” refers to ceiling-mounted fan coils, while “Brezza BF” refers to fan coils mounted on the floor. The fan coils are hydraulically connected to the manifold of their own apartment by 3/4 "diameter multilayer pipes.

The main data are listed in the following table:

<table>
<tr><th>Ecoflam Brezza</th><th>M.U.</th><th>BI 202</th><th>BF 202</th></tr>
<tr><td>Max heating Power</td><td>kW</td><td colspan="2">2.6</td></tr>
<tr><td>Min heating Power</td><td>kW</td><td colspan="2">1.2</td></tr>
<tr><td>Max Cooling Power</td><td>kW</td><td colspan="2">1.3</td></tr>
<tr><td>Min Cooling Power</td><td>kW</td><td colspan="2">0.6</td></tr>
<tr><td>Max airflow</td><td>m^3/h</td><td colspan="2">280</td></tr>
<tr><td>Min airflow</td><td>m^3/h</td><td colspan="2">85</td></tr>
<tr><td>Water Flow Rate</td><td>l/h</td><td colspan="2">225</td></tr>
<tr><td>Pressure Drop</td><td>kPa</td><td colspan="2">6</td></tr>
<tr><td>Water content</td><td>l</td><td colspan="2">0.4</td></tr>
<tr><td>Power Consumption</td><td>W</td><td colspan="2">65</td></tr>
<tr><td>Max Absorbed Current</td><td>A</td><td colspan="2">0.29</td></tr>
<tr><td>Weight</td><td>kg</td><td>13</td><td>19</td></tr>
<tr><td>Dimensions</td><td>mmxmmxmm</td><td>355x505x225</td><td>720x529x230</td></tr>
</table>

Table 2.3: Main characteristics of the “Ecoflam Brezza” fan coils

With the aim of HAPPENING project, fan coils will be completely dismissed, because the new emitters in the room will be the micro-heat pumps with source represented by the neutral water circuit generated by the central air-to-water heat pumps in the boiler room.

The current presence of fan coil as emitters, however, is a good point for the implementation of the new system: in fact, in any room, where fan coils will be replaced by micro heat pumps, hydraulic connections, proper electrical connections and drainage pipes for summer cooling purpose are already present, therefore minimal interventions will be required inside the dwellings, reducing annoyances to the tenants.

In particular, with regard to the size and connections of the new equipment under design, they have already been preliminarily verified, in order to assess the possibility of installing the micro heat pumps, which will probably have slightly larger dimensions than the machines currently present. For the vertical wall-mounted fan coils, the presence of space on the sides was verified, while the width, length and depth of the false ceilings on the first floor were found to be adequate for the installation of even slightly larger machines inside. In this way, the HAPPENING solutions for heating and cooling can be correctly implemented, without affecting large spaces in the home.

Precisely in this regard, it should be noted instead that it was not possible to find an adequately large space in the rooms for the installation of a machine for the production of domestic hot water for a single apartment, powered by the neutral water circuit. In fact, for the installation of such a heat pump with integrated storage it is necessary to have a shaft or an unused wall inside each dwelling, which is not among those of Verzuolo, whose dimensions are already modest and all the space fully occupied by the tenants.

An alternative solution must therefore be found, which can guarantee the supply of DHW to all the tenants of the building, and which at the same time is produced by using as much as possible the renewable energy deriving from the photovoltaic system that will be installed.

2.2.2.5 Electric System

The electrical system in the building will be reused, with appropriate modifications and extensions, to power the new devices that will be installed as part of the HAPPENING project.

The current system is in fact compliant with current regulations, with all the required protection devices, moreover the power used on the distributor meter is already 50 kW, due to the power request that was made to allow the refrigeration unit to function, then never used, so it is not necessary to require an increase in power for the integration of the photovoltaic system and / or for the power supply of the central heat pumps.

Existing switchboards and switches can also be used inside the apartments; the electrical parameters of the micro heat pumps will have to be checked, in order to assess whether the size of the electrical cables supplying the fan coils today are of adequate section, or if they will need to be replaced, obviously using the same passages.

2.2.2.6 BMS System

With the renovation of the building in 2008, a first system for the automation of the systems had already been installed. This was branded "Trend Controls" and provided for a controller in each electrical panel, connected to its probes and relays, with the possibility of communication between the various control units located in the building on a LAN network using proprietary protocol.

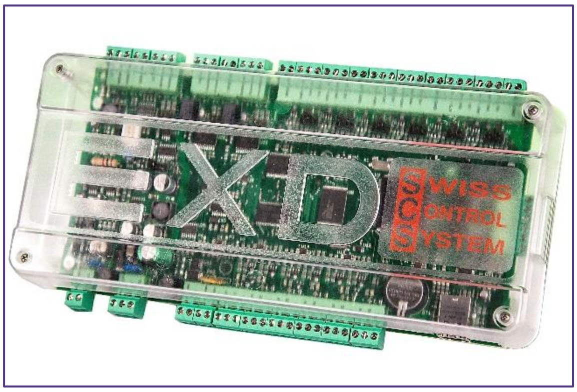
In order to allow communication between them (in addition to providing internet access to the tenants), a data network was implemented in the condominium, with firewall and central switch in the boiler room and PoE switch for each dwelling.

Recently, TECNOZENITH carried out a revamping of the entire BMS system present. A completely new system, branded Swiss Control System, was installed to replace the existing controllers.

This new system features significant improvements in performance and thermal system utilization. The new SCS EXD10 controllers feature a native BACnet interface, the open communication protocol developed by the American ASHRAE, which is becoming the most widely used standard in the building management system.

However, they are freely programmable, i.e. it is possible to overwrite the regulation strategy at any time, even remotely, from the TECNOZENITH server in Saluzzo, where it is also possible to view and modify the parameters via the internet connection of the Verzuolo building; it is also possible to expand the system by adding the EXD100 expansions (already present in the boiler room), which increases the number of possible controllable points.

SCS controllers can interface many protocols used in HVAC systems, such as the KNX, Modbus RTU, BACnet MS-TP or M-bus protocol. Currently, all the controllers installed communicate via Modbus with MID certified electrical meters, to know the consumption of the apartments and the heating system, as well as using the same protocol for interfacing the touch-screen sensor.



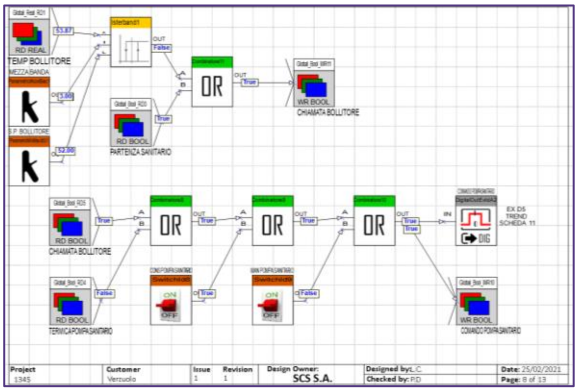


Figure 2.17: SCS EXD10 controller (left) and a page from strategy regulation of DHW system (right)

The BMS system of the Verzuolo condominium has a controller for each of the apartments, the controller of the centralized heating and DHW production systems, the controller for the restaurant rooms and the controller for the kitchen of the latter.

For instance, tenants can partially act on the BMS system, by choosing the internal set point of the dwellings, via touch screen sensors, acting on ± 1.5°C respect to the general set point temperature imposed by BMS.

