RepliCable and InnovaTive
Future Efficient Districts and cities

D4.4: Implementation plan of the Spanish demonstrator

WP 4 , T 4.2

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[1] PU = Public

PP = Restricted to other programme participants (including the Commission Services)

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Versions

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Abbreviations and Acronyms

BEMS	Building Energy Management System
CHP	Combined Heat and Power
DEMS	District Energy Management System
DH	District Heating
DHW	Domestic Hot Water
EPS	Expanded Polystyrene
ESCO	Energy Service Company
ETICS	Exterior Thermal Insulation System
HEMS	Home Energy Management System
ICT	Information and Communications Technology
LPG	Liquefied petroleum gas
RITE	Regulation of thermal installations in buildings
ICIO	Tax on Construction, Installation and Works

0 Abstract

The aim of the implementation plan of the Spanish demo site is to accomplish the CITyFiED project objectives, that are the reduction of the energy demand and the greenhouse gas emissions and to increase the use of renewable energy sources. The definition of the implementation plan for the Spanish demonstrator will be made taking into account the following aspects:

- **Technical definition of the Spanish demo site:** A brief summary of the residential district of Torrelago will be made, where the buildings that form the residential district, the construction elements of the buildings and the system by which thermal energy is provided to these buildings will be defined.
- **Building retrofitting technical solutions:** The façade retrofitting renovation strategy will be defined to obtain a reduction in the thermal energy demand because of the implementation of an ETICS solution and taking into account the observance of the Spanish technical building code.
- **District heating system renovation strategies:** It will be held the description district heating system renovation strategies. The description of the new heating network, the individual thermal comfort control, the installation of a CHP system and the Building Management System will be defined
- **Smart grid interventions and ICT:** CITyFiED platform formed by ICT technologies for grid management solutions that will interconnect and manage all the devices and intelligent systems will be defined
- **Private procurement processes:** The acceptance of the CITyFiED project has been evaluated by the distribution of a questionnaire between the neighbours of Torrelago. it is also necessary to meet a number of licenses relating the different points of the project
- **Planning:** It will proceed to the definition of planning chosen for the implementation of the project.

1 Introduction

The objective of this deliverable is to define and develop the implementation plan of the complete renovation for the Spanish demo. This renovation has considered the technical definition of the Spanish demo and the implementation plan includes technical solutions and specifications of the retrofitting process. The implementation plan also includes private procurement processes, from selection of equipment and installers to requests of licenses and permits. Finally the implementation plan has a planning that includes owner's commitments and manufacture and installation times.

1.1 Relationship with other WPs

Deliverable	Task	Relation
D4.1	T4.1	Technical definition of the Spanish demo.
D2.1	T2.1	Retrofitting solution of building envelope.
D2.7	T2.2	CHP solution for thermal and electrical production.
D2.16	T2.3	Report on technologies for steering the buildings energy demand and minimizing peak loads in the district heating system.
D2.18	T2.3	Definition of renewable systems for district heating.
D2.26	T2.3	Report on eliminating of disadvantages of conventional distribution systems.
D2.27	T2.3	Report on new efficient heating and cooling systems to improve the efficiency of energy generation systems.

Table 1.1: Relationship with other WPs

1.2 Contribution from partners

Partner	Contributions
CAR	Technical definition of the Spanish demo site. End-users acceptance and end-users' commitments. Deliverable coordination.
DAL	Sections concerning district heating and electricity generation. Deliverable coordination.
MON	Sections concerning smart grid interventions Energy demand prediction using simulation model, expected heating and electric demands.
3IA	Sections concerning the building retrofitting.

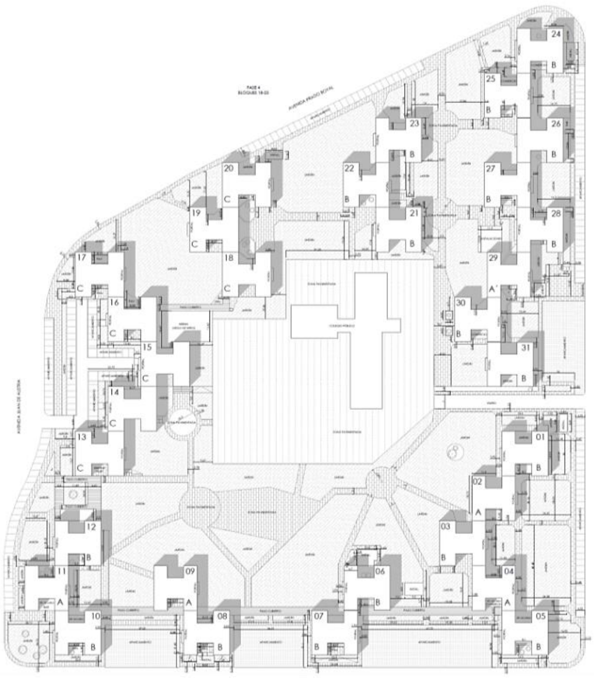
Table 1.2: Contributions from partners

2 Technical definition of the Spanish demo site

The objective of this section is to summarize the information from D4.1 "Technical definition of the Spanish demo Site (Laguna de Duero, Valladolid, Spain)" [1] in order to establish the current situation and starting conditions of the demo site.

2.1 Description of the district

Torrelago is a residential district located in Laguna de Duero, near Valladolid, formed by 31 buildings that respond to three different typologies, A, B and C, containing a total 1,488 dwelling where more than 4,000 residents live. The district was constructed around 1980 and is divided in two administrative phases: Community of Owners of Phase I is formed by 12 blocks (1 to 12) and Community of Owners of Phase II is formed by 19 blocks (13 to 31).



Block A

(2, 4, 9, 11, 29)

Block B

(1, 3, 5,6, 7, 8, 10, 12, 21, 22, 23, 24, 25, 26, 27, 28, 30, 31)

Block C

(13, 14, 15, 16, 17, 18, 19, 20).

Figure 2.1: Site plan of Torrelago district buildings and classification by building type

The district is also characterized by its high construction density (198.4 dwellings/ha) and high population density (514.4 inh/ha) in relation to the other parts of the town.

The group of buildings of the Spanish demo site represents the idea of the district because of their spatial organization, with a common convergence to green and public space areas, and their strong similarities on design and construction elements. The central space of the area is occupied by a school, although this does not belong to the district and is not subject to the CITyFiED project.

Figure 2.2: Aerial view of Torrelago district

2.2 Buildings description

Torrelago district is a homogeneous residential area made of medium constructive quality buildings built around 1980 that are nowadays in a progressive ageing. The district is formed by 31 buildings that respond to three different typologies, A, B and C, containing a total 1,488 dwellings.

Figure 2.3: Block type A

Figure 2.4: Block type B

Figure 2.5: Block type C

All the blocks are H shaped, and their dimmensions presents little variations depending on the typology.

The conditioned area in Laguna de Duero demo site has been defined according to Spanish Technical Building Code [2], Energy Saving Document (CTE-HE1). It is important to note that the conditioned area of Torrelago district reaches the amount of 143,025.36 m^2. The following table contains different area messurements:

Building type	Conditioned Area [m^2]	Number of buildings	Total C.A. [m^2]
Type A block	4,228.08	5	21,140.40
Type B block	4,579.92	18	82,438.56
Type C block	4,930.80	8	39,446.40
TOTAL TORRELAGO	**-**	**31**	**143,025.36**

Table 2.1: Useful, built and conditioned area in Torrelago district

Building plans

Every type A and B building has ground plus twelve floor levels, occupied by an entrance hall and a total of 48 dwellings with a surface of about 80 m^{2}or 95 m^2 .

Figure 2.6: Block type A plans

Figure 2.7: Block type B plans

Type C buildings have also ground plus twelve floor levels, occupied by an entrance hall and a total of 48 dwellings with a surface of about 95 m^2 each one.

Figure 2.8: Block type C plans

Dwellings are in private ownership and each one usually belongs to a family. Therefore, the buildings are multi-property and multifamily. Moreover, there is a Community of Owners among all the dwelling owners of each building (for managing the common parts of the building) and another two bigger associations, among all buildings in Phase I (blocks 1 to 12) and among all buildings in Phase II (blocks 13 to 31).

Constructive elements

All blocks were built up following the same constructive systems. Their foundation consists of single and continuous concrete footings, and they have a reinforced concrete structure system. The façade is made of brick cavity walls without insulation layer (12 cm ceramic brick + 5 cm air chamber + 7 cm ceramic brick + 1.5 cm gypsum plaster) and presents numerous pathologies, such as thermal bridges, fissures due to thermal expansion, fissures along the expansion joints or air infiltration through the facade.

In A and B blocks, the surface of kitchens and clotheslines is covered by a 8 cm ceramic lattice that the majority of residents have broken to place a window, after adding to the kitchen the space of the balcony. These works have changed the appearance of the building and the uniformity of the façade. In C blocks only the surface of clotheslines is covered by the 8 cm ceramic lattice that any resident has broken, so the appearance of the building and the uniformity of the façade have not changed.

The original windows are single glazed metal-framed windows, nevertheless, many residents have installed a second window outside the original one, in order to reduce heat losses. The partition walls are made of a single layer of brick.

Finally, the roof system consists of a asbestos cement pitched roof without insulation layer.

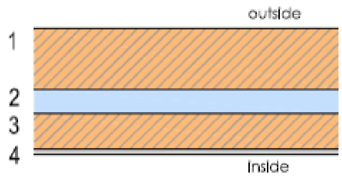
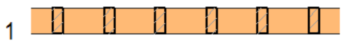
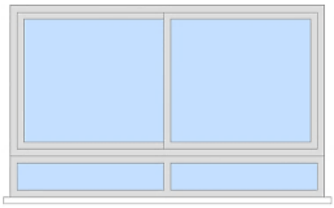
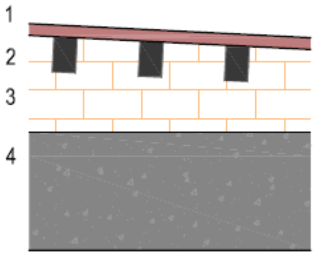
Element	Detail	Picture
Brick cavity wall 1. Ceramic brick wall of 12 cm 2. Air chamber of 5 cm 3. Ceramic brick wall of 7 cm 4. Gypsum plaster of 1.5 cm		
Ceramic lattice 1. Ceramic lattice of 10 cm		
Window 1. Single glazed aluminum window		
Roof 1. Asbestos cement (Uralita roofing) sheets 2. Wooden strips 5 x 7.5 cm. 3. Brick wall partition 4. Reinforced concrete slab of 25 cm		

Table 2.2: Construction element details

Thermal caracterization of the building constructive elements leads to the following transmittance values:

	Construction elements				Windows	
	External wall	Roof	Slab	Partition	Frame	Glass
U-value	1.36 W/m^{2}C	0.82W/m^{2}C	1.70 W/m^{2}C	1.64 W/m^{2}C	3.8 W/m^{2}C	3.7 W/m^{2}C
Solar factor						0.76

Table 2.3: U-values of the Torrelago district constructive elements

Pathologies in the façades

The main building problems are found in thier façades, that where built whitout any insulation layer, have suffered from some previous interventions and nowadays present several pathologies. However, the facade is who gives a homogeneous image to the group of 31 buildings.

All buildings were built between late 70s and early 80s, and during this period of more than 30 years, blocks have been remodeled inside, while keeping the original dimensions and composition of windows.

As said before, façades consist of two brick sheets with air chamber (12 cm ceramic brick + 5 cm air chamber + 7 cm ceramic brick + 1.5 cm gypsum plaster) and, in some areas, there is a 8 cm ceramic lattice. The façades of buildings show the next pathologies and previous interventions:

- **Thermal bridges in joint between façade and slab**, indicated by condensations produced in these joint lines.

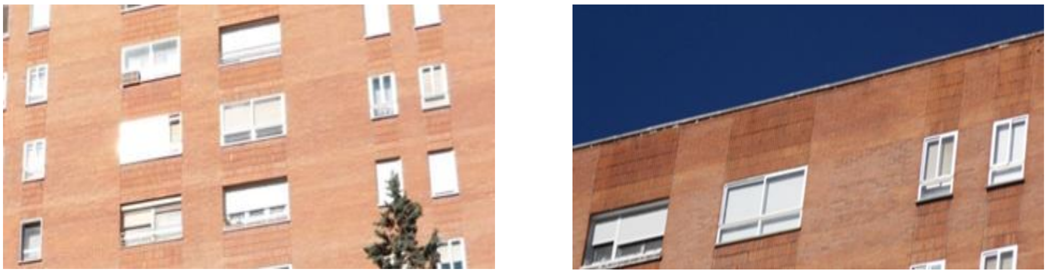


Figure 2.9: Thermal bridges in joint between façade an slab

- **Fissures in façade and expansion joints**, due to excessive thermal expansion.

Figure 2.10: Fissures in façade and expansion joints

- **Buckling of the façade**, some façade areas are not perfectly kept in its plane and have small bulges.

Figure 2.11: Buckling of the façade

- **Efflorescence on the bricks**, due to condensation problems.

Figure 2.12: Efflorescence on the bricks

- **Reinforcement in the bottom of façade with steel profile**, to prevent detachment of bricks.

Figure 2.13: Reinforcement in the bottom of façade with steel profile

- **Lattice breakage in blocks type A and B,** due to works made by residents to place a window after adding to the kitchen the space of the balcony.

Figure 2.14: Lattice breakage in blocks type A and B

2.3 Energy system description

Before the intervention, the energy system of the district is composed by two independent gas-fired boiler rooms. These two District Heating systems (in the future DH) provide thermal energy for each of the districts Phases: District Heating 1 (in the future DH1) provides energy for 12 blocks in Phase I; and District Heating 2 (in the future DH2) supplies energy for 19 buildings of Phase II.

Figure 2.15: DH1 and DH2 areas of energy distribution

The following schemes show the location of the two natural gas boilers, represented with a flame, and the distribution pipes, represented with red lines.

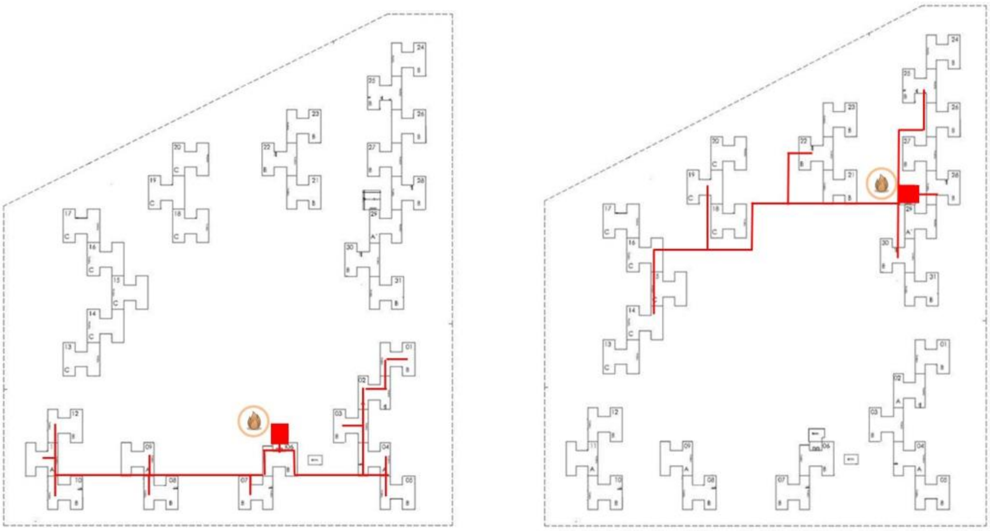


Figure 2.16: DH1 and DH2 location schemes

The individual thermal demand of each dwelling is not taken into account. Users can only control the temperature by closing the radiator valve. Moreover, the typical problems of most centralized systems that do not have individual control of thermal demand exist. For example, dwellings in the intermediate floors are overheated, whereas the higher floors hardly reach the comfort temperature conditions.

District Heating 1

District Heating 1 was composed by two gas-fired boilers with a total capacity of 5,938kW (working at a 70% of its theoretical capacity due to its state), two heat recovery systems, four pumps with fixed flow with five storage tanks of 5,000 litres installed in the return of the circuit, two tanks and two pumps with fixed flow for the DHW. The following diagram shows the boiler room of DH1, as well as the different elements mentioned.