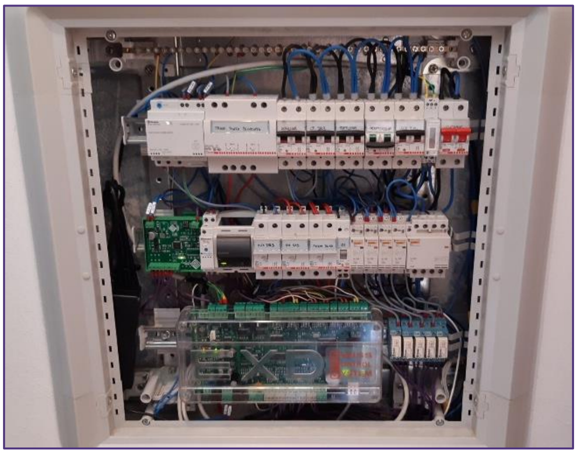



Figure 2.18: Interior of a switchboard of a dwelling (left) and a touch-screen sensor (right)

Being widely versatile and interfaceable, the BMS Swiss Control System can also be used once the solutions of the HAPPENING project have been implemented, modifying the regulation strategies (possibly creating ad hoc algorithms) and the controllers' communications, and eventually adding expansions, in order to integrate with the algorithms of the PLC systems of heat pumps and micro heat pumps.

3. Current energy demand

In this chapter, the characteristics of the building from the point of view of energy performance will be illustrated, analysing its energy demand after the renovation and energy requalification interventions of 2008, and comparing these data with the actual consumption measured for the building.

As already mentioned in the previous chapters, during the previous complete renovation of the building, the Italian legislation in force at that time was respected from the point of view of the energy performance to be obtained from the building, which was based on the law of 2006.

This means that the choice of the type and quantity of insulation installed, as well as the performance of the windows installed, have been sized in order to comply with the transmittance parameters in force at the time.

It will be useful to compare these calculated values with what is actually consumed in these years of use to view the discrepancies, to be able to explain them and to view the real primary energy consumption.

The primary source used for the heating equipment is natural gas, since, through the condensing boiler, this fossil energy vector is used for heating and the production of domestic hot water production, for the latter purpose, all year round. The apartments each have small LPG cylinders for the preparation of food from the gas stoves, which are periodically refilled, as well as the kitchen of the restaurant, which has its own dedicated gas line for the stoves, with a dedicated meter. This means that the amount of gas measured by the meter arriving at the boiler room is actually used only for heating and DHW purpose.

Electricity is used only to power the equipment in the thermal heating system and for the services of the dwellings, including the power supply of the fan coils, whose electrical consumption can be defined as irrelevant compared to the total primary energy used for heating. This is because the chiller for summer cooling never came into operation, which would have had a significant impact on the electricity consumption of the building.

3.1 Heating/cooling demand

The energy demand for heating and cooling of the building was calculated by TECNOZENITH by means of software for the dynamic energy simulation of the buildings. The software used for the calculation is Edilclima®. This Italian software, the first version of which was born in the 1990s, when energy audits for buildings were introduced by law in Italy, has over the years established itself as the main calculation engine among professionals in the sector in Italy. Within the software, through graphic input, it is possible to model the building, insert the characteristics of the envelope, systems and use, and perform dynamic simulations on its energy performance. Broadly speaking, it has a method of data entry very similar to Design Builder, a much more internationally known software. This type of software is widely used by TECNOZENITH, for the simulations on energy efficiency carried out by the company.

The geometric data and the characteristics of the envelope are entered as input data, together with the location and exposure, the type of systems present and the occupation of the dwellings.

The program returns as output the calculated heating and cooling needs of the building and the primary energy required by the building, in dynamic conditions throughout the year.

From the computation carried out, it appears that for the whole building, including the restaurant, of the Verzuolo demo case the overall energy demand for heating settles at 30,000 kWh, while the energy demand for cooling is 8,200 kWh. From this data, it is possible to obtain the value of primary energy that for the heating is intended as the gas consumed by the boiler adding the efficiency of the heating system in the calculation; instead for the cooling, since the refrigeration uses electricity, includes the efficiency of the electricity generation national mix, the distribution grid losses and the efficiency of the building cooling system. This leads to primary energy values of 35,000 for heating and 22,400 for cooling.

In the following chart, both primary energy for heating and cooling are reported, divided according to the share of every dwelling and the restaurant.

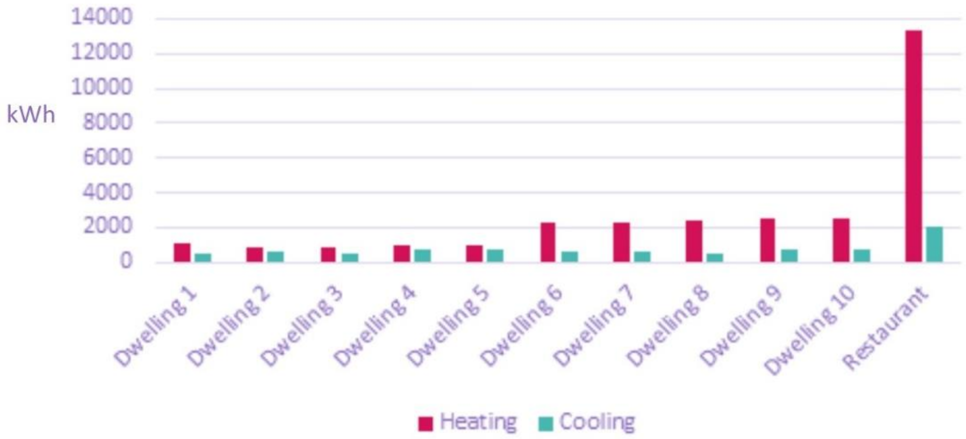


Figure 3.1: Share of calculated energy consumption divided by users of Verzuolo building

As can be seen from the graph, the largest share of primary energy is dedicated to the restaurant, both in cooling and, above all, in heating, due to the large size and lack of adequate insulation on the external walls. The difference is less visible in summer, as the thick stone walls and the location on the ground floor, with the southernmost part in fact underground, limit the restaurant's cooling demand.

However, the restaurant will be excluded from the redevelopment works within the HAPPENING project and will continue to use the old boiler and fan coil heating system.

With the data indicated above, the Verzuolo demo case building has a gross energy performance index of 85.77 kWh/m^2, classified in energy class C according to the energy performance certificate provided by the Piedmont Region. The energy performance index is a parameter used in the Italian legislation to evaluate the building and it is derived from the primary energy consumption for heating and DHW.

These data refer to the annual simulation of the systems, according to the default parameters set by the simulation software, with operating times and set points established by law for this type of building.

Since this system has been in operation for more than 10 years, it is possible to understand the real trend of consumption starting from the energy bills. As regards gas consumption, this chapter refers only to the portion of gas used for heating, while the portion for the production of domestic hot water has been separated and is dealt with in the following chapter.

On the other hand, an analysis in this sense is not possible with regard to summer cooling, since, as already mentioned, the chiller has never started working.

The data relating to the gas consumption of recent years by the entire building are reported below.

The following table shows the overall consumption of the building in recent years, which shows the share of domestic hot water and the portion relating to heating. This table summarizes the global data obtained from the gas bills.