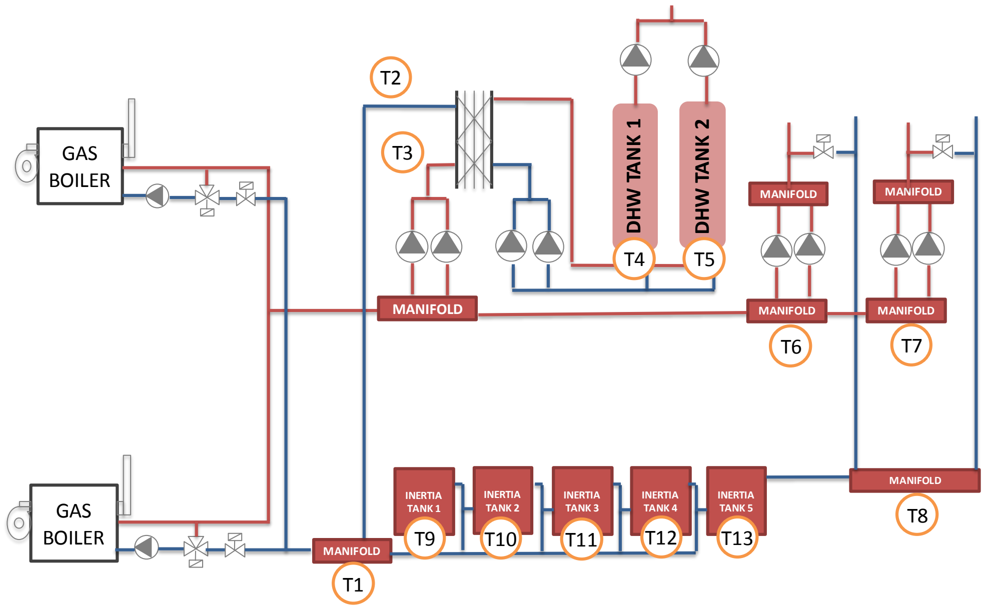


Figure 2.17: DH1 boiler room scheme

- **Boiler room:** The boiler room of DH1 was located near to the building number 6 and contained two gas boilers of 2,672 kW and 3,266 kW. Each boiler has a heat recovery gases exhaust system. The main features of the heat generation system are shown in the table below.

DH1 Boiler 1	DH1 Boiler 2
Model: YGNIS WA2000	Model: YGNIS WA2000
Gas burner: MONARCH WEISHAUPT	Gas burner: MONARCH WEISHAUPT
Power: 2,672 kW	Power: 3,266 kW
Year: 1991	Year: 1991
Theoretical efficiency: 89%	Theoretical efficiency: 89%

Table 2.4: DH1 boilers characteristics

Figure 2.18: DH1 boilers room

- **Distribution System:** distribution pipes, which run through all buildings providing heat, are divided in two branches, with their respective pumps, one for the first six buildings and another for the remaining six. Currently, there are no heat exchangers, which makes very difficult to manage the demand for thermal energy in each dwelling. The nearest buildings to the boiler room reach internal temperatures above the average of DH1.

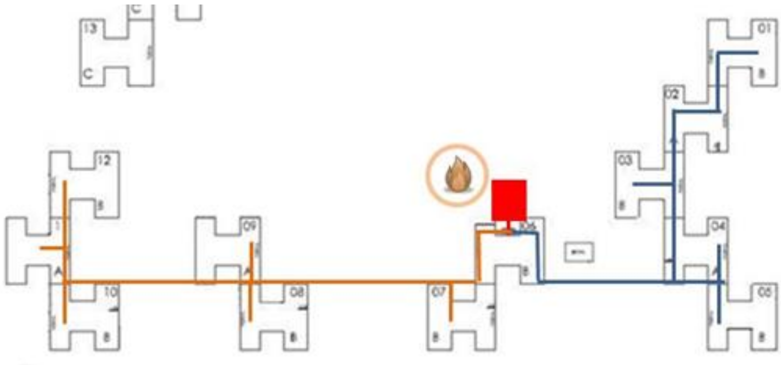


Figure 2.19: DH1 distribution system

Figure 2.20: DH1 distribution pumps

- **Domestic Hot Water:** There were two heat exchangers and two storage tanks to produce DHW. Flow temperature to produce DHW in boilers room was 80^{o}C and return temperature was 60^{o}C. Heat recovered in boilers was used to preheat water to produce

DHW, with a previous storage in the buffer tanks. The five tanks were situated before the two DHW storage tanks (3,000 litres each). There were two circuits to distribute directly DHW from the boilers room to the dwellings, one circuit for buildings 1 to 7 and one circuit for buildings 8 to 12.

DHW Exchangers	DHW Pumps	DHW Distribution Pumps
Model: SIGMACAL UFP-53 60 MH	Model: WILO TOP S-80/10	Model: GRUNDFOSS MMG132M-4
Number of exchanger: 2	Number of pumps: 2	Number of pumps: 2

Table 2.5: DH1 DWH system characteristics

Figure 2.21: DHW system in DH1

- **Control system:** The heating system is controlled by an analogical system that manages the flow temperature from the boiler and the temperature of storage DHW tank. The heating temperature set point was configured by maintenance personnel according to their experience, the weather conditions and the requirements of the neighbours. Heat flow temperature was usually between 70°C and 80°C.

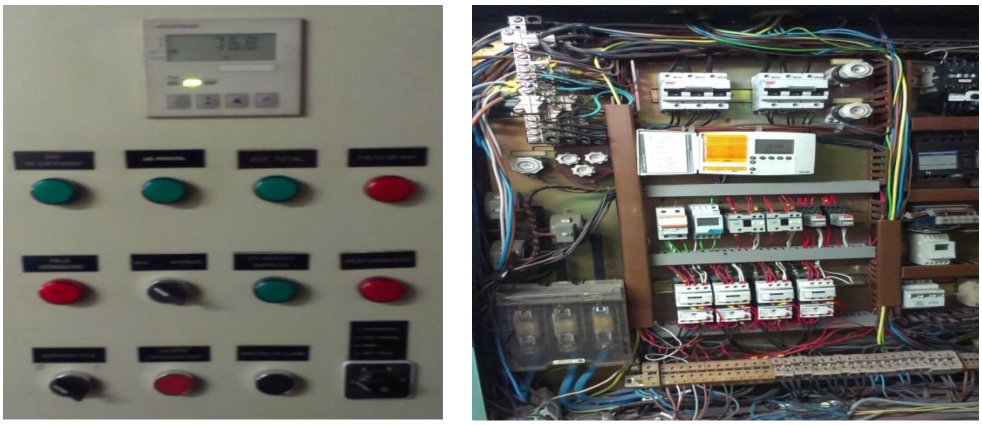


Figure 2.22: Detail of the control system

- **Building distribution:** The heating pipes in each building have been renovated recently so are in perfect conditions. New valves have been placed for an individual switching and been provided with proper insulation. The main inefficiency detected in the existing heating distribution system of DH1 is the lack of heat exchangers in the buildings. The heat distribution pipes pass through each building before moving to the next and so on.

Figure 2.23: Distribution heat and DWH pipes elapse inside of the building

District Heating 2

The boiler room of District Heating 2 is near the block 29 and has three boilers with a total power of 8,715kW. The boiler room was reformed some years ago, by replacing the diesel fuel boilers for another ones using natural gas. Moreover, exchange substations were installed in each building block, providing the system with more functionality. A management system was implemented in DH2 and substations include energy meters.

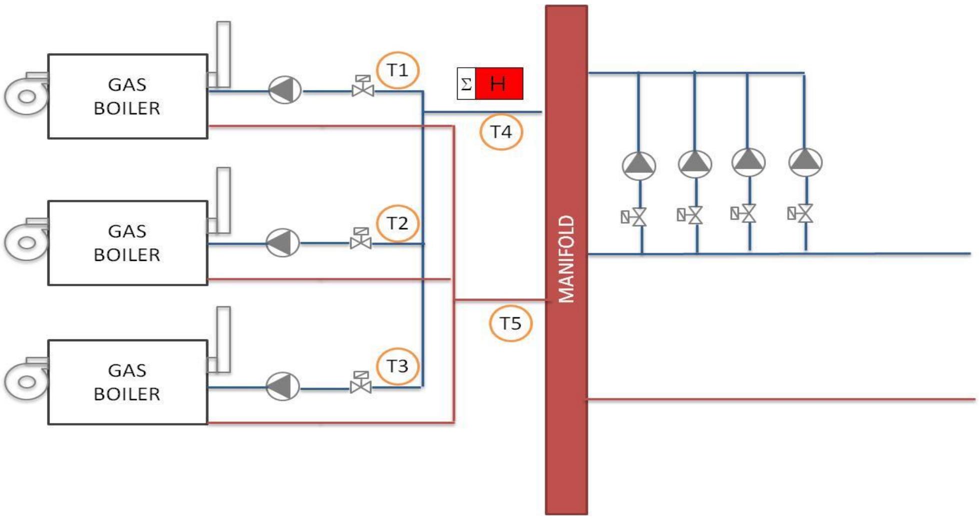


Figure 2.24: DH2 boiler room scheme

- **Boiler room:** The operating mode of heat generation in DH2 is based primarily on hours of operation configured according to the experience of the maintenance personnel, who is a neighbour of the Community of Owners of Phase II and who knows the behaviour of the buildings.

DH2 Boiler 1, 2 and 3	DH2 Pumps 1	DH2 Pumps 2
Model: YGNIS EM2905	Model: SEDICAL SIM 200/240	Model: SEDICAL SIM 125/190
Gas burner: MONARCH	Number of pumps: 2	Number of pumps: 2
Power: 2,905kW		
Year: 1999		
Theoretical efficiency: 89%		

Table 2.6: DH2 boilers and pumps characteristics

Figure 2.25: Boilers room in DH2

The maintenance staffs were commissioned to carry out the reform. During the years of service to the community operating variables of each process, have been optimized to provide maximum comfort to the neighbours. The way used to adjust in the best way the operation curves of the flow temperature with respect to the outside temperature is to provide a series of temperature data loggers in representative dwellings of each block to evaluate the behaviour of each building.

The conclusions obtained from these tests were that there is a temperature difference between two Celsius degrees in dwellings of intermediate floors and the top floor, which is the most disadvantaged one since the cover is not isolated.

Phase II do not have any individually controllers in each house and this is the reason for which they have the same problems of overheating in intermediate floors plants to achieve comfort temperatures of the top floors high.

- **Distribution System:** the distribution pipe is divided into five circuits that supply thermal energy to seven exchange substations. These substations are the connection element between the distribution circuit and consumers and produce DHW by heat exchangers and storage tanks. The distribution of thermal energy is formed by double variable flow pumps for each circuit, control valves, hydraulic balancing and security systems.

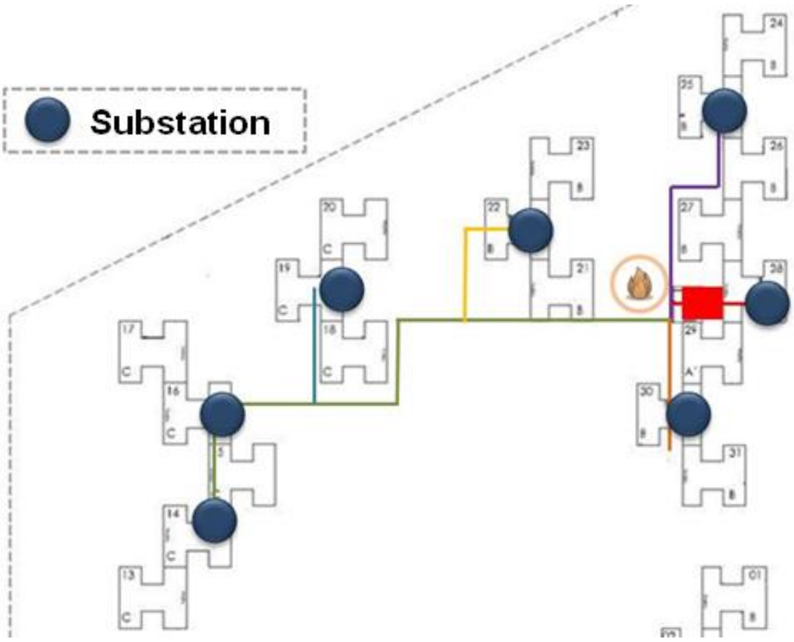


Figure 2.26: DH2 distribution system

- **Substations:** DH2 has seven substations. The next figure and table show a scheme of one substation of DH2 with some elements of its substation, as the heat exchanger or the storage tanks, and the current status of the main equipment included in the substations of DH2, respectively.

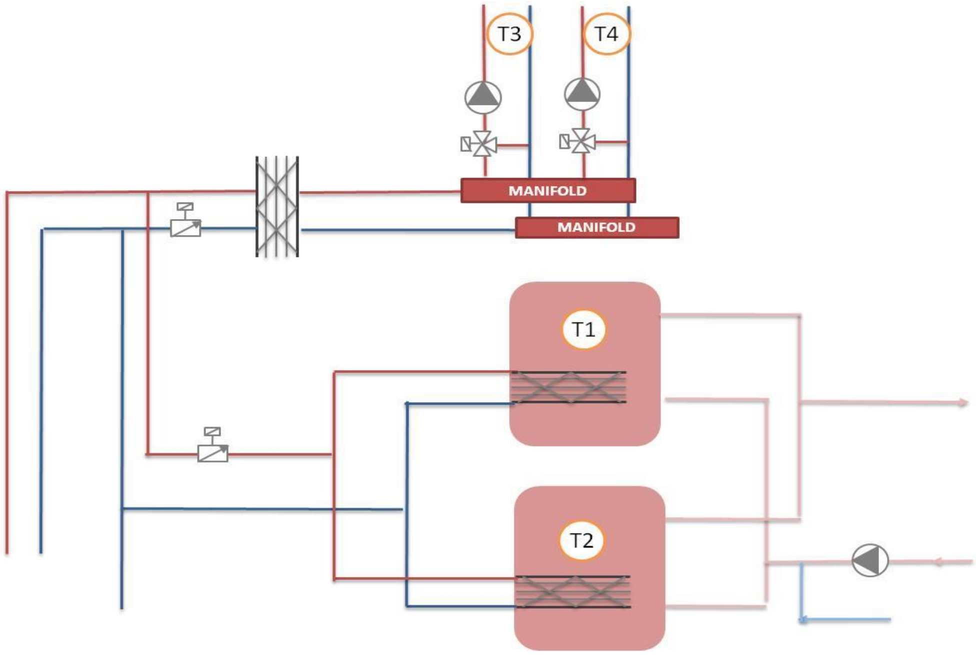


Figure 2.27: Schematic diagram of substation in DH2

Substation	Heating System	DHW	Distribution Pumps
Substation buildings 13 and 14	820 kW heat exchanger	Two 1,000 litres tanks	Pump water distribution for each building
Substation buildings 15, 16 and 17	1,250 kW heat exchanger	Two 1,000 litres tanks	Pump water distribution for each building
Substation buildings 18, 19 and 20	1,250 kW heat exchanger	Two 1,000 litres tanks	Pump water distribution for each building
Substation buildings 21, 22 and 23	1,250 kW heat exchanger	Two 1,000 litres tanks	Pump water distribution for three buildings
Substation buildings 24, 25 and 26	1,250 kW heat exchanger	Two 1,000 litres tanks	Pump water distribution for three buildings
Substation buildings 27, 28 and 29	1,250 kW heat exchanger	Two 1,000 litres tanks	Pump water distribution for three buildings
Substation buildings 30 and 31	820 kW heat exchanger	Two 1,000 litres tanks	Pump water distribution for two building

Table 2.7: DH2 substations characteristics

- **Domestic Hot Water:** the DHW system is performed at each substation by heat exchangers and accumulation tanks.

Figure 2.28: Heat exchanger and pumps installed in each substation of DH2

- **Control System:** the control system of DH2 has been recently renovated and it has a modern Honeywell supervisor control system that manages the boiler room and associated substations. This control system will be modified to integrate it in the control system implemented for the new District Heating. The system operation is managed by a central control station through which all process variables heat generation and distribution are controlled.

Figure 2.29: Boilers room in DH2

2.4 Definition of needs

According to the request from the Communities of Owners of Torrelago and after the analysis performed, the needs to retrofit the façades following functional and energy efficiency criteria together with the actualization of the energy systems and energy management facilities were established.

To achieve these objectives it is necessary to insulate the façades and improve the performance of the district heating. The analysis of the thermal envelope of the buildings evidences the existence of significant heat losses.

The fact that there are two District Heating areas to heat buildings is an important advantage as those energy systems are not usual in Spain. It is advisable to transform the actual DH systems in more efficient, sustainable and smart ones. The future intervention in the framework of CITyFiED project will work with the premises for reducing energy costs, introducing renewable energy sources and allowing a bigger control capacity with smart metering.

Moreover, more efficient use patterns are expected. This purpose implies a direct channel of information between the technical team and the Spanish demo site residents.

3 Building retrofitting technical solutions

The aim of the intervention in the Spanish demo site is to accomplish the CITyFiED project objectives, which are to reduce the energy demand and greenhouse gas emissions and to increase the use of renewable energy sources by developing and implementing innovative technologies and methodologies for building renovation, smart grid and district heating networks and their interfaces with ICTs. To achieve these objectives, an intervention strategy has been defined, taking into account the following aspects, façade retrofitting and energy system renovation, developed in this document.

Today we find the urban area of Torrelago built under high energy consumption can be reduced significantly. This excess not only harms the end user economically with the resources used in their home, it affects their comfort and the environment with emissions.

Found this situation, it was decided to give the most appropriate solution taking into account the needs, architectural objects and installations that deal with the issue and get the best response to scope. Once obtained the information is compared and modelled with energy simulation tools, it is checked with tests and measurements during the process, diffuses and especially evaluated during the process, so it can serve as a reproducible platform.

3.1 Façade retrofitting renovation strategy

The intervention project that concerns us consists of two communities neighbourhood privately owned, which were built in several stages between 1978 and 1981. The Phase I is composed of 12 blocks and Phase II of 19 one, building block in height of about 43 meters. It will be over 12 heights above ground level, aimed at local and entrance to housing, which remains largely transparent on pillars, which allows passage to the communal garden. The residential district of building has an H-shaped plan that joins at least one other and sometimes two nearby typologies, organized into 4 apartments of 100m^2 becoming 48 neighbours within a total of 1,488. The facades of different measures are red envelope forming the ceramic blocks to respond to more than 4,000 residents.

The façade is a main element to address in order to achieve the energy efficiency in the retrofitting of buildings. The façade represent the largest part of the heat transmission surface and includes a number of critical components (like windows) and thermal bridge phenomena.

The aim of the façade retrofitting is the energy refurbishment of Torrelago buildings through their façades, made of brick cavity walls and closed by ceramic lattices in some parts, as well as achieving a new architectural design for buildings, more aesthetic and functional.

3.2 Technical solutions

Retrofitting building drastically reduced demand and energy consumption district by implementing passive measures based Exterior Thermal Insulation System (ETICs) for the rehabilitation of the facades of 31 buildings, and active based on the modernization of district heating.

The rehabilitation of the facades is central to achieving the energy efficiency goals pursued in relation to reducing energy demand. Based on simulation results energy buildings conducted on existing walls double sheet, air chamber and a thickness of 25 cm, is installing a solution ETICs with expanded polystyrene (EPS) 8 cm thick that reduces the demand for buildings close to 40%. Moreover, to improve the management, planning and control of work rehabilitation is developing a BIM model district.

The facade elements on which it is involved are two, brick cavity walls and ceramic lattice, and the solution adopted for each of them is described below:

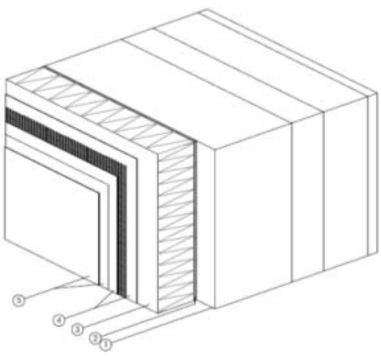
Brick cavity walls

Most of the façade surface is made of brick cavity walls without insulation layer (12 cm ceramic brick + 5 cm air chamber + 7 cm ceramic brick + 1.5 cm gypsum plaster). The original wall has a width of 25.5 cm and a U-value = 1.36 W/m^{2o}C. Façades presents numerous pathologies, such as thermal bridges, fissures due to thermal expansion, and fissures along the expansion joints or air infiltration through the facade.

There will be no intervention on the structure, installations, indoor spaces, building's' uses and size and composition of window opening on façades.

The façade solution consists of an ETICS (Exterior Thermal Insulation System) that will be attached to the exterior wall of the buildings. This system will be composed by:

- 8 cm expanded polystyrene (EPS) sheet for insulation (density 15-20 kg/m3) fixed by adhesive mortar and mechanical anchors.
- 1.5 cm mortar layer (cement mortar + fiberglass mesh + cement mortar + white finishing mortar).



1. Existing wall
2. Adhesive mortar
3. EPS insulation sheet insulation
4. Cement mortar + fiberglass mesh + cement mortar
5. Finishing mortar

Figure 3.1: ETICS System detail

Some of the issues considered for the selection of this solution were its resistance, stability, security, durability, cost-effectiveness, ease of assembly and modulation possibilities.

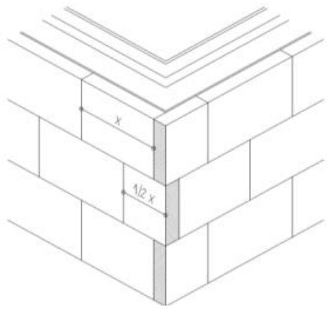


Figure 3.2: Detail of the placement of the EPS sheets in the corners

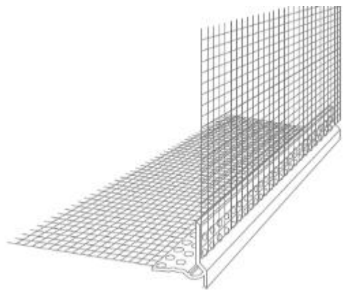


Figure 3.3: Fiberglass mesh detail

After de retrofitting, the resulting wall (1.5 cm mortar finish + 8 cm EPS + 12 cm ceramic brick + 5 cm air chamber + 7 cm ceramic brick + 1.5 cm gypsum plaster) will have a width of 35 cm and an U-value = 0.34 W/m^2K. The Spanish Technical Building Code [2] requires a U-value ≤ 0.66 in Laguna de Duero climatic zone (D2).

The ETICS solution defined takes into account thermal and comfort issues (temperature and humidity) as well as aesthetic design. Block final appearance will be mainly white, with some coloured areas on each block.

One of the technical solutions adopted involves the maintenance of the new façade solution. The finish has been sought is considering two variables:

- The self-cleaning exterior treatment to final finish makes when it rains contaminants caused to pollution slide along front.
- The colour of the final paint which is mixed with the acrylic. It is based on tones that do not exceed a limit of solar radiation recommended by the supplier of the ETICS solution. Thereby the front will be less discoloration caused to solar incidence.

Figure 3.4: Infographics of the appearance of buildings and results of the intervention

Ceramic lattice

The surface of kitchens and clotheslines is covered by a ceramic lattice that the majority of residents have broken to place a window, after adding to the kitchen the space of the ventilated gallery. These works have changed the appearance of the building and the uniformity of the façade.

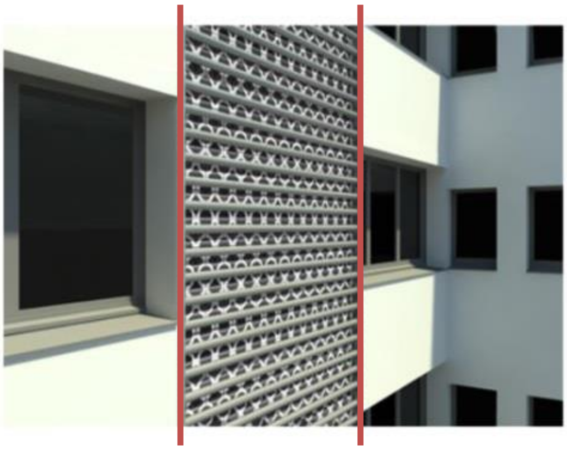


Figure 3.5: Original ceramic lattice work (photo) & future solution (infographic)

The kitchen facade solution provides a uniform front white base color. Therefore the existing painted ceramic lattice and the space occupied by the window opening is remained. If in the future the tenant decides to open this space is ready to give an image of homogeneous design.

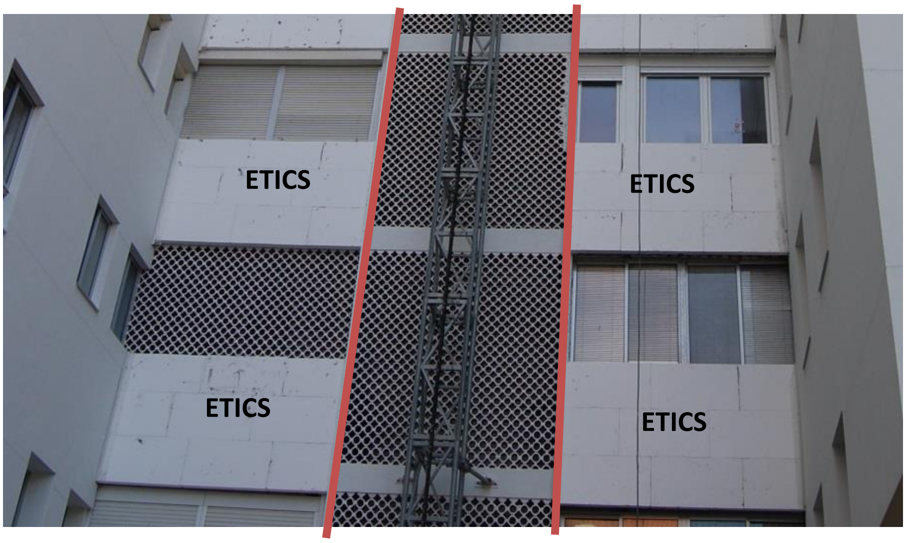


Figure 3.6: Current solution for the kitchen façade (the process has not finished)

It can be observed a central area of ceramic lattice over which will be placed new lattice tubular aluminium, fixed due to an auxiliary structure, covering the original area, Fig. 3.6, and giving a uniform and aesthetic solution to these façade, Fig. 3.5.

The solution for anchoring the lattice, structural beams is performed with a metal profile along 40 meters of the façade, Fig. 3.7 y 3.8.

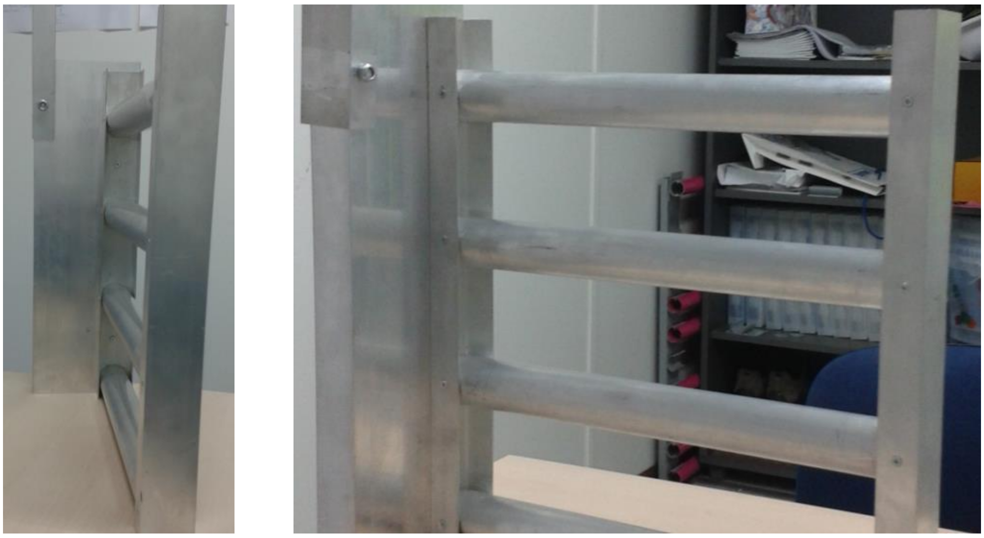


Figure 3.7: Tubular aluminium lattice

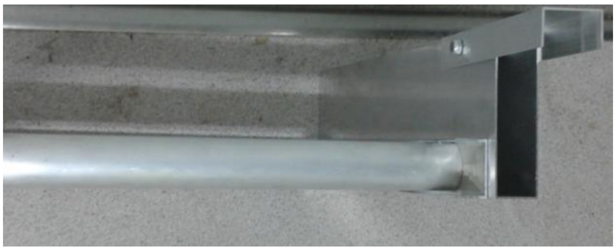


Figure 3.8: Plan view of the placement system attached to the structural slab of each floor

3.3 Natural design solutions

This project seeks a design that preserves the social identity of the place. Therefore the tenants have always felt these 31 elements in height, Torrelago blocks, as something that makes original to the district, looking on one side the increased thermal with the insulation of the envelope, and secondly a design appropriate to its social heritage as community.

The architectural proposal has sought to improve energy efficiency system allowing for its lightness and finish, a facade rehabilitation intervention in the urban heritage, according to district Torrelago. The group formed by 31 blocks gives a unitary image, by one side with a base colour, and secondly with the differentiation of groups of blocks under colours that contrast and complement. Thus there is an overview homogeneous and in turn 8 groups that have a rhythm and character. Moreover, the project considered other natural solutions which involved: the block orientation, sunlight, colorimetry, temperature and ventilation.

- **Natural ventilation** is the process that exchanges air from the interior of a building to the outside without any mechanical equipment. The air movement is caused by the different pressures due to the temperature differences or to the incidence of wind. Natural ventilation was contemplated in the original project. The problem is that some tenants over the years have closed this space clothesline making its largest kitchen.

Currently only some dwellings preserved natural ventilation with which the blocks were designed.

- **Daylight** may not provide the sufficient luminance at any time it is needed. Therefore in some facades, for the shape of blocks in H, sunlight does not reach sufficiently. Therefore we paint all beside Kitchen facades with white base to give more light to this space.

Figure 3.9: Groups H shaped buildings 1-5 and 6-7

- **Colour**, additionally, is an important factor on the thermal performance of buildings. Colour election according to climatic requirements is important to reduce solar gains during the summer or to improve solar gains during winter. Colour may also be classified by the field of colour psychology that identifies the associations and effects on human emotions. These were considered by groups of blocks for improved guidance from tenants of residential district.

Figure 3.10: Area beside kitchen facades painted in white colour

3.4 Observance of the Spanish Technical Building Code [2]

The observance of the Spanish Technical Building Code (CTE) is necessary to obtain the building permit, nowadays in Spain. This technical code was justified in the technical project and it is divided into different systems: structural, fire, access and use, salubrity, noise and energy savings. Thus each of which is analysed according to certain requirements:

Characteristics of the blocks for Phase 1 of intervention:

Building conditions	Phase 1
Total number of buildings	7
Types of block	A and B
Measures A block	22.20 x 21.55 m
Measures B block	22.20 x 22.90 m
Number of block A	02 and 04
Number of block B	01, 03, 05, 06 and 07
Total number of floors	12 + 1
Surface ETICS	40,422.85 m^2 approx.
Surface lattice	1,250 m^2 approx.

Table 3.1: Conditions of the blocks Phase 1

<u>Structural System named CTE DB-SE</u>

The aim of the basic requirement "Structural Safety" is to ensure that the building has adequate structural behaviour actions, and predictable influences to which it may be subjected during construction and intended use (Article 10 of Part I of CTE).

CTE in Article 2 (Part I) talk about the architect responsible for the project: "*designer should indicate the project report (technical project) in which can register the planned works and if these include or performances in the existing structure; understood, if not, that the works do not involve the risk of damage.*"

- Application on this project:

There is a weight calculation in facade of the constructive solution in Annex 1.

<u>Fire Protection System named CTE DB-SI.</u>

The aim of the basic requirement "Safety in case of fire" is to reduce to acceptable limits the risk that users of a building suffer damage caused by accidental fire products as a consequence of the characteristics of their design, construction, use and maintenance (Article 11 of Part I of CTE). This document should apply only to building elements modified by the retrofitting building as indicated Article 3, Item 6.

- Application on this project:

The construction solution of building project requires EPS insulation to place according to

- ETAG No. 004,
- Have at least a level of behaviour as material Euroclass: B-s2, d0.