	Heating [Sm³]	DHW [Sm³]	Total [Sm³]
2018	5060	2276	7336
2019	4260	2051	6311
2020	4611	1985	6596

Table 3.1: Overall Measured Gas Consumption

The consumption of natural gas for heating is indicated, monthly, in the graph below. The variation of the values between the different years, for the same reference month, is partly due to the habits of the tenants: in recent years different users have alternated in the various apartments; but, above all, to the external climatic conditions: as the average external temperature decreases it obviously corresponds to an increase in gas consumption, in order to internally maintain the desired set point conditions.

In particular, in the years taken into consideration as a reference, the degree days were: 2762 in 2018, 2644 in 2019 and 2615 in 2020. In these years, therefore, we have always remained below the standard Verzuolo degree days, calculated to 2834.

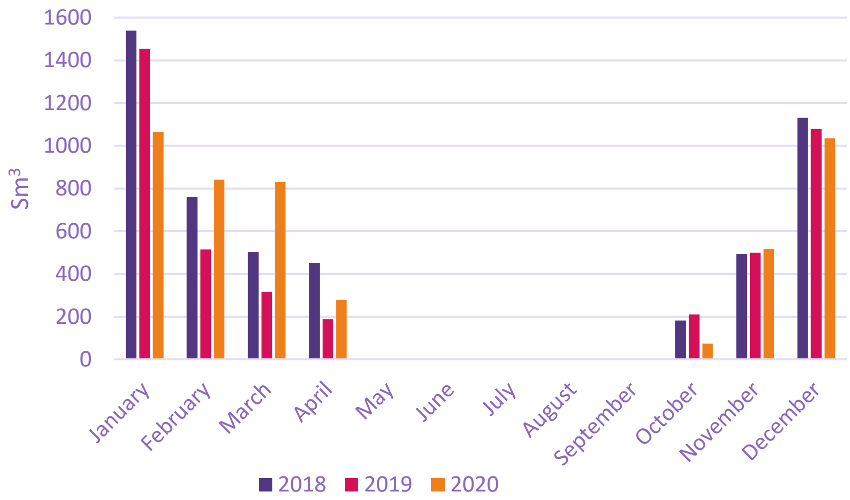


Figure 3.2:Monthly gas consumption for heating [Sm3]

Annual values are summarized in the following table:

	[Sm³]	[kWh]	Degree Days
2018	5,060	48,525	2,762
2019	4,260	40,853	2,644
2020	4,638	44,478	2,615

Table 3.2: Gas consumption for heating

By calculating the energy used for heating, derived from the cubic meters of gas used, it can be seen that the kWh used for this purpose are higher than the corresponding primary energy estimated in the computational calculation as a project requirement.

The explanation lies mainly in the functioning of the system and in the average habits of the tenants of the housing, which differ from what the software expects as standard.

First, the heating system has been kept in operation in recent years from 6 in the morning to 24 in the evening, in a longer time than the 14 hours per day scheduled. This operation has been adopted to ensure greater comfort inside the apartments and adapt to the different styles of the tenants, but also to meet the needs of the restaurant, with which the apartments share the heating circuit, which requires prolonged heating. in the evening, at dinner time.

Another variable to take into consideration is the fact that users can, through BMS, act on the internal setpoint to be maintained in the household: while the energy performance calculation software fixes the set point at 20 ° C (as required by law), they have all set a higher required temperature inside, of about 21 ° C, so that the energy required by the system increases.

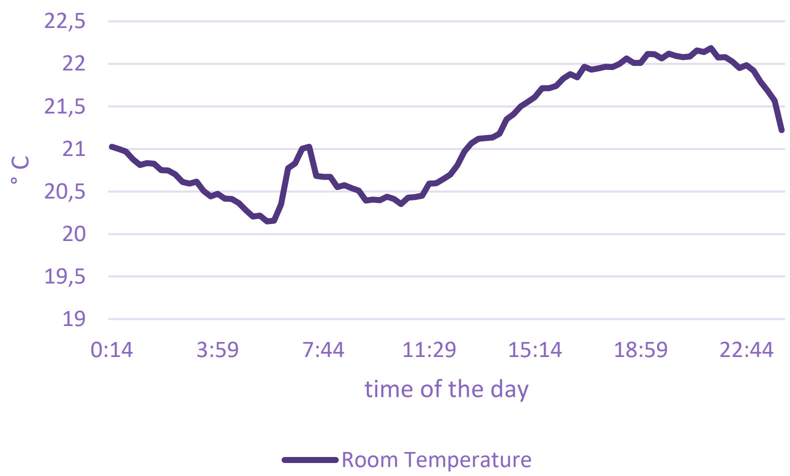


Figure 3.3: Average bedroom temperature in a dwelling on March 23rd March 2021

To prove the validity of these observations, a calculation of the same building was carried out on the simulation software, inserting however 21 °C as the internal set point temperature and the operation of the system with the real times: the result of this new computation results in 48,000 kWh of primary energy required for heating, which is very close to what is actually consumed in natural gas by the boiler during these years.

For the efficiency of the building included in the HAPPENING project it will be necessary to evaluate only the portion of energy necessary for the purposes of air conditioning the rooms of the dwellings, as the restaurant will continue to maintain the fan coil system powered by the existing boiler.

Therefore, the thermal energy requirements of the dwellings alone are shown below, already shown previously in Figure 3.1, which form the basis for the sizing of the systems.

	Heating Demand [kWh]	Cooling Demand [kWh]
Dwelling 1	1065	504

	Heating Demand [kWh]	Cooling Demand [kWh]
Dwelling 2	823	548
Dwelling 3	827	541
Dwelling 4	904	695
Dwelling 5	912	746
Dwelling 6	2229	618
Dwelling 7	2267	572
Dwelling 8	2415	538
Dwelling 9	2466	665
Dwelling 10	2502	775

Table 3.3: Share of calculated thermal energy demand divided by dwellings of Verzuolo Building

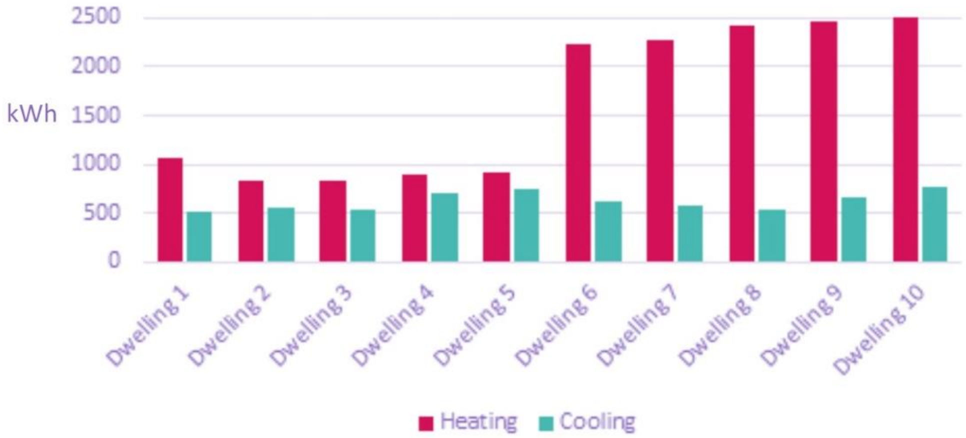


Figure 3.4: Share of calculated thermal energy demand divided by dwellings of Verzuolo Building

The total thermal energy demand of the **dwellings** settles at **16,000 kWh** (52 kWh/m^2), while the cooling demand is around **8,000 kWh** (26 kWh/m^2). These values correspond to a primary energy demand of 20,000 kWh and 21,000 kWh respectively. The thermal power peak for heating system of the dwelling is calculated in 19 kW, while it is possible to quantify the peak power for cooling in 10 kW.