Safety in case of use and accessibility named CTE DB-SUA

The objective of the basic requirement "Security of use and accessibility" is to reduce to acceptable limits the risk of users suffer immediate damage in the use of buildings as a result of the project characteristics, use and maintenance, and facilitate access and use non-discriminatory, independent and secure them to people with disabilities.

- Application on this project:

The intervention of this project is in facade of the blocks but there are not changes in the measurements of the window which affect the use of tenants.

Salubrity named CTE DB-HS

The aim of the basic requirement "Hygiene, health and environmental protection", is to reduce to acceptable limits the risk that users inside buildings and under normal conditions of use, suffer discomfort or disease and the risk of that buildings deteriorate and that harm the environment around as a result of the characteristics of the design, construction, operation and maintenance (Article 13 of Part I of CTE).

- Application on this project:

The ETICS system is considered waterproofed by the CTE. The minimum degree of impermeability for ETICS is 4 or 5 depending of the final surface what means that is appropriate to use in Valladolid, where is required 3, lower than the properties of the facade system. The degree of impermeability depends on the rainfall area, wind zone and the degree of exposure to wind. Besides the system is water vapour permeable.

Zona pluviométrica:	IV
Terreno:	IV
Clase de entorno del edificio:	E1
Zona eólica:	A (26 m/s)
Altura del edificio:	16-40 m
Grado de exposición al viento:	V3
Grado de impermeabilización:	**2.** Según tabla 2.5, DB- HS1
Condiciones solución de fachada:	**R1 +C1** (con revestimiento exterior)

Figure 3.11: Torrelago characteristics regarding CTE DB-HS

<table>
<tr><th>Grado de impermeabilidad</th><th colspan="4">Con revestimiento exterior</th><th colspan="4">Sin revestimiento exterior</th></tr>
<tr><td>≤1</td><td colspan="4" rowspan="2">R1+C1(1)</td><td colspan="4">C1(1)+J1+N1</td></tr>
<tr><td>≤2</td><td>B1+C1+J1+N1</td><td>C2+H1+J1+N1</td><td>C2+J2+N2</td><td>C1(1)+H1+J2+N2</td></tr>
<tr><td>≤3</td><td colspan="2">R1+B1+C1</td><td colspan="2">R1+C2</td><td>B2+C1+J1+N1</td><td>B1+C2+H1+J1+N1</td><td>B1+C2+J2+N2</td><td>B1+C1+H1+J2+N2</td></tr>
<tr><td>≤4</td><td>R1+B2+C1</td><td colspan="2">R1+B1+C2</td><td>R2+C1(1)</td><td>B2+C2+H1+J1+N1</td><td colspan="2">B2+C2+J2+N2</td><td>B2+C1+H1+J2+N2</td></tr>
<tr><td>≤5</td><td>R3+C1</td><td>B3+C1</td><td>R1+B2+C2</td><td>R2+B1+C1</td><td colspan="4">B3+C1</td></tr>
</table>

(1) Cuando la fachada sea de una sóla hoja, debe utilizarse C2.

Figure 3.12: Spanish Technical Building Code. CTE DB-HS

Noise protection named CTE DB-HR

The aim of the basic requirement "Protection against noise" is to limit, inside buildings and under normal conditions of use, the risk of discomfort or illness that noise can cause users due to the characteristics of their design, construction, use and maintenance.

- Application on this project:

The scope of this document HR is established generally for the CTE in Article 2 (Part I) except in cases that below:

d) Works of extension, modification, renovation or rehabilitation of existing buildings except in the case of complete renovation. Also excluded integral rehabilitation works of officially protected because of their cataloguing cultural assets like buildings, where compliance with the requirements suppose alter the configuration of its facade or distribution or interior finish, so incompatible with the preservation of such buildings.

Therefore the project is exempt from application of this justification.

Energy saving named CTE DB-HE

The aim of the basic requirement "Power Save" is to achieve a rational use of energy necessary for the use of buildings, reducing consumption and sustainable limits also get a share of this consumption from renewable energy sources, such as consequence of the characteristics of their design, construction, use and maintenance (Article 15 of Part I of CTE).

- Application on this project:

Implementation criteria in existing buildings:

- Criteria 1: no worsening, aggravation.
- Criteria 2: flexibility.
- Criteria 3: damage repair

The definitive solution has a U-value 0.34 W/m^2K, which applies with the requirements of the Spanish Technical Building Code that determines U-value ≤ 0.66 in this climatic zone (D2).

D.2.14 ZONA CLIMÁTICA D2

Transmitancia límite de muros de fachada y cerramientos en contacto con el terreno **U_{Mlim}: 0,66 W/m^2 K**

Composición por capas (de exterior a interior)	λ	d	Cp	μ	e	R	m	Sd
1ª Mortero de cemento o cal para revoco, 1600<d<1800	1	1700	1000	10	0,5	0,01	9	0,05
2ª EPS Poliestireno expandido (0,037W/mK)	0,04	30	1000	20	8,0	2,16	2	1,6
3ª 1/2 pié LP métrico o catalán 40<e<60(mm)	0,69	1140	1000	10	12,0	0,17	137	1,2
4ª Cámara vertical no ventilada e = 5cm				1	5,0	0,18		0,05
5ª Tabicón LH doble 60<e<90 (mm)	0,38	930	1000	10	7,0	0,19	65	0,7
6ª Enlucido de yeso, 1000<d<1300	0,57	1150	1000	6	1,5	0,03	17	0,09
Total de las capas					34,0	2,73	230	3,69
Transmitancia del muro de fachada M1-1:					$R_{si}+R_{se}$=	0,17	U_M =	0,34

Figure 3.13: Spanish Technical Building Code. CTE. DB-HE

ETICS are composed by an isolation made by EPS. This isolation is protected with a cement mortar, fiberglass and another sheet of cement mortar. They all together give a good fire protection. The Spanish regulation CTE asks to prevent the outdoor propagation of fire a qualification of the system at least B-s3, d2. With the system provided we get B-s1, d0, what is significantly better than required.

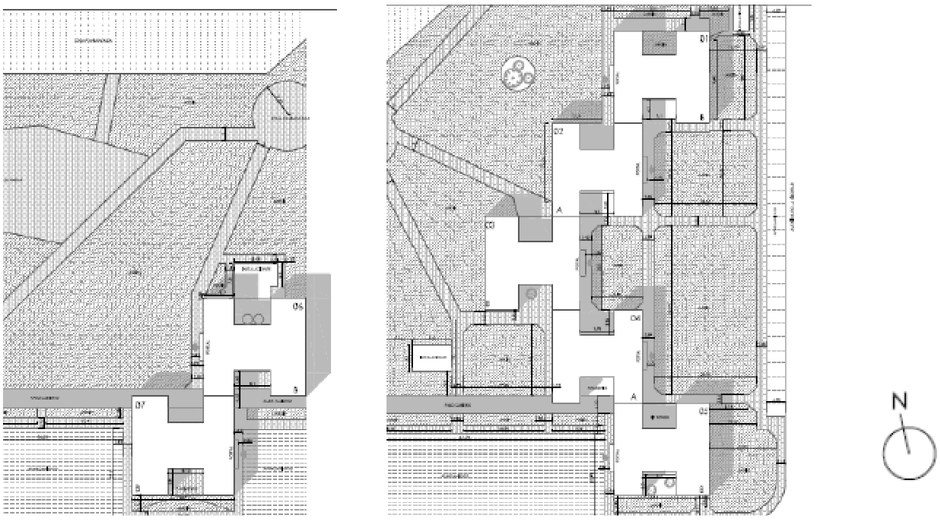


Figure 3.14: Plan of location of the blocks to the orientation of the HE

According to the orientation of the 7 residential blocks from phase 1 are obtained these parameters to be considered in building solution district.

- Thermal transmittance of the façade wall. D: 0.27 W/m^{2}K.
- Thermal transmittance of the gaps window. D: 1.2 - 1.4 W/m^{2}K.

4 District heating system renovation strategies

The strategies proposed for the renovation of the centralized system of thermal energy for heating and domestic hot water are based on the junction of the two existing DH networks in only one with the introduction of renewable energies, replacement of the distribution system of thermal energy and implementation of heat exchange substation for Phase I and modernization of substations in Phase II.

The deployment of a new District Heating concept, to cover the demand optimizing the production of thermal energy by means of a mix of energy sources, is being carried out. The use of renewable must be maximized with the biomass-boiler system, that improves energy efficiency, stabilize prices and reduce CO_2 emissions.

It is planned to install individual thermostats into the dwellings so that each user can manage their conditions of comfort in the most appropriate way and to improve control over their individual consumption of thermal energy. Also energy meters will be installed in each dwelling to monitor the main variables of thermal consumption of the users and to obtain typical power consumption profiles that can provide more information to optimize the district heating system.

This measure to assess the consumption of each dwelling is a policy of forced compliance transposed from the board of the European Economic Community 2012/27/EU [3] and is developed to reduce the energetic waste that makes community facilities for end users. In Spain it is a usual practice that users of common services pay depending on the area of their home. In this particular case, residents of Torrelago pay all the same for the general services because their homes have similar features. We are not aware that thermostatically controlled valves are installed in any home and are very common for users who have heat in their homes open the window before closing the radiator.

Some of the more energetically disadvantaged homes that have been refurbished have increased radiator elements thinking that could increase their comfort conditions regardless that they couldn´t modify the flow and temperature received from the network of heat. This raises a problem in balancing the hydraulic system.

Some of the houses in Phase I, which do not have heat exchange substations in each building, especially the most disadvantaged energetically, have been refurbished by raising radiator elements thinking they could increase their comfort conditions regardless not could vary the temperature and flow they received from district heating. This aspect is certainly a problem in balancing the hydraulic system. With the installation of new substations exchange and reform of each heat pipe housing problem will be solved.

All elements of the district heating network will be integrated on an advanced control and monitoring system that will manage all the variables involved in the process of generation and emission distribution with thermal energy. Also be integrated into the control system thermal energy meters to be installed on every level of each subsystem.

Two District Heating systems will join in only one through a pipe. Then, there will be just one district heating, that will provide of thermal energy to the 31 buildings of the Spanish demo site and that is composed by two rings and two plants of production connected to the grid: One of this will be the boiler room of DH2 and the other one, a new biomass boiling room.

It was decided to start interventions in Phase I because Phase II are under the terms of an energy services contract for which the contractor performing the necessary reforms in the facility with a commitment by a certain duration with conditions in the price of energy, maintenance, full guarantee and financing facilities. For these reason the operation of the installation in Phase II is assigned to the company that made the reform while the contract is current, until 2016.

The current state of the heating and hot water Phase I has more need of interventions.

There is more possibility of obtaining conclusions of the saving measures and energy efficiency measurement making a comparison between the current and the future state in Phase I because it has more information on consumption and operating modes of the facilities.

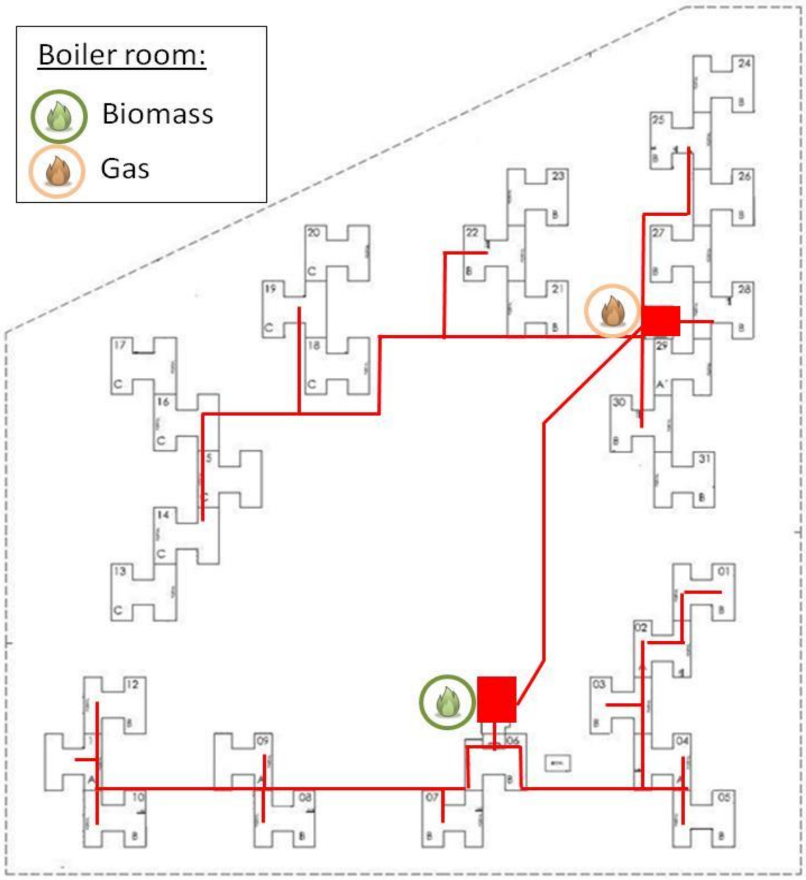


Figure 4.1: New District Heating

This new district heating will be composed, in general terms, by three biomass boilers, three gas boilers, a CHP system, a distribution system and a set of substations.

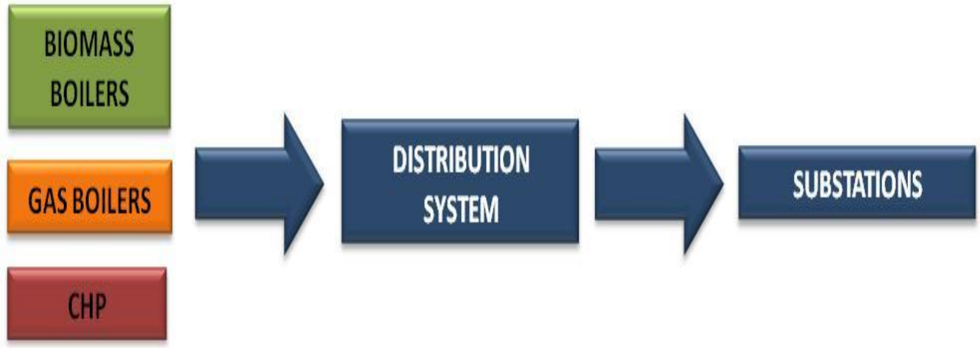


Figure 4.2: New District Heating elements

4.1 Plan of Implementation for the District Heating 1

The location of the new boiler room meets the guidelines of the property, replacing the current boiler room, which will be demolished completely. The new building is planned for facilities exempt, separated by at least 3 meters from the nearest tower, avoiding interference, with it, such as vibration, noise, and spread of fire or hearth movements. On the other hand meets the requirements of current legislation, especially as regards safety in case of fire.

Its plan is a rectangle of 28.00 x 16, 20 meters, half buried to a depth of 6 meters and 2 meters above ground. It is divided into a boiler room area, with a surface area of 228.80 m2, which must adapt to the measures chosen models boiler and storage tank chip internal measures 13.00 x 9.10 x 8.00 meters (946.40 m3). Furthermore, the existing boiler room was partially reconditioned, reducing the floor space for the location of the inertial accumulators.

It is planned a regular prismatic volume, looking for compactness and simplicity, against a strong field conditions due to the high presence of water because the land is based on an old dried lake. The main problem to overcome is the high presence of water in the soil, which requires adopting less conventional and more expensive solutions. From the solution of diaphragm walls, with a depth marked by the land itself, can be studied variants, from a space half buried until completely buried. For this reason we proceeded to the accomplishment of a geotechnical study for the assessment of the security measures necessary before excavation.

Figure 4.3: Torrelago district

The main conclusions of the geotechnical study reveal water 1.5 meters underground and the necessary implementation of in situ walls, reinforced concrete 45 cm thick and estimated at 12 meters form a tight box to the presence of abundant water in the depth will be performed. Also it has had to support structures for excavation and maintaining the security of the earth.

Figure 4.4: Detail of the support structure

The sizing of the required power must take into account the thermal demand of buildings and uptime district heating system. Planning sized boilers must consider the operation along with a buffer tank. Therefore, the point of installation sizing is not governed by the indication of nominal load, ie the thermal load of the building, but rather by the operating time (period length and thermal heating demand).

In any DH system, a priority regime of the heat sources connected has to be defined. This is in order to secure the operation of the most efficient and most cost-effective plant (such as CHP plants) and fuels during base-load periods. More expensive sources such as heat only boilers, based on oil or gas, are used for short-term peak loads only.

Heat sources can be either directly connected to the distribution system or indirectly connected through a heat exchanger.

An indirect connection uses a heat exchanger in the building to transfer energy from the distribution system of heating DH, primary system, the distribution system of the building, the secondary system. This type of implementation through heat exchangers allows that the distribution system of the heat source can work with different temperatures and pressures, allowing more flexibility in the design. Heat generators operate at higher temperatures to prevent an excessive dimensioning, thus reducing space requirements and initial investment.

The methods of connecting the heat generating source with the different buildings should not be confused with the method used in connecting customers to the heating system with DH system. DH distributes energy from the heat source through the supply lines to the inlet of client and returned after the heat is removed. Delivery is made by pumps which create a difference pressure between the supplies and the return pipes of circulation.

The pumps are selected to overcome resistance to flow in the supply and return pipes and the differential pressure between the client installation that is hydraulically most remote from the thermal energy generation and distribution point. The use of variable speed pumps to control ensures that the power consumption is minimized.

Heat losses in modern DH distribution depend on a number of many factors as the length of the system in relation to heat loading, the isolation level and temperature level. Normally, the annually heat losses are in the range of 5 to 20 %.

DH systems can be controlled by two different principles. Either the temperature remains constant while the flow rate varies, depending on the pressure, or flow rate is fixed and the temperature ranges in order to meet existing demand at all times. It could be also controlled by different combinations of the two systems. Generally, the flux variation responds much faster to changes in demand that changes in temperature. Therefore, variable speed pumps are important elements of modern DH systems.

Controlling a DH system is generally carried out by a centralized Building Management System. Continuous monitoring of key elements, such as temperatures and pressures of DH that the system meets the demand of customers. The pressure and temperature transmitters are installed in order to provide data to the management system.

There are integrated substation meters to assess the lost in the network distribution and thermal demand of each building.

The generation method is a hot water heat exchanger included in the storage tank. The use of heat exchangers reduces costs and also minimizes the requirements of space and permanent loss of hot water tanks. This method has the advantage that it can produce instantly and continuously.

As an initial approach, it was intended to install boiler 2.5 MW and a 1 MW in the new biomass plant, but finally, it was decided to install three boilers, two of 1,250kW and 950kW, improving power fractionation. Existing boilers will remain in the boiler room of Phase II as a reserve for use at peaks and likely failures or outages biomass periods.

The thermal power generation will be made from three biomass boilers, two boilers of 1250 kW and the other of 950 kW, all of them of Viessman brand and model Pyrotec. It is a boiler of biomass of the latest generation, with three fumes steps, for a maximum working pressure of 6 bar used with biomass fuels with a maximum moisture content of 50 %.

The main features of the selected boilers are reflected in the following table:

Characteristic	Boiler: 1250 kW	Boiler: 950 kW
Model	Pyrotec 1250	Pyrotec 950
Useful power	1,250kW	950 kW
Minimum power	312 kW	285 kW
Performance	91%	91%
Length	5,992 mm	5,447 mm
Width	1,612 mm	1,612 mm
High	3,230mm	3,035mm
Weigh	12,919 kg	11,463 kg
Water volume	2,482 litres	1,943 litres
Maximum pressure	6 bar	6 bar
Maximum operating temperature	100 °C	100 °C
Exit flue connection	450 mm	400 mm

Table 4.1: Biomass boilers characteristics

Figure 4.5: Biomass boiler room

Here we have a scheme of this boiler room. The generating elements and the distribution elements of the boiler room are represented on it.

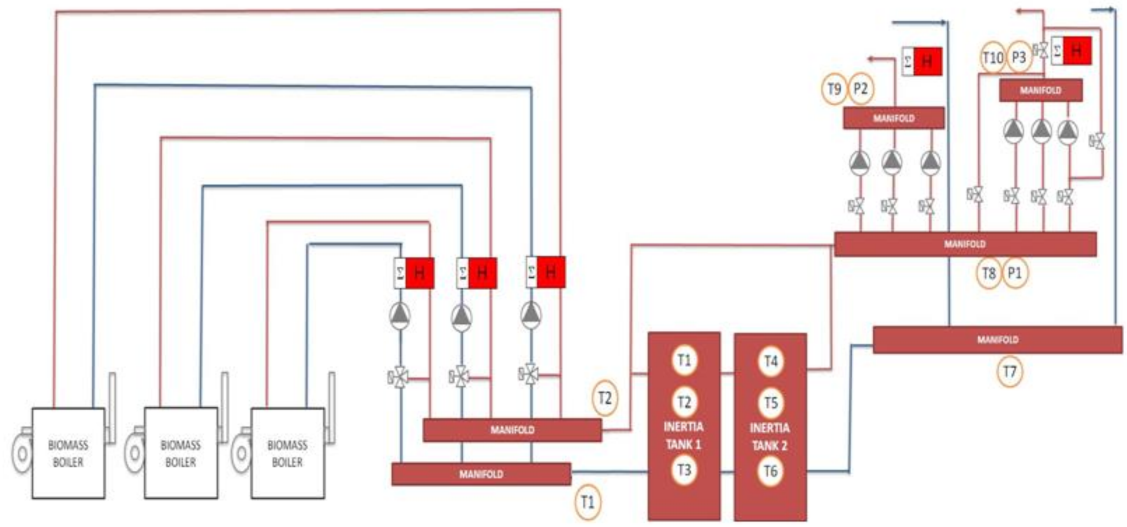
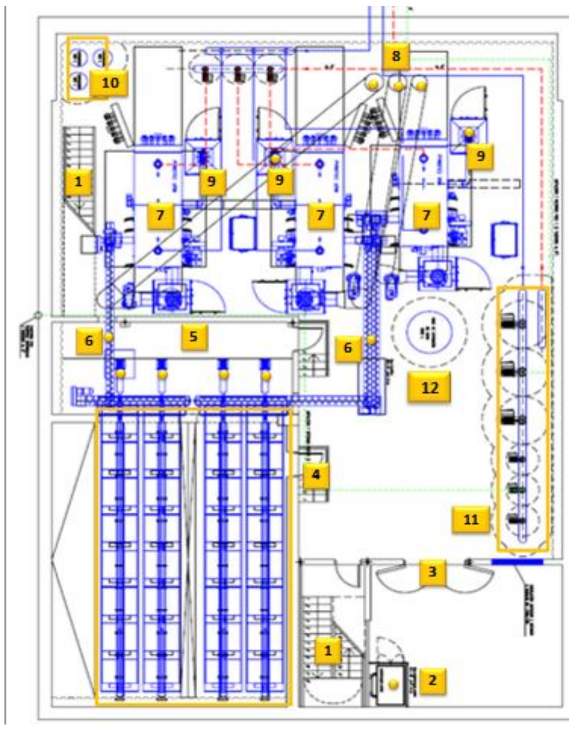


Figure 4.6: Biomass boiler room

Inside the boiler room it will be possible to distinguish two areas. One corresponds to the biomass silo with a small room where it is the necessary equipment that is required to move the silo ground. The other area is for the boiler room.

Next figures show the different elements of this boiler room. The first one was the first idea of the location of different elements. The second one is the final location and the explication of the differences.



Point 1: Stairs.

Point 2: Lift for extracting the ashes to the outside

Point 3: Entrance to the boiler room

Point 4: Biomass silo

Point 5 : Hydraulic system for moving the silo ground

Point 6. Augers to transport biomass from the silo to the boilers.

Point 7 : Biomass boilers

Point 8: Chimneys. There is one for each boiler.

Point 9: Storage containers for the ashes.

Point 10: Bilge pumps

Point 11: Pumping system

Point 12: heating expansion vessel

Figure 4.7: Initial boiler room scheme

Next figure shows the finally location of the boiler room elements. Pumping system (5) and the heating expansion vessel (12) were thought to change its location. The original installation has five inertia deposits which pretended to be utilized in the new facility but due to technical and economic constraints it was decided to include in the new room two 12,500 litres inertia tanks that are located next to the entrance door.

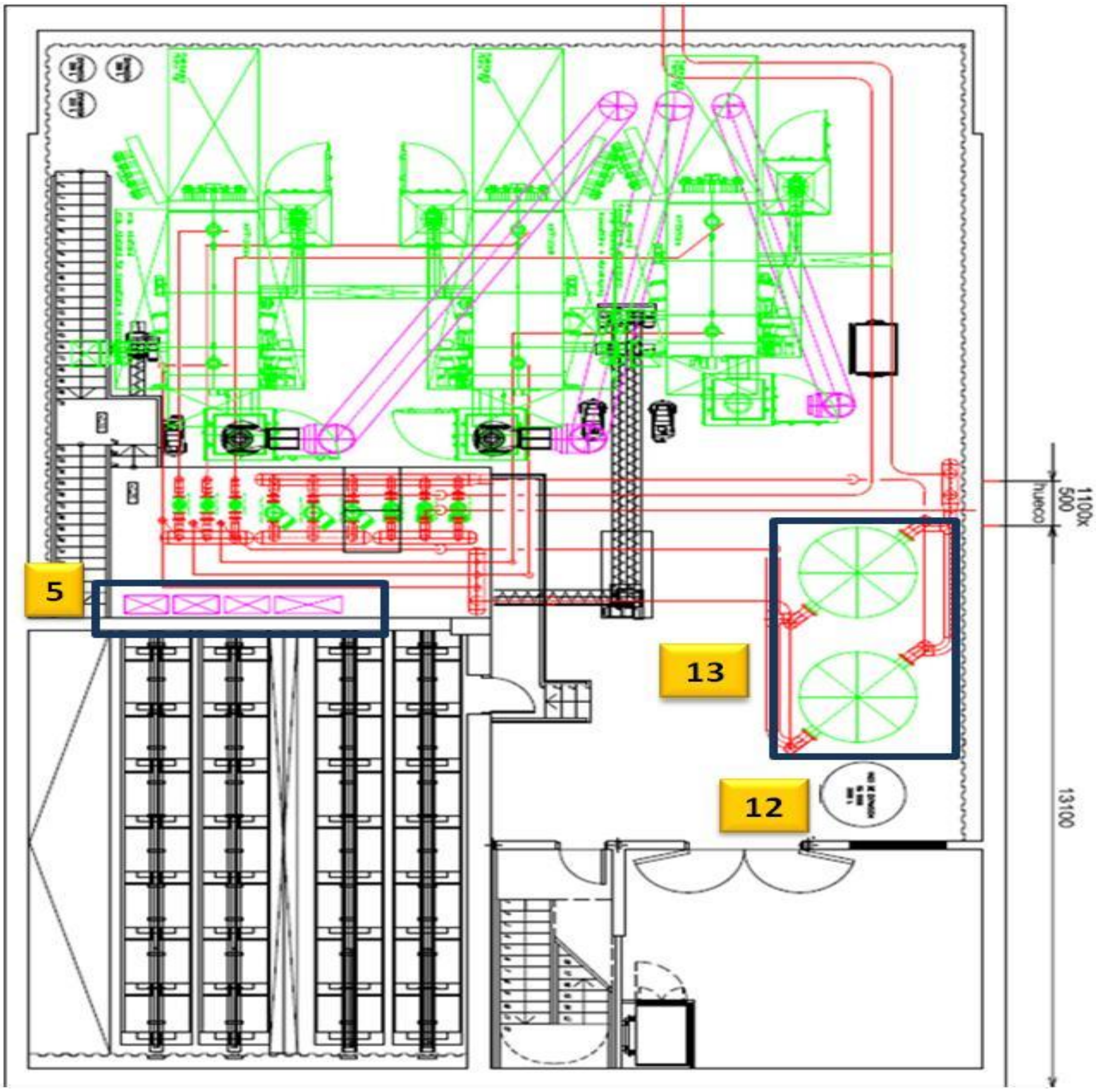
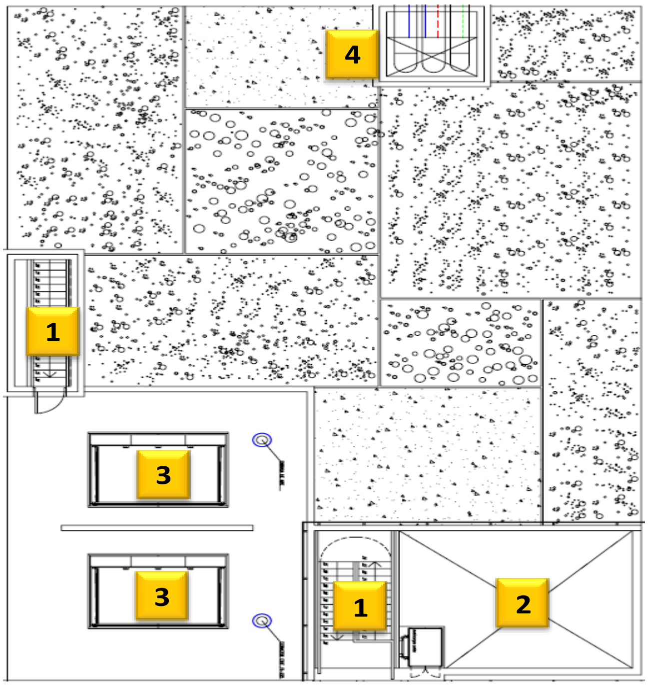


Figure 4.8: Final boiler room scheme

The outer surface is slightly elevated above the initial height and in it differs in two zones: One of them is formed by rectangles of coloured gravel and corresponds to the surface of the boiler room and the other area corresponds to the biomass silo roof. This is a flat area where biomass will be discharged through two large hydraulic hatches that connect the outside with the silo.



Point 1: Stairs to the boiler room.

Point 2: Forecourt

Point 3: hydraulic hatches

Point 4: Departure from chimneys.

Figure 4.9: Outside boiler room scheme

During the reform it was preceded to the demolition of half of the existing room to accommodate the new space for district heat generation. To ensure supply of domestic hot water to all residents of Phase I we need to keep in service the existing gas boiler. There was a delay in the execution of works due to late in delivery of equipment that generated the need to rent some diesel generation equipment to provide thermal energy for heating and hot water to buildings during the course of the works.

Figure 4.10: Temporary rented heat generators

The evacuation of the fumes to the outside is done through three chimneys; one for each boiler, they are located on the number 6 portal, because is the block next to the boiler room. To comply with current regulations, they are sized so that the mouth of the chimney is located at least one meter above the ridge of the roof, walls or other obstacles or structure that gave less than 10 m. It has been suggested installing fireplaces inside the shutters but for security reasons during this first year has installed the chimney of a new biomass boiler outside the facade to maintain in operation the original gas boiler. This decision has the disadvantage that it will not be able to isolate that part of the fireplace until the facade is hidden.

Figure 4.11: Chimneys

A general manifold where distribution pumps are mounted will also be installed. There will be two pumping systems

- Pumping System of Phase I: It consists of three variable flow pumps, designed to give 50 % of the design flow each one. Two pumps will be always working and the other work will be in reserve. The operation will be alternative to avoid deterioration of the pump that is not operating.
- Pumping System of Phase II: In the same way that for Phase I, this system consists of three variable flow pumps, designed to give 50 % of the design flow each one. These pumps have a higher dimension since the thermal energy required in Phase II is bigger because of that phase has more dwelling. Furthermore, this pumping system is reversible, under normal operating conditions pumped from Phase I to II, however, in specific cases it the boiler 2 which is in operation may be pumped Phase II to Phase I.

Next picture shows the six pumps that are installed. The three left ones are the pumping system of Phase II, while the three right ones belong to Phase I. They are easily distinguishable because of their size difference. The black device on them corresponds to the drive.