3.2 DHW demand

The computational calculation of the energy demand required by the building through software also shows in output the primary energy demand for the production of domestic hot water: a centralized DHW similar to the real one has been parameterized. The result obtained was 9,400 kWh of energy required for DHW production.

From the results from the computation software is possible to see that the largest share of energy consumption for DHW production is used by the restaurant, with its great amount of hot water used for food preparation and washing.

The share part corresponding to the ten dwelling settles at **6,000 kWh**, corresponding to 19 kWh/m². The power required for the production of domestic hot water, to ensure that all residential users are served without inefficiencies even in the event of high simultaneous demand, is 30 kW.

The data of the real consumption of natural gas by the boiler for the production of DHW, obtained by extrapolating the values from the overall gas bills, are the following:

	[Sm³]	[kWh]
2018	2,276	21,827
2019	2,051	19,669
2020	1,985	19,036

Table 3.4: Yearly gas consumption [Sm3 & kWh] for DHW Production

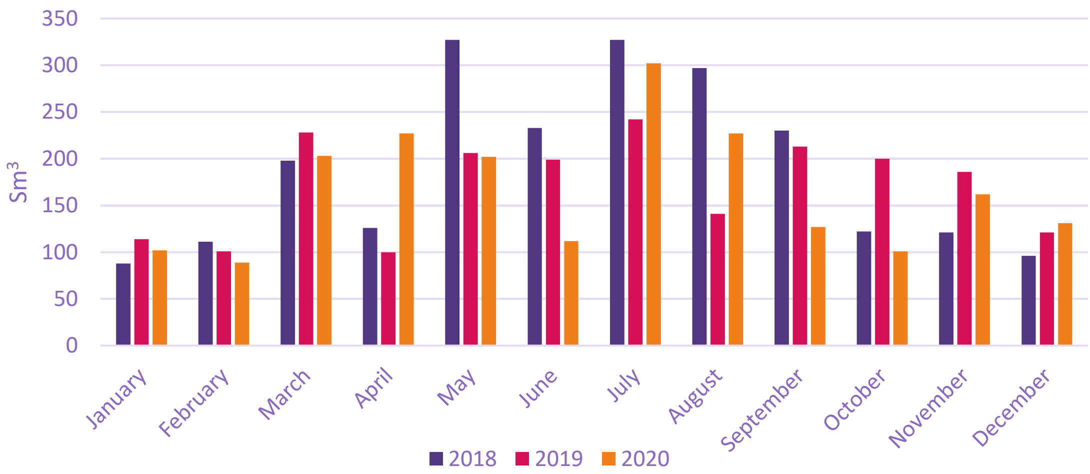


Figure 3.5: Monthly gas consumption [Sm³] for DHW Production

Even in this case, the gas boiler used for the DHW production is the same for restaurant and dwellings: without any meters installed, it is currently difficult to separate the two type of users. Therefore, considerations on computation results and gas bills can be done on the whole building consumption. The monthly consumption during the years shown in Figure 3.5 show a common average monthly trend over the years, with a greater use of domestic hot water during the summer months.

Even if the use of domestic hot water is less predictable than it can be for heating energy, depending much less on climatic conditions and more, instead, on the habits of users, it is still possible to explain the increase in consumption in months of May, June and July with a greater use by the restaurant, which works more in these months, and by the greater number of showers on average carried out during the summer period.

Actual consumption is greater than the demand calculated by the software, with an increase of about 25%, due in part to the discrepancy between the habits of use of domestic hot water programmed in the software algorithms and the effective use of all users of the building.

The biggest difference lies in the fact that the software cannot parameterize the system with heat storage for DHW production, so the hot water leaving the boiler is considered as directly used by the users, without considering the intermediate circuit with the boiler set with a higher set point, to ensure the correct temperature to be sent to the users.

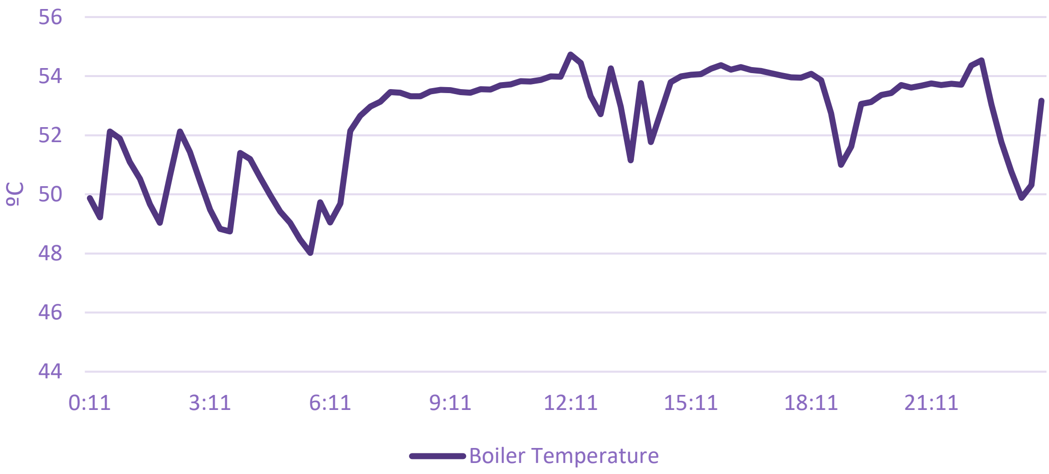


Figure 3.6: Boiler Temperature [ºC] variation on a day

The chart above shows the temperatures inside the puffer for DHW production during an average day, measured by the temperature probe inside it, connected to BMS system. The set point temperature to keep inside it during the day is set at 53°C, with a dead band of 1°C. Therefore, the gas boiler for DHW purpose has to produce water at a higher temperature respect to the normal supply DHW temperature (around 40°C-45°C). Once a week, during the night, the BMS system automatically brings the temperature set point of the storage tank to 65 °, keeping it for a quarter of an hour, and then resetting itself to the standard value. In this way the risk of legionella proliferation inside the tank is avoided.

It is possible to see the peaks of utilization of domestic hot water during lunch and in the evening, corresponding to a decrease of the inside temperature of the buffer tank.

3.3 Electric demand

The building has a single POD with its corresponding meter, which supplies electricity to all the dwellings. The restaurant has its own separate meter.

To divide the consumptions among the various users and to view any anomalous power peaks and the energy consumed, in each apartment there is an electricity meter installed immediately downstream of the main disconnector, inside the home switchboard. In the electrical panel of the central heating system (boiler room) there is also a meter, in this case three-phase, to count the electricity consumed for this purpose.

The overall electricity consumption of the building obtained from the building's electricity bills are shown in the following table.