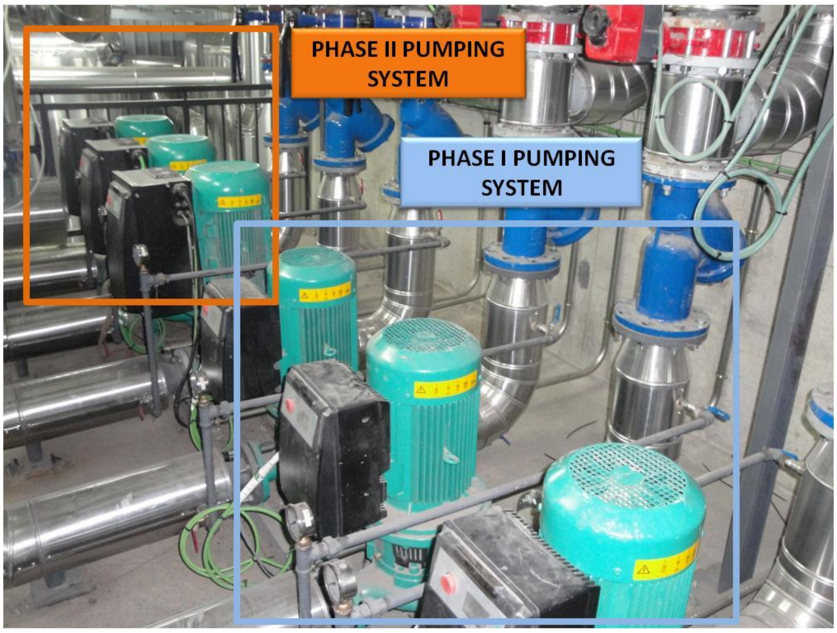


Figure 4.12: Pumping system

Furthermore, by the above pumping system, there another three pumps corresponding to the boilers and that are designed to supply water to the boiler. These pumps are constant flow ones and prevent the decrease in the return temperature below 65°C. These pumps have a smaller size than previous drive and do not have driven.

Figure 4.13: Boiler pumping system

Because of the thermal power installed in the boiler exceeds 70kW and to know the exactly thermal demand generated, one heat meter in the primary circuit of each boiler is installed. In addition, an energy meter is placed to record the consumption of thermal energy of each phase.

Figure 4.14: Thermal energy meter

These boilers have a control system of the wood chip feeding that change depending on the heat demand. They can modulate between 30% and 100 % of their power, i.e. between 285 and 3,450 kW. This modulation is carried out thanks to the system of regulation and control that is installed.

The particles that aren´t burned in the process of combustion of biomass are collected through a cyclone system located at the outlet of the boiler and before the chimney, avoiding them to go abroad. Its objective is to minimize dust emissions through the exhaust filter

From there, they will be removed by an auger to a container of 800 l to be extracted from the boiler using a lift installed on the forecourt. These ashes are managed as waste.

Figure 4.15: Cyclone system

Figure 4.16: Ashes container

Deposits of inertia will be located at the entrance of the boiler. Initially it was planned the idea of re-use the 5 deposits of inertia of the old Phase I boiler room. Finally, that idea was discarded and it was decided to install two 12,500 litres tanks, getting a final total volume of

25,000 litres. These deposits have an insulation 12 cm of polyurethane foam and the exterior is finished on aluminium sheet in such a way that it manages to reduce heat losses.

From the data provided by the manufacturer of boilers, for calculations concerning the volume of the buffer tank should be considered a minimum volume of 7 litres / kW, so that the minimum volume will be:

$$Volume_{minimum} = 7\frac{liters}{kW} \cdot 3.450\ kW = 24.150\ l$$

These deposits will be connected in line and will have bypasses to be possible to separate each of the deposits in case of breakdown or maintenance.

The energy stored in an inertia tank could be calculated as:

$$E = \rho \cdot V \cdot C_p \cdot \Delta T$$

Where

- E = stored energy.
- ρ = density of water (1.16 kg/l)
- V = Volume in litres (up to 25,000 l / deposit)
- CP = specific heat of water (4210 J/(kg·K))
- ΛT = Temperature difference

Figure 4.17: Inertia tanks

Next to each boiler an expansion vessel of 200 litres will be installed to protect the installation against the heat transfer fluid expansion caused by high temperature.

Figure 4.18: Expansion vessel

A heating expansion tank of 5.000 l will be installed too and it will be located next to the deposits of inertia. It is composed by an air compressor to compress an air chamber which is located inside and that is separated from the water by a flexible membrane installation. When system water increases its volume due to temperature, pressure increase in the circuit is absorbed by the expansion tank. When the system temperature decreases, the volume decreases thus returns water tank assigned to the installation.

Figure 4.19: Heating expansion tank

Biomass chosen will be wood chip, G100, wood that has been cut into small pieces a few centimetres in size, with humidity below 30 %, with 3.0 kWh/kg of estimated calorific value.

Figure 4.20: Wood chip

The woodchip will be discharged by trucks that have moving floor and a capacity of 24 tons. It is planned to conduct the discharge in the morning, between the time of entry of Miguel Hernández School which is situated in front of the boiler room and the break time of the College. The truck will arrive to the point of supply thanks to an access that has been built for it, so that it is adapted to the weight of the truck. The duration of the discharge operation will have a maximum time of one hour and it frequency depend on the season but it is possible to approximate to two discharges per week in December, January and February, and a discharge per week in November, March and April, and a discharge each fifteen days in May and October and a discharge per month from June to September.

The following photos shows a discharge of biomass and hydraulic hatches through which the biomass is discharged

Figure 4.21: Biomass discharge

Figure 4.22: Hydraulics hatches

This silo will have a surface area of 72.4 m2 and a height of 5.9 m. knowing that the apparent density of the wood chip is 250 kg/m^3 it is possible to calculate the maximum capacity of the silo.

$$Volume\ silo = Surface \cdot height = 72{,}4m^2 \cdot 5{,}9m = 427{,}16m^3$$

$$Maximum\ capacity = \rho_{chip} \cdot V_{silo} = 250\frac{kg}{m^3} \cdot 427{,}16m^3 = 106.790\ kg$$

Wood chips are stored into the biomass silo that has a moving ground to dose the biomass. The movement is provided by a hydraulic system that is located in an adjacent room to the biomass silo. The hydraulic cylinders are arranged alternately, when the first cylinder pulls, pushes the second pushes.

Figure 4.23: Silo ground

Figure 4.24: Hydraulic system

After that, there will be two augers to transport biomass from the silo to the boilers. One of them feds two biomass boilers (1,250 and 950 kW) and the other one feds just one boiler (1,250 kW).

Figure 4.25: Biomass auger

The first step of the combustion process, as we have seen, is the introduction of biomass into the boiler through the auger. There is pre-dried and degassed under a primary process air. The complete degassing is performed on an outdoor grill. Then secondary air is introduced under precise control, so that the synthetic gas is completely burned. That is transmitted to the three heat exchangers of the boiler, getting high heat transfer and a high efficiency.

The following image shows the inside of the boiler where wood chips are burning.

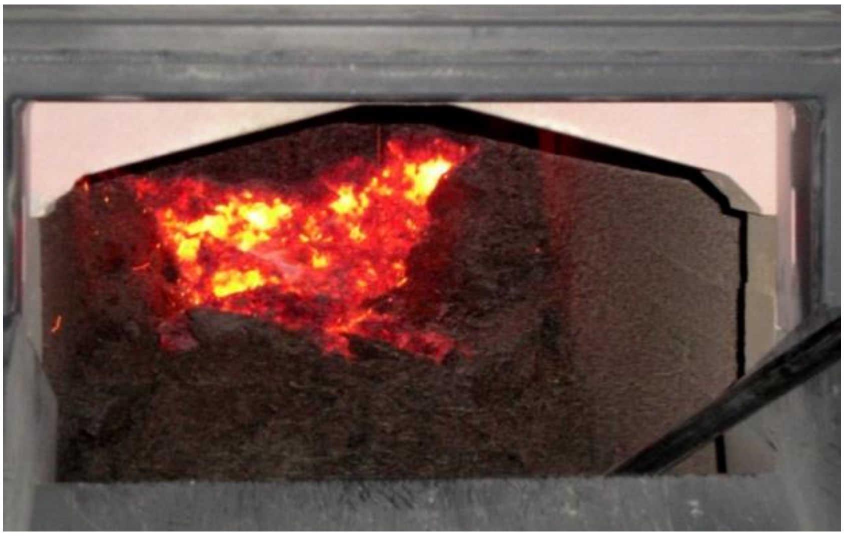


Figure 4.26: Inside of the boiler

The regulations biomass boiler rooms are not clear in the sense of the obligation to install a fire detection system in the tank of biomass accumulation. It was decided to install a fire detection and fire extinguishing with CO_2 to avoid fires.

A fire-fighting system will be installed in the tank of biomass to act in case of fire.

Figure 4.27: Fire-fighting system

The external appearance of the finished boiler room can be seen in the following picture.

Figure 4.28: Biomass boiler outside view

4.2 Plan of Implementation for the District Heating 2

The boilers of the old boiler room of DH2 will remain as support for use in peak periods or lack of supply biomass. Currently, this boiler room is not yet integrated to the district heating because the Community of Owners of Phase II is managed by an energy services contract with different company that cannot be disassociated until 2016. In the future, it will be incorporated in the refurbished DH by performing the necessary actions to integrate into the system.

Global installation is composed by a gas and biomass boiler room and is represented in the next image. A CHP system will be added too, to provide an amount of thermal energy demand of DHW and part of electricity demand that is needed in biomass boiler room.

The existing pump system between DH1 and DH2 should be able to carry water on both directions of traffic.

- In normal operation, if the biomass system is able to cover the heat demand of all dwellings, this system will pump water from the general manifold of DH1 to the hydraulic bottle DH2.
- In situations of failure or lack of supply in the biomass of DH1, this system will pump hot water from the hydraulic bottle located in DH2 to the manifold of DH1. This change in the direction of energy flow is made through a bypass and a set of cutting valves.

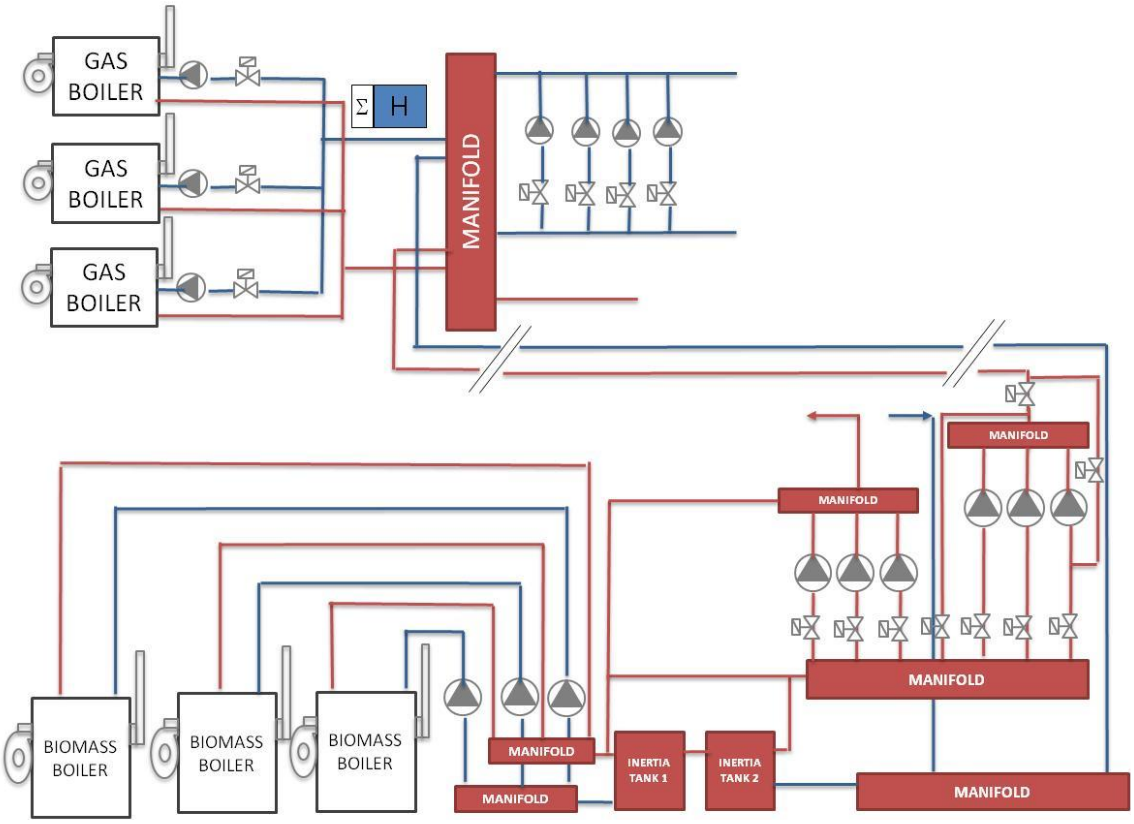


Figure 4.29: Schematic diagram of the future DH

The operating strategy of the facility has been specifically designed so that it works in the best way possible, and the steps are:

- Biomass boilers start producing working against the inertia tank.
- If there is demand, the inertia tank begins to work against the circuit.
- When the inertia tank is cold, biomass boilers work against the inertia tanks.
- If the required power cannot be supplied only through the biomass boilers, control system will send an order that makes biomass boilers to feed the circuit of DH1 and the natural gas boilers to feed the DH2.
- Due to the above, the biomass boilers don´t need to use all his power into the grid so that power can work a part against the ring and a part against the inertia tanks.
- In this way it becomes the initial process.
- If in the morning the inertia tank is hot, it is not necessary that the boiler works and the inertia deposits will work against the circuit.

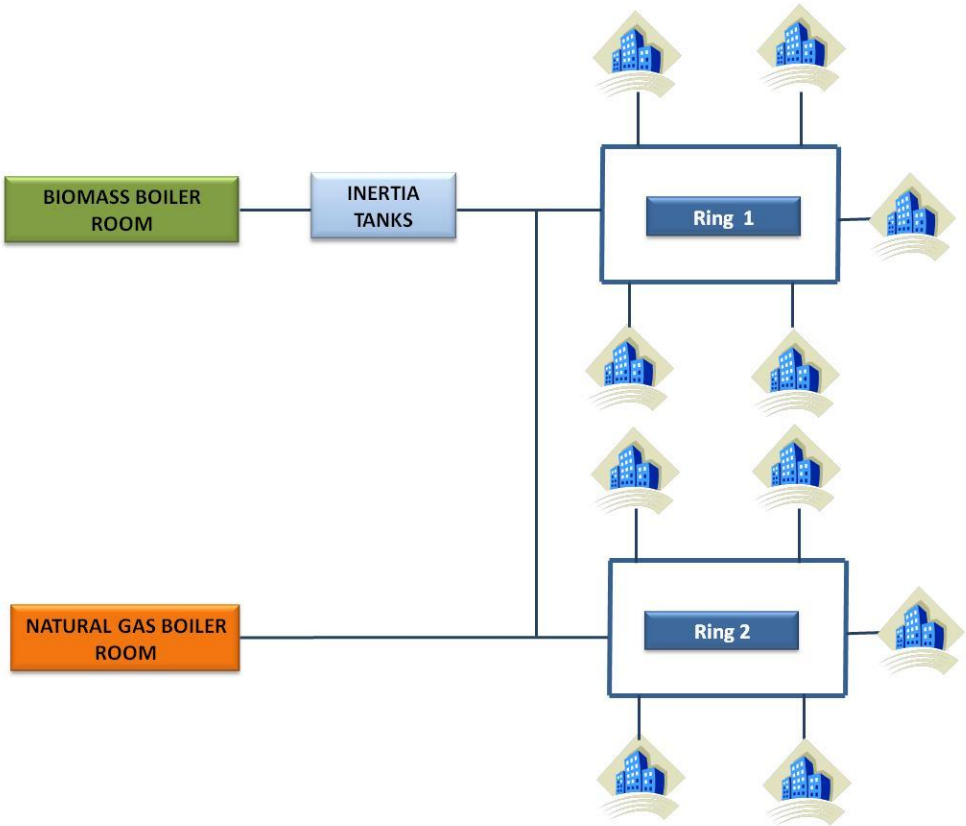


Figure 4.30: Operating strategy

Heat distribution to substations at Phase I will be through existing pipelines of DH1 and heat distribution to substations at Phase II will be through existing pipelines of DH2. There will be a hydraulic connection between central heat production of Phase I, where the fuel is biomass and the current production plant in Phase II, fired by natural gas

The piping layout has been made taking into account the hours of operation of each subsystem and the hydraulic circuit length.

Figure 4.31: Distribution system

4.3 Heating exchange at building level

New DH will have a total of 19 substations. Twelve of them located in Phase I and the reaming 7 in Phase II, as can be seen in the next figure.