Electricity Consumption	[kWh]
2016	19,925
2017	20,002
2018	21,143
2019	18,107

Electricity Consumption	[kWh]
2020	16,689

Table 3.5: Yearly electricity consumption [kWh] from bills

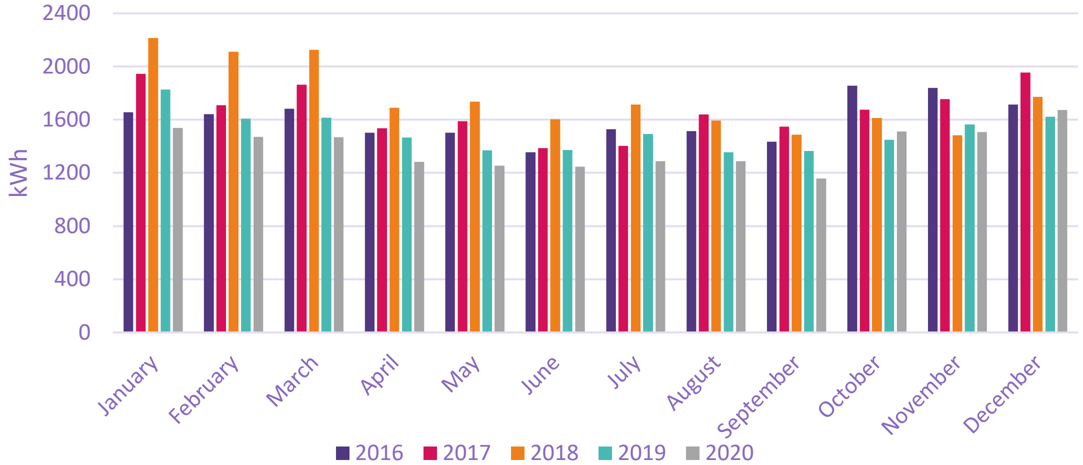


Figure 3.7: Monthly electricity consumption [kWh] from bill

During the year, consumption tends to drop in the summer months, due to a lower need for lighting, a lower consumption of the thermal system and a lower presence in the dwelling by the occupants, for the summer holidays.

In regard to the distribution of the consumption of the different uses, in an average winter month, the heating system consumes from 30% to 35% of the energy supplied to the distributor's POD, while the remainder is used by the 10 apartments. The greatest contributions to the consumption of the heating system derive from the boiler and electronic and non-electronic circulators. The peak power engaged is around 3.5 kW, considering that protections and wires of the switchboard are already sized for higher values, because of the presence of the chiller, never used.

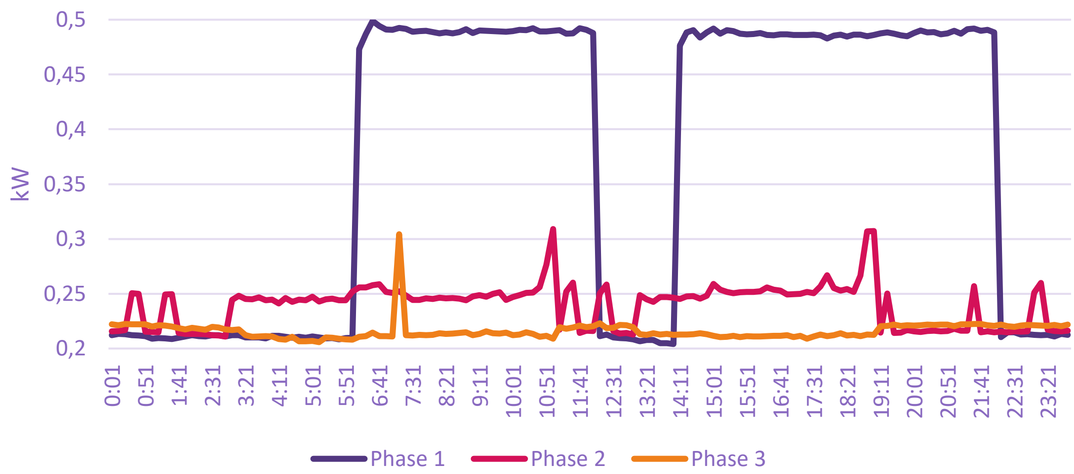


Figure 3.8: Electric Power [kW] on three phases used in the Gas Boiler Room

The remaining electricity taken from the grid but not consumed in the boiler room is used by dwellings: the contribution of each user in February 2021 is shown in the following graph. This is to be understood as purely indicative and representative only of the current situation, as consumption between the apartments varies according to the different seasonal habits of the occupants and the renters themselves, which can change over time.

Inside the apartments, the greatest electricity consumption concerns the use of washing machines and, occasionally, hairdryers and kettles, while a lower share concerns lighting and fan coil systems and air extractors from the bathrooms. The peak power for each dwelling is around 2.5 kW on average however, rarely reached by users and with a low contemporaneity factor.

The general structure of the electric system will be maintained also after HAPPENING solution implementation: when new appliances will be installed, an update of the original electrical project will be carried out, verifying size and protection currently present and foreseeing for new ones, to integrate properly the heat pumps, for instance, and the new PV system.

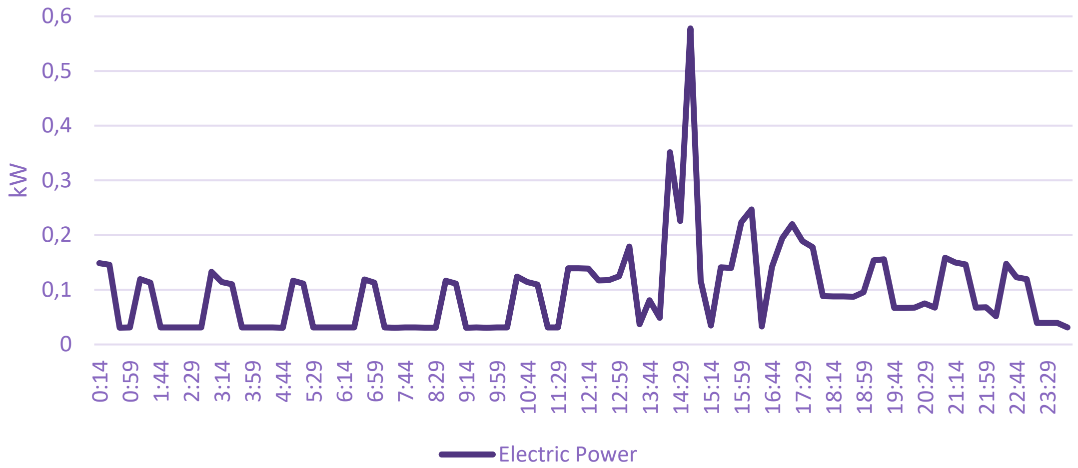


Figure 3.9: Average electric power [kW] profile used in a single day for a dwelling

4. User requirements

The evaluation and choice for the installation of the new technological solutions developed as part of the HAPPENING project for the Demo Case Building in Verzuolo cannot be separated from a comparison with the current residents of the apartments.

In fact, they will be the end users, those who will interface most with their HVAC system that will be installed, who will be able to report any inefficiencies and who will be able to provide appropriate feedback for everything regarding the new systems, from the internal comfort obtained, both in summer and winter, to the ease of interfacing and management to the noise level of the equipment.

To the advantage of the study of the conditions of the post-efficiency building is the fact that the users are quite diversified both by age group and by way of living the building, as better explained in the following chapter, so their requests and considerations can represent observations that come from points of view that are also very different from each other.

The condominium administrator, who is also the co-owner of the Demo Site building in Verzuolo, carried out investigations to understand the needs of the tenants and understand their wishes, with a view to renewing the systems.

4.1 Type of residents

The ownership of the Demo Case di Verzuolo building is private, owned by the Delgrosso family. The partner TECNOZENITH operates as a global manager of everything concerning the building, including ordinary and extraordinary maintenance. Residents inside the dwellings are renters.

Since the different apartments are very small, they have never been rented by families with children, as there are no bedrooms other than the unique double bedroom.