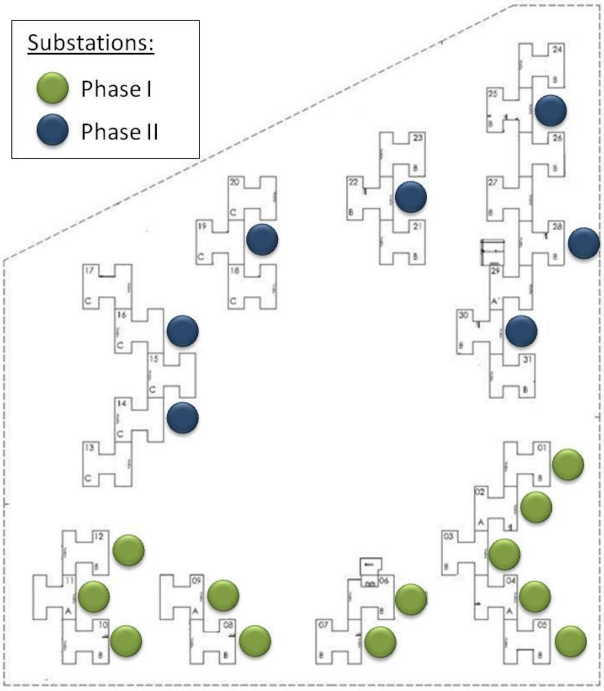


Figure 4.32: Substation location

4.3.1 Substation Phase I

The space where are located the new substations in Phase I is in the storage rooms on the ground floor where bicycles and appliances neighbours are saved. These rooms have a small size of about 9 square meters, and involve the problem of installation of equipment for the exchange of thermal energy between the district heating system and new heating and domestic hot water system. Apart from the inconvenience of installation must take into account that each element requires minimum space for proper maintenance.

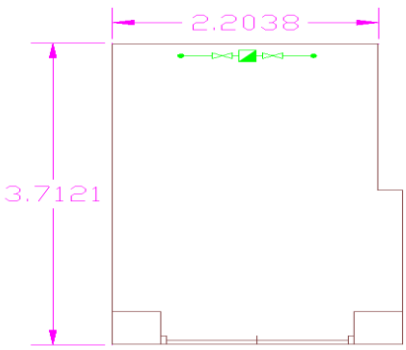


Figure 4.33: Substation space

For these reasons it was decided to make the substations in a specialized industry and then transfer them to assemble. Next table reflects the main equipment installed in these substations and their main characteristics.

Figure 4.34: Substation elements

In the following table are detailed outline the main equipment of the substation thermal energy exchange.

Main equipment	Features
Thermal energy meter (Heating system) with automatic flow equilibrator with 2-way motorized valve.	Belimo energy valve DN 65, Q=25 m3/h, 230 V
Thermal energy meter (Heating system) with automatic flow equilibrator with 2-way motorized valve.	Belimo energy valve DN 40, Q=10 m3/h, 230 V
Automatic flow controller with 2-way motorized valve	2-way motorized valve
Automatic flow regulator k -flow	k -flow -
High efficiency pump Wilo Stratos GIGA 40/1-32/2,3	DN 40/PN16; V=4500 l/min; P=2,3 kW, I=4,7 A,
3-way mixing valve	Kvs=40, DN-50
Manual cutting valve	DN-65, PN-10, Tº: Up to 65ºC
Manual cutting valve	DN-50, PN-10, Tº: Up to 65ºC

Main equipment	Features
Filter (Y)	DN-65, PN-16
Plate heat exchanger (AISI-316)	P= 340 kW, Primary T=85/70ºC, Qp=2,.000 l/h, Secondary temperature=65/80ºC, Qs=20.000 l/h
Security valve	DN-32
2-way valve	Kvs=215, DN-65 Pmax=6bar
Expansion vessel	V=200l , Pmax= 6bar Tmax= 120 ºC
2 way seat valve	kvs=2,5 DN-20, 24V
Energy meter	Q=0,6 m3/h , M-Bus
Expansion vessel	V=200l
Flow switch pipe 2 1/2 "diameter	PN-10.
Thermostatic mixing valve for DHW	T=36-53ºC, Tmax=90ºC, P=10 bar
Retention valve	DN-15 Tª 110ºC. P= 25 kg/cm2
Retention valve	DN-40 Tª 110ºC. P= 25 kg/cm2
Storage tank of 1000 liters capacity for DHW (Dietrich, B-1000)	Pmax (Primary) = 12 bar, Pmax (secondary) = 10 bar
Sphere cutting valve	1 1/2" PN-10
Valve set for the connection between pump and pipe	DN65
Balance cutting valve	DN-15
Steel pipe	UNE-EN-10255, 2 1/2"
Steel pipe	UNE-EN-10255 de 2"

Table 4.2: Substation main equipment

The substation will consist in a 350 kW heat exchanger for heating system. A shutoff valve, regulating flow and differential pressure with 0-10 V control in the primary heat exchanger, which open or close depending on the heat demand of the building, the external conditions and the schedule configured. In the heating exchange stations will have an energy meter to quantify the thermal energy demand of each building. The energy meter raised for this purpose has also incorporated the function of control and equilibration the hydraulic installation and will be equipped with the appropriate communications to be integrated into the control system of district heating network.

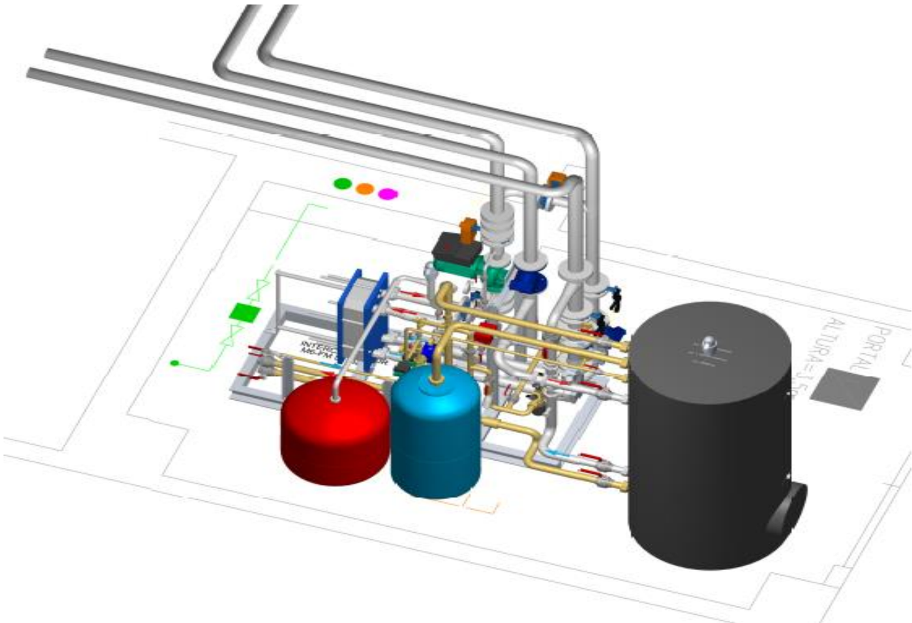


Figure 4.35: Substation scheme

To distribute the thermal energy according to the needs of each building, variable drivers on the circulating pumps will be installed. These pumps are adjusted depending on the flow provided to a pressure sensor installed on the main pipe of each circuit. In the future operation when the pressure increases means that valves on the dwellings are closing and less flow is needed to meet the needs of the building. When the pressure decreases the control system of the facility will increase the flow until get stable pressure in the pipe and maintain the required flow rate in each radiator.

Domestic hot water system will work continuously maintaining a regular set point temperature in the storage tank and circulating the water for circuit consumption. The system is designed for the user to have hot water at any time immediately as will be heating the entire circuit by two pumps will be operating continuously. The reason to duplicate these pumps is because it expected to work continuously and must ensure service to customers. A thermostatic mixing valve in the distribution of DHW will be installed to manage the temperature in the circuit.

The Domestic hot Water accumulator will have an energy meter to quantify the energy demand. The energy meter raised for this purpose has also incorporated the function of control and equilibration the hydraulic installation and will be equipped with the appropriate communications to be integrated into the control system of district heating network. Some temperature sensors will send sufficient information to the control system to command the various valves, pumps, security systems, etc.

Figure 4.36: Accumulator for DHW

Figure 4.37: DWH and heating expansion vessel and heat exchanger

At the portals 1 and 12, which are the ends of each of the two branches portals, this valve is replaced by a three-way valve and a flow, so we ensure a minimum flow for each branch, always keeping the flow is demanded.

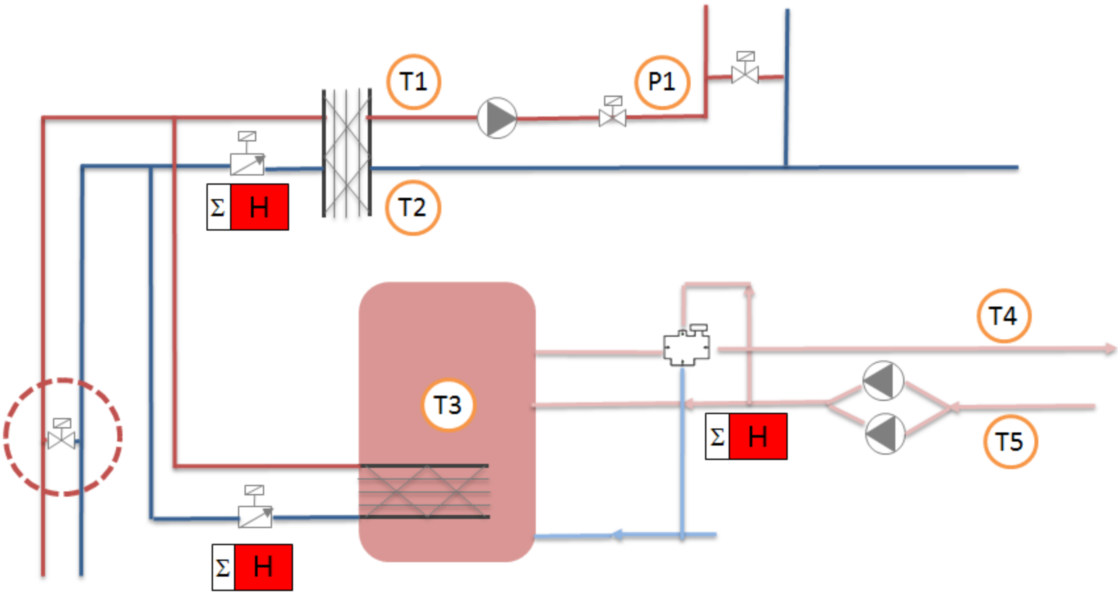


Figure 4.38: Substation number 1 and 12 scheme

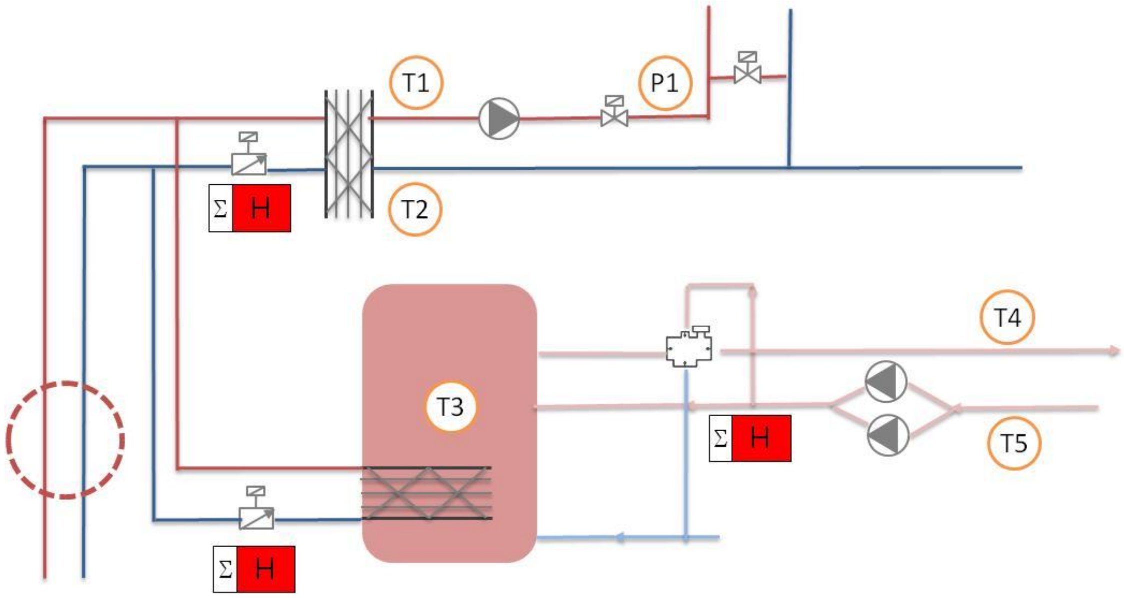


Figure 4.39: Substation number 2 to 11 scheme

4.3.2 Substation Phase II

The seven existing substations in DH2 will be used to distribute thermal energy to the buildings of Phase II. There is a heating exchanger of 820 kW or 1,250 kW, depending on the substation and two 1,000 litres inter accumulators for the production and storage of DWH. A counter of thermal energy in distributing heat to each building and another counter in the production of DWH will be installed.

Keep in mind that the idea is to integrate the whole DH into a single heat regulation and control system. For this reason, remove some of the existing items and others will be installed.

Substation	Interventions
Buildings 13 and 14. Buildings 15, 16 and 17. Buildings 18, 19 and 20. Buildings 30 and 31.	Existing heating pumps will be maintained. The current cut off valves in heating and DHW systems shall be substituted for equilibration and control valves with thermal energy meter incorporated.
Buildings 21, 22 and 23. Buildings 24, 25 and 26. Buildings 27, 28 and 29.	Existing heating pumps will be maintained. These substations have two pumps operating alternately distributing water to the three portals. It aims to change all the secondary heat exchanger, installing two manifolds and pump distribution for each portal. A mixing valve shall be installed before each pump to vary the flow temperature depending on the outside temperature. The current cut off valves in heating and DHW systems shall be substituted for equilibration and control valves with thermal energy meter incorporated.

Table 4.3: Interventions in substation Phase II

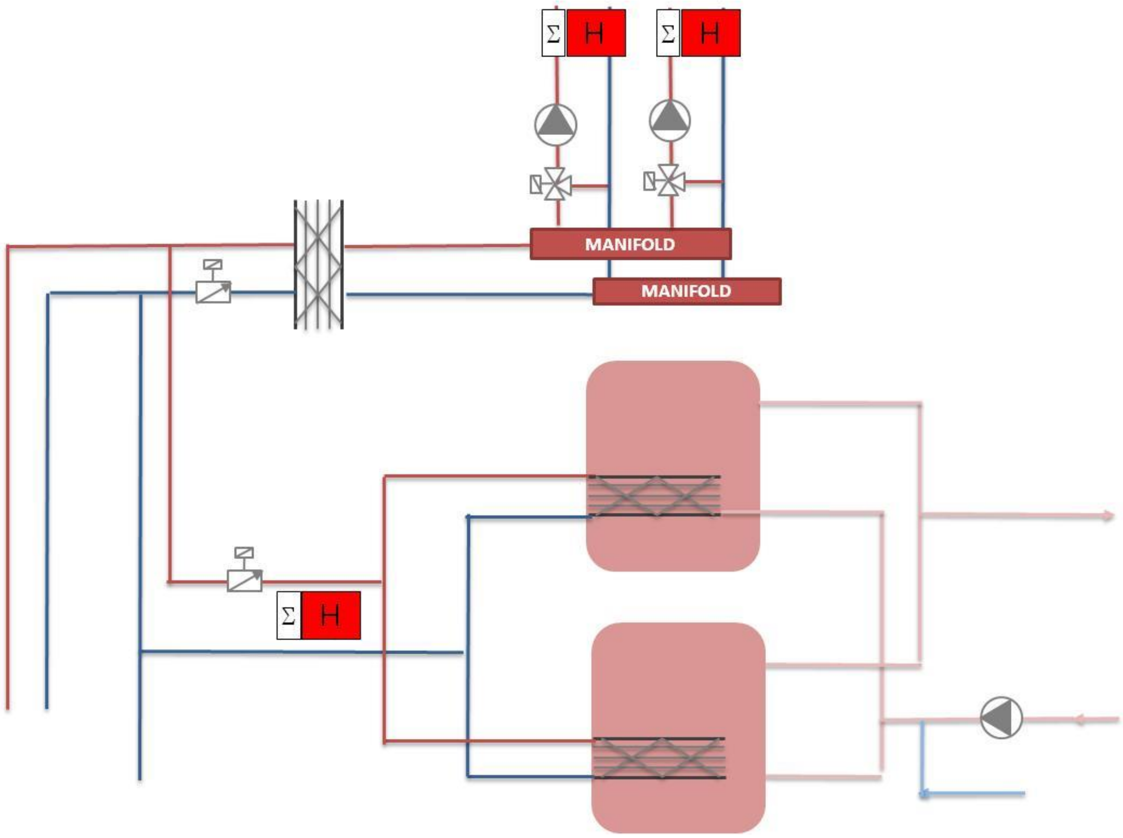


Figure 4.40: Substation scheme

4.4 Cogeneration heat power

It is intended to install a renewable energy system that will contribute to the installation of thermal and electric energy for self-consumption. CHP, that is an efficient and clean approach to generate electric power and useful thermal energy from a single fuel source, will be implemented. The diagram scheme is represented in the next figure.