The configuration of the dwellings, on the other hand, has favoured other types of clientele as tenants, who prefer small apartments but with great services like those of the Verzuolo building.

Among the tenants who have alternated over the years, the largest share is represented by young single workers, both male and female. The apartments were chosen as the first home to go and live alone, due to their good quality and low running costs.

This type of user, in addition to being more attentive to environmental and energy issues, will probably be the one who will most use the new devices in the field and who will want to verify the effectiveness of the interventions carried out, perhaps through control synoptics, having more familiarity with apps and sites web.

Currently the category of young workers (in the age group between 24 and 35 years) represents the largest share of residents, and within it we find differences in qualifications and type of work performed. Other categories of people currently residing in the building are couples of different working ages, without children.

During the past years, the building has also been frequently inhabited by retirees, while it has never been inhabited by students, as Verzuolo is not a university town.

4.2 The Specific demands and received feedback

In order to illustrate the work that will be undertaken in the building, which includes all the implementation of the technologies and solutions developed in the HAPPENING project, but also to understand the needs regarding the air conditioning systems, the owners, with TECNOZENITH technicians met all the current renters.

The meetings were held individually for each tenant, both so that they were less restricted to express themselves freely, and not to create a gathering with a sort of assembly, to limit possible infections from Covid-19.

The wishes, doubts, advices, and proposals received are summarized below:

- The users were very satisfied with the possibility of being able to take advantage of a future summer air conditioning system, which may not impact on the current costs paid for the services. This verdict was unanimous, especially supported by the tenants with bedroom facing south.
- Regarding winter air conditioning, they declared that they consider the current system adequate for maintaining pleasant internal conditions, but they say they are in favour of replacing fan coils with micro heat pumps, above all for the advantage of summer air conditioning.
- The concern that arose most among the tenants was the impact of the works on the building and on their homes. They asked for clarification on the timing of construction works when they will begin. TECNOZENITH illustrated the work to be carried out in detail, indicating the installation of the photovoltaic system, for which it will be evaluated even without the installation of scaffolding, if possible, and assured that most of the work will be carried out in the heating system, with little trouble for the households. With regard to the installations of micro heat pumps, it was explained that the interventions will be minimal, limited to the replacement of the internal machines and the installation of a few devices, considering to be able to complete the intervention in a single day for each household, being TECNOZENITH a company used to install appliances of this kind.
- Regarding micro heat pumps, many tenants immediately asked about the size and number of machines to be installed inside the buildings and were very concerned about having areas of the house occupied by rooms or technical appliances for this purpose. This question comes in particular from all the tenants on the first floor, the smallest in size, showing the shortage of space already present at present for their furnishings. TECNOZENITH explained that as far as the micro heat pumps are concerned, they will have almost the size of the fan coils currently installed.
- Some tenants, once they described the general configuration that the building's new HVAC system will have, expressed the desire, if possible, not to install heat pumps in the condominium courtyard, which could steal parking space. Another issue that arose was the noise of the heat pumps themselves, which worried above all about possible nuisances during the night. To these questions, TECNOZENITH has responded by indicating that it is already evaluating an alternative

to the courtyard for heat pumps, being this, moreover, shared with another property and another building. As for the noise, the acoustic impact would have been evaluated once the heat pumps were installed, already low from the datasheet, and if outside the limits, suitable interventions for acoustic insulation will be carried out.

- Some tenants said they hope that the new systems will be effective and easy to use and have asked whether the presence of photovoltaics to power the heat pumps would lead to a reduction in the costs of operating the system in the future. The owner has clarified that the amount of energy carriers arriving from the outside will significantly decrease and that a lowering of energy costs will be very likely, but the impact will only be assessable when the system is operating.

In summary, the tenants have proved to be well disposed to the interventions to be carried out, without anyone taking a contrary position. In particular, they were very attracted by the future presence of summer air conditioning, while the main concerns shown were on construction times and on the spaces occupied inside the buildings.

5. Conclusions

In summary, the Italian Demo Case is a historic building located in Verzuolo that underwent retrofitting interventions in the last years. The building has a single private owner, with the apartments now being rented with a lease.

Apart from the dwellings there is also a restaurant on the ground level of the building, which is out of the scope of the project. Therefore, it is generally left out of this study, although in some cases it was not possible to fully disaggregate it as some systems deal simultaneously with both the dwellings and restaurant.

The climate of Verzuolo is temperate, characterized by hot and humid summers and rigid winters, in which the minimum temperature often drops below 0 °C. According to the Koppen-Geiger climate classification, Verzuolo falls within the Cfa category. Precipitation occur all year round, but with prevalence in the spring and autumn season, while snowfalls are frequent in winter.

Therefore, the buildings in the area must be equipped with a robust heating system that can operate properly even with very rigid external conditions: the design temperature of the heating systems typically settles at -8°C.

The building has a centralized heating and DHW production system, with a common distribution hydraulic system. The heat generator is a condensing natural gas boiler, which is located in a common boiler room together with auxiliary equipment such as circulating pumps or a DHW buffer tank. The emitters in the dwellings are fan coils installed either in the false-ceiling or wall-mounted. A BMS system is also available, which controls the different heating equipment.

Regarding the electric system, the building has a single point of delivery (POD). Then, each dwelling has its own electrical panel with disconnectors, contactors and protection switches. In these panels, there is also a controller of the BMS system integrating sensors, acting on devices and interfacing the electric meters present.

Regarding the energy demand required for the future system design, an analysis for the dwellings has been performed using the Italian software Edilclima, so the necessary energy for heating, cooling and DHW are estimated. The results are 16,000 kWh (52 kWh/m^2) for heating, 8,000 kWh (26 kWh/m^2) for cooling and 6,000 kWh (19 kWh/m^2) for DHW. The values obtained confronted to the actual energy consumption for heating, deducted from the gas bills, are a little underestimated due to the different temperature set points between the dwellings and the Italian standards. For the DHW energy, the impossibility to distinguish between the water destined to the restaurant and the water destined to the dwellings derives on the impossibility to have precise feedback about the accuracy of the software predictions.

As for the type of residents, in Verzuolo Demo Case Building the largest share is represented by young single workers, both male and female. The apartments were chosen as the first home to rent and live alone, due to their good quality and low running costs. Due to space issues all the inhabitants are without children.

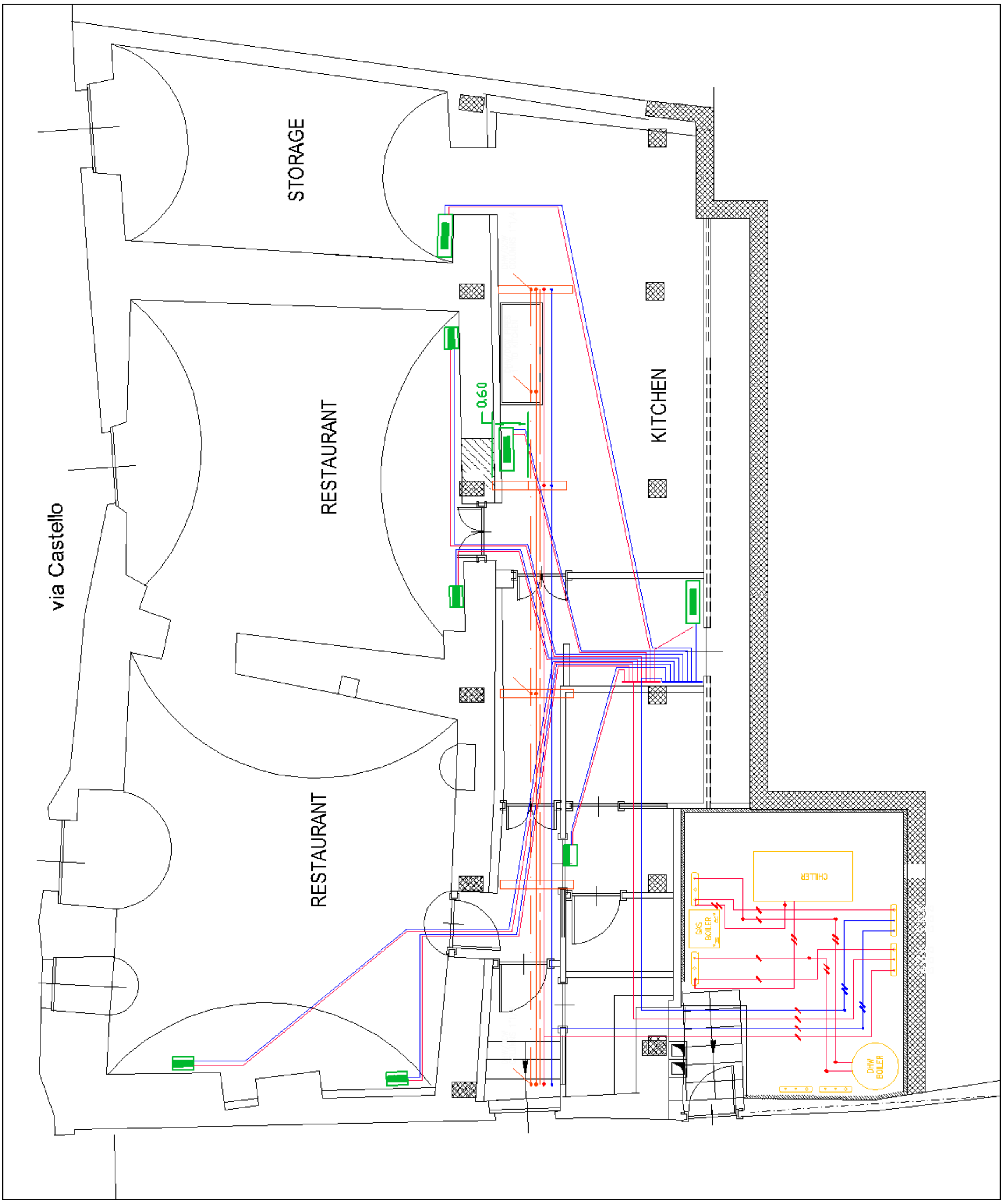
There have been meetings with the tenants to assess the current conditions and present the new system. When doing so, all the feedback has been positive regarding the installation of a cooling system. There were just some concerns about the space occupation of the new units and the possible noise from the heat pumps.

Annexes

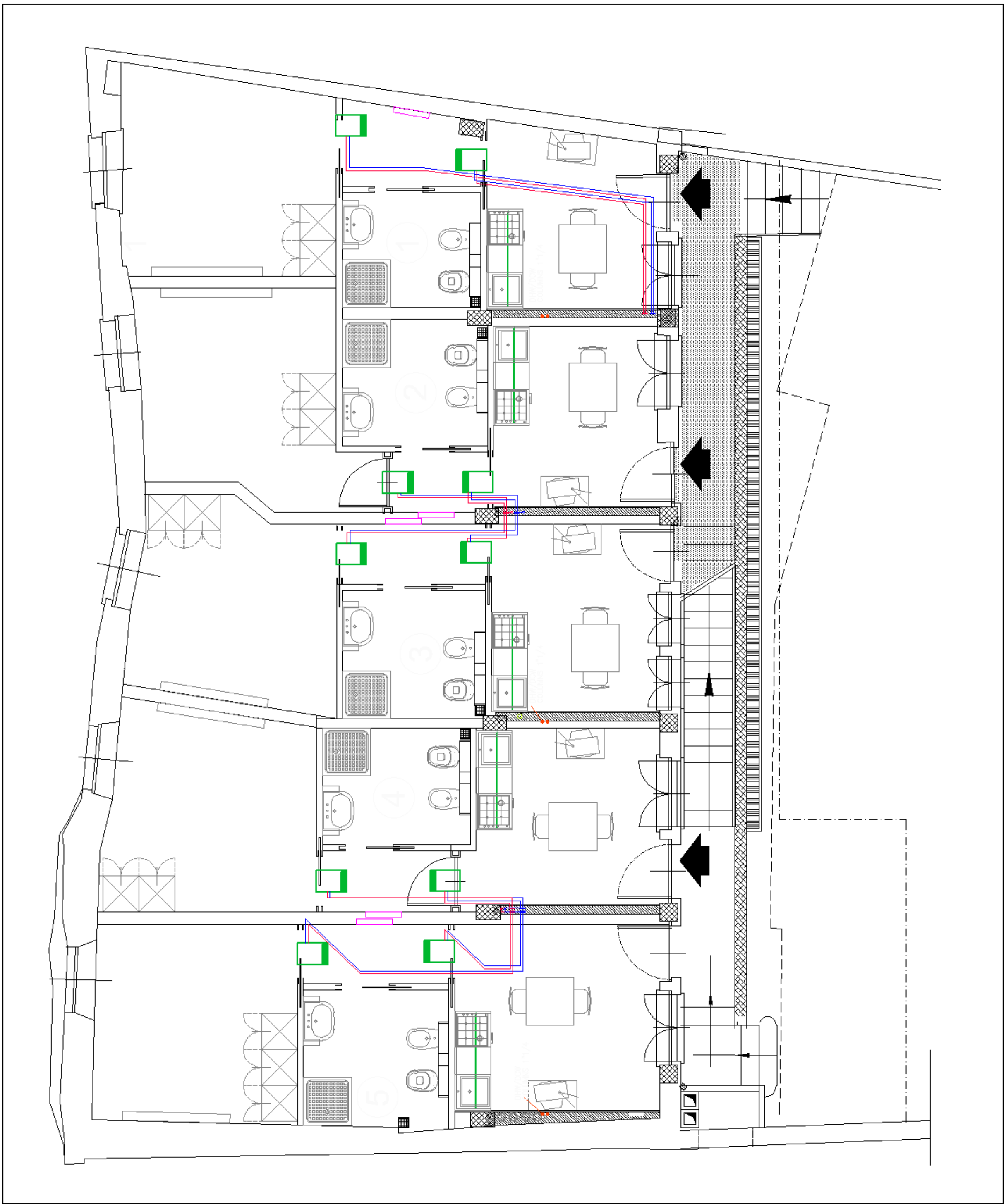
Annex 1: References

- TECNOZENITH archives and data (own data)
- Verzuolo municipality website. Available in: www.comune.verzuolo.cn.it
- Charts by weather data from the website: www.ilmeteo.it

Annex 2: Ground floor project plan with indication of HVAC systems

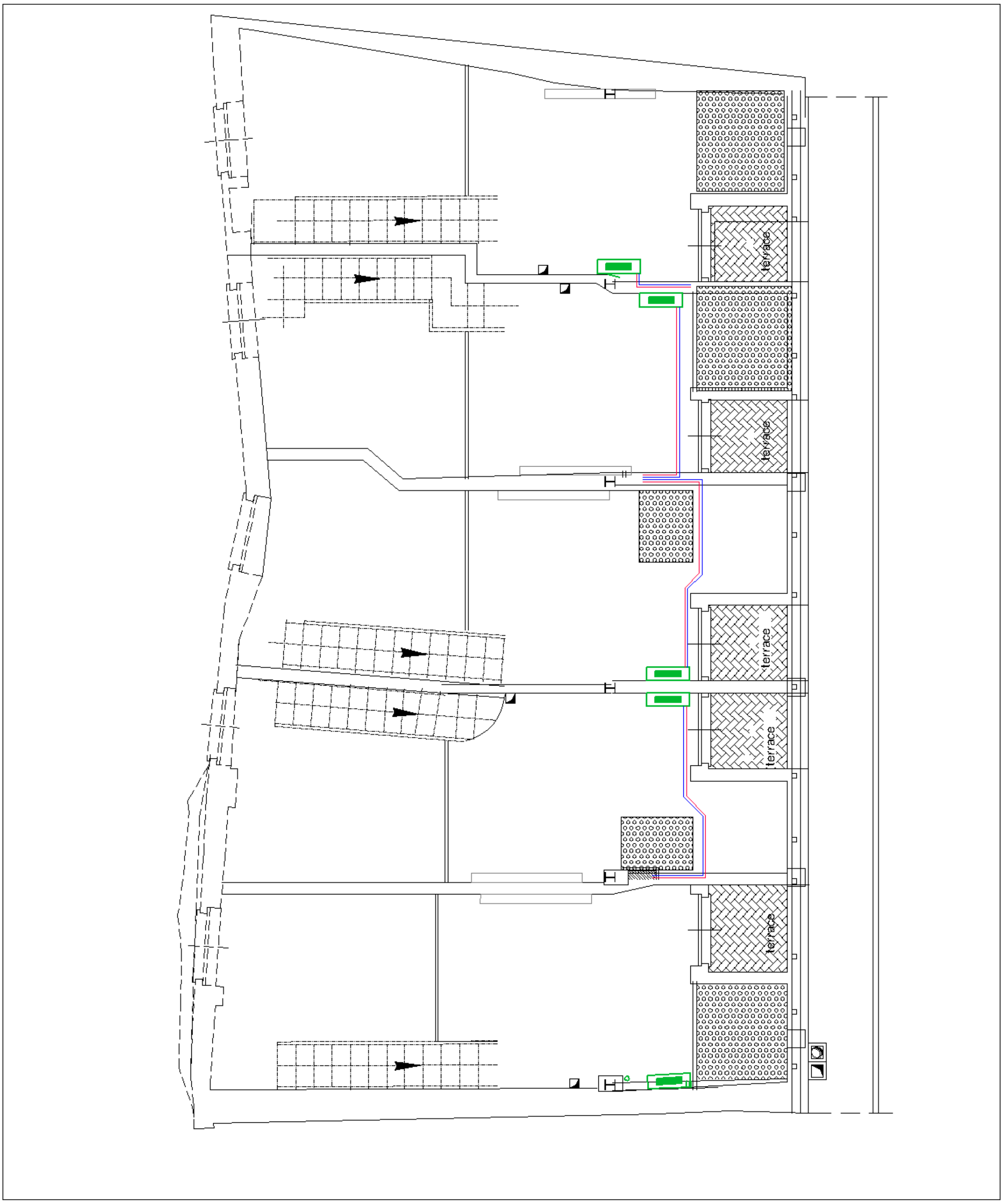


Annex 3: First floor project plan with indication of HVAC systems

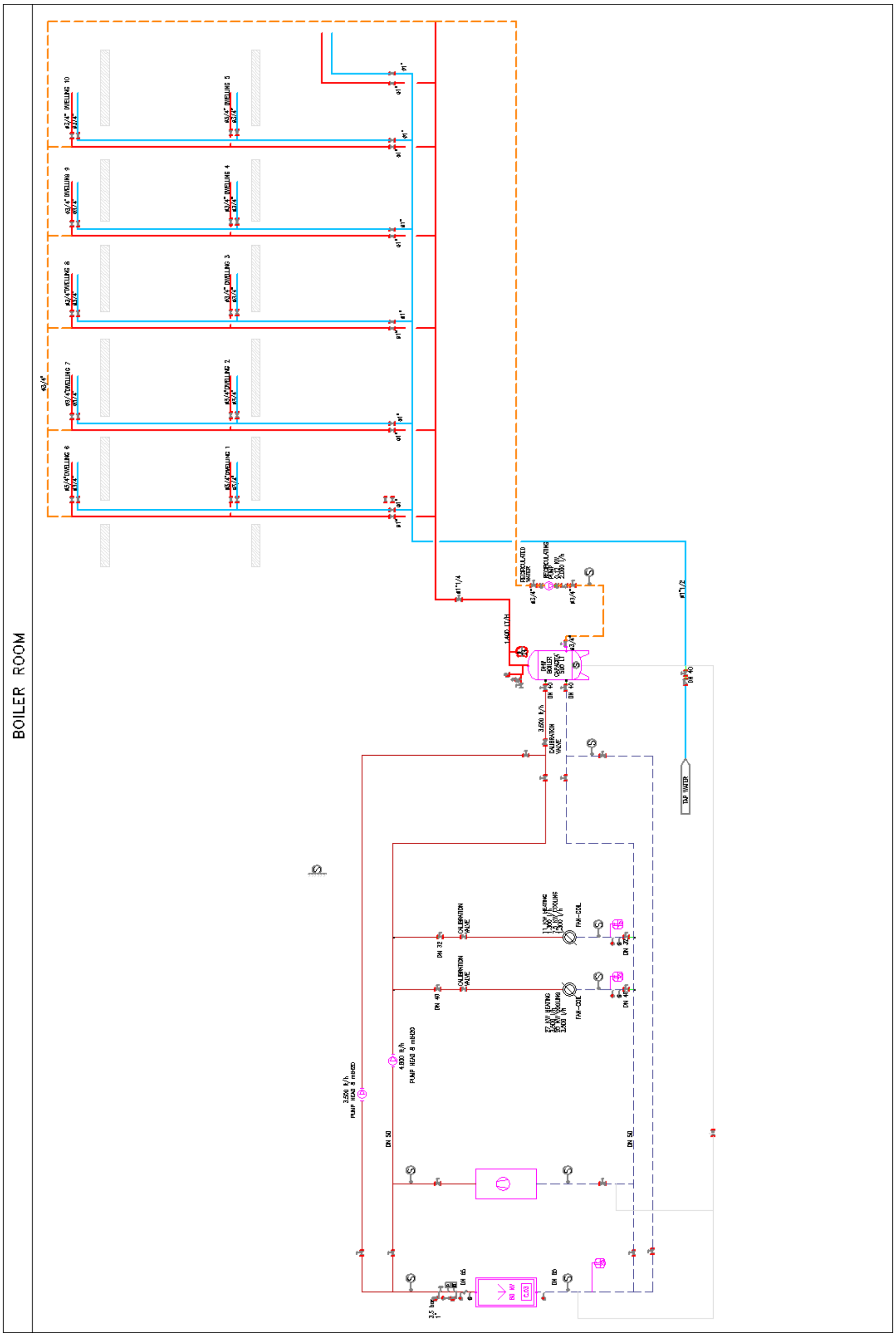


Annex 4: Second floor project plan with indication of HVAC systems

Annex 5: Mezzanine project plan with indication of HVAC systems



Annex 6: Current Hydraulic Scheme

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