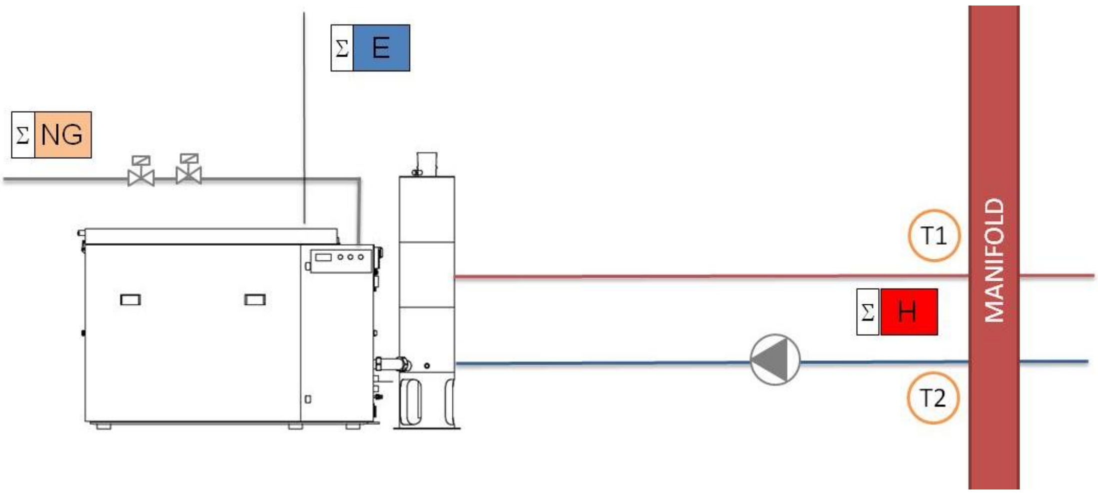


Figure 4.41: Schematic diagram of cogeneration system

There are two possible ways to size the CHP Plant. One way is using thermal demand and the other one is using electric demand.

- Electricity demand is composed by the sum of the electrical demands of the boiler rooms, substations, block elevators and common areas of the different dwellings.
- Thermal demand is composed by the sum of heating and DHW.

CHP decision is based on the next steps:

- Calculate thermal and electric demand of the installation.
- Calculate CHP size.
- Determine CHP plant sizing from electric demand.
- Determine CHP plant sizing from thermal demand.
- Decision between the best sizing election.
- Calculation of the energetic parameters.
- Economic analysis.

The current Spanish legislation taxed pouring surplus electricity to the grid and the price of the batteries make the best scenario for the installation of a cogeneration plant sized for the self-electric consumption.

The main difficulty in accurately size the facility for own consumption resides in the exactly knowledge of the electrical energy used in each moment to assess the possibility of covering the electrical demand through cogeneration plant and dimension it in the best way possible balancing all technical constraints and economical. For these reasons CHP will be sizing from electric demand in self-consumption.

Nowadays we have two possible supplies of natural gas and therefore two possible locations of cogeneration equipment. It could be located into old natural gas boiler room in Phase I near the new biomass boiler room or into natural gas boiler room in Phase II. The idea is to produce the energy that it is possible to consume by the installation in that moment, so a base demand is going to be use for the sizing to avoid losses. The best option to increase the operating hours of the CHP equipment is sizing to cover the electrical demands of the DHW demand system.

CHP could be located into natural gas boiler room of Phase I to cover the into biomass boiler room. The electric energy will be use in this boiling room so electric losses will be reduced. Next to biomass room was natural gas boiling room number 1, so it is easy to feed the CHP plant with this type of fuel.

Thermal energy surplus could be stored in the different inter accumulators of the substations. As we know, there are 12 substations in Phase I with an accumulator of 1,000 litres in each one and there are seven substations in Phase II with two accumulators of 1,000 litres in each one.

Thermal energy produce from this CHP will be use in the district heating to cover a percentage of DWH energy. There is the possibility to add the electric energy in the near substations.

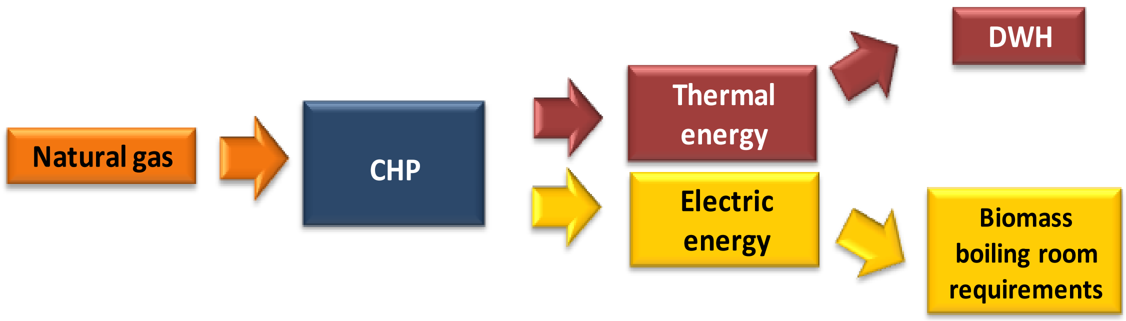


Figure 4.42: CHP energy use

The technical and economic viability is being studying to choose the best cogeneration installation.

4.5 Building Management System

For the management of DH system an advanced control system using a communication architecture distributed in star topology is going to be implemented. Control panels will be implemented in each generation system and exchange substations for the management of heating and DHW in each building. The control panels in each subsystem will be managed by a Trend IQ3 device system with some expansion cards for collecting facilities signals. Each control panel is sized to handle the required variables of each subsystem and be able to perform all tests and tasks that have been raised in this project.

We opted for the implementation of the whole control system through the renowned brand Trend because we are integrators of this system. This is an advantage in a project of these characteristics in which they intend to test and evaluate different strategies and measures of saving and energy efficiency. We have taken into account the key indicators by which performance measures and raised energetic efficiency savings are evaluated. In the following graphic general scheme with data points variables for the boiler room are showed.

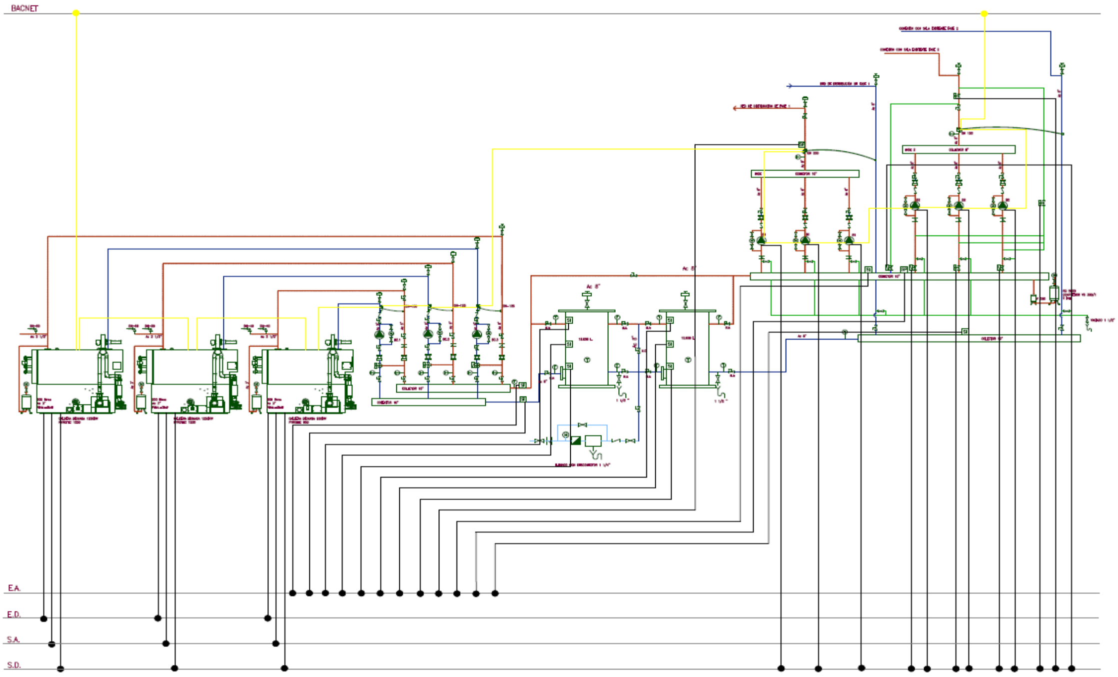


Figure 4.43: Data points in the boiler biomass room

It is proposed to integrate all subsystem of the DH in a Building Management System for regulation and control. The control panels of the facility will have enough inputs and outputs to manage the energetic demands of each substation and adjust the power delivered by the generator of heat. In the next graphic, general schemes with data points of variables for the heat exchange substations are represented.

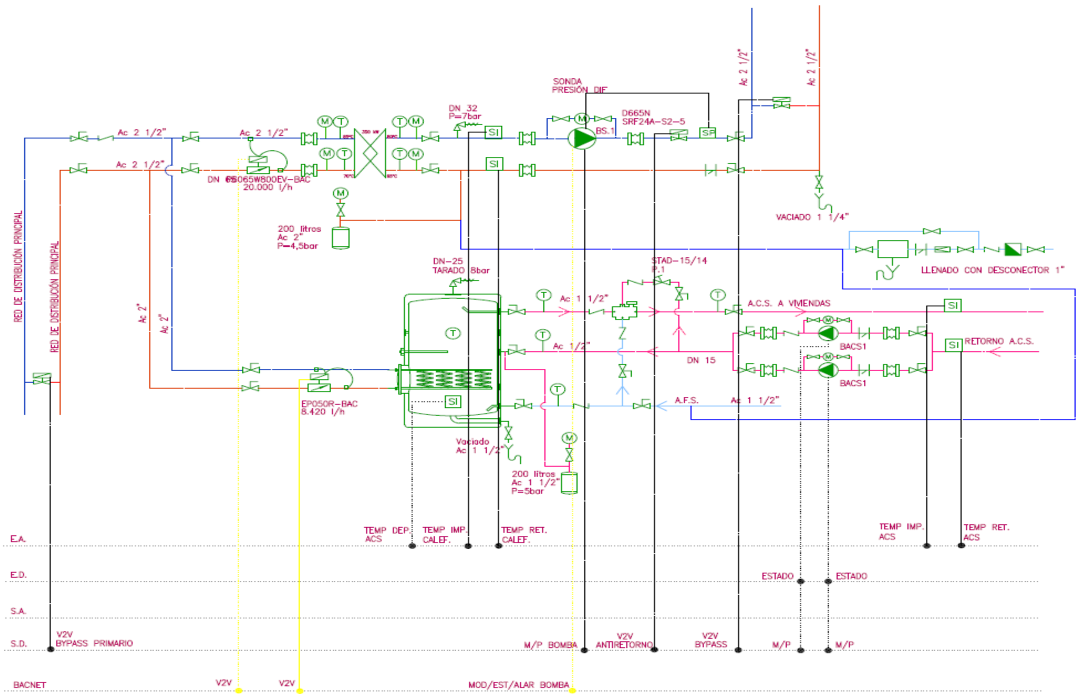


Figure 4.44: Data points in the substation

The BMS is communicated through Ethernet technologies and TCP / IP network. The IQ3 controller includes a web server that can provide access to the user through their website, or a PC or mobile device running Internet browser. The controller is accessible through any place with appropriate security settings network and necessary permissions for each level, through an internet connection. The security system enables access to particular groups of pages to be restricted so that users are only presented with the necessary information.

Figure 4.45: BMS in Torrelago DH

All control systems are connected to supervisory 963 Trend software. This supervisory software provides the user, with colour graphics pages, live information from the system and enables parameters to be adjusted. The pages can be engineered to suit the individual system requirements, backdrop, multiple graphic images, trends pages, error, alarm, overridden text, active content, and variables from the system, and maps of variables.

These Control panels will be connected via network cable and a data bus with Bacnet protocol touring all buildings. The communications architecture of the system is shown in the following graph that represents the union of all buildings in the neighbourhood Torrelago.

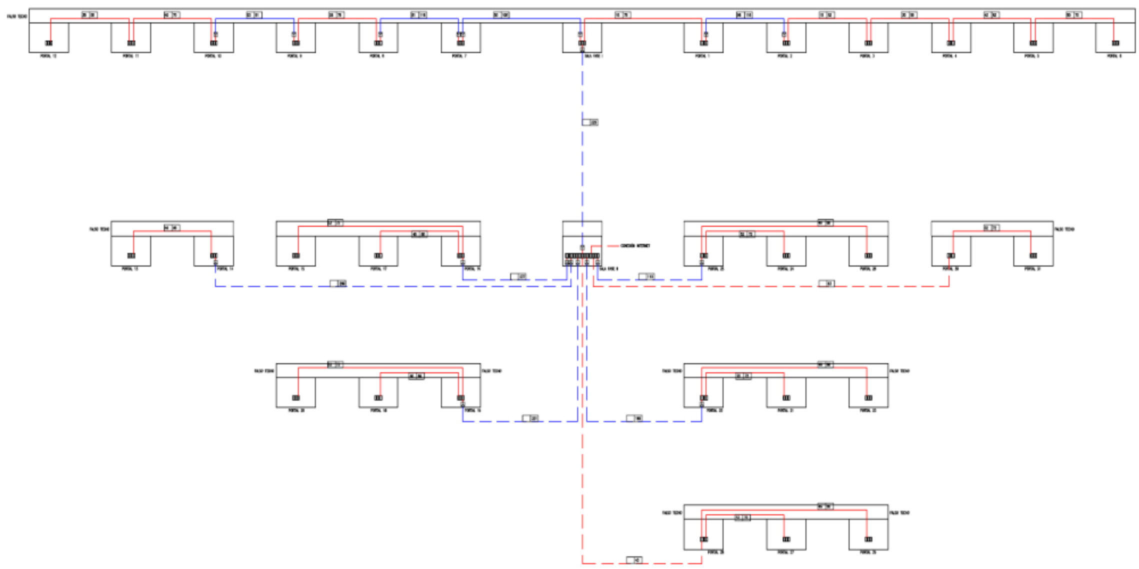


Figure 4.46: Communication architecture

The boilers are operated by a control system that manages all the parameters involved in the generation of heat as well as the system of transfer of biomass. For the integration of the boilers in the building control system, a gateway communication via Modbus protocol and Trend has been implemented to be able to integrate all the variables that are important for the proper development of the project.

Figure 4.47: Gateway device

For the integration of heating and DHW systems in substations it has opted for integration through Bacnet communication protocol of heat pumps and energy counters. These energy meters are also accessible via internet because they have their own Web server for monitoring.

Figure 4.48: Equilibration and control valves with thermal energy meter.

The control panel of the boiler room will include a master controller and the necessary cards to manage all inputs and outputs and a Modbus communication gateway for integrating the control system of the heat generation system.

Figure 4.49: Building Management System

4.5.1 Individual thermal comfort control

One of the main goals of any energy system is trying to adjust production to demand, for it has proceeded to identify the facility building level and end-user level, thus complying with Directive 2012/27/EU European Parliament [3] concerning energy efficiency by forcing the Spanish households with central heating installations apposes individual counters before December 31, 2016.

Initially, end users did not have any individual household level regulation, presenting disagreements of overheating in the central floors and high internal temperature loss after heating system stopped for schedule.

Each building has a distribution ring in which there is a single point of entry and exit of heating in each dwelling. In this type of distribution there is a circuit that goes through all the radiators and that is connected to the general line , so that distribution grid run through common areas to the utility ducts in the stairwells continuing circular distribution circuits to each area of the building.

In the following figure is represented current circuit flowing through the radiators of different dwellings. In the future, a two -way monitored valve and an energy counter will be installed.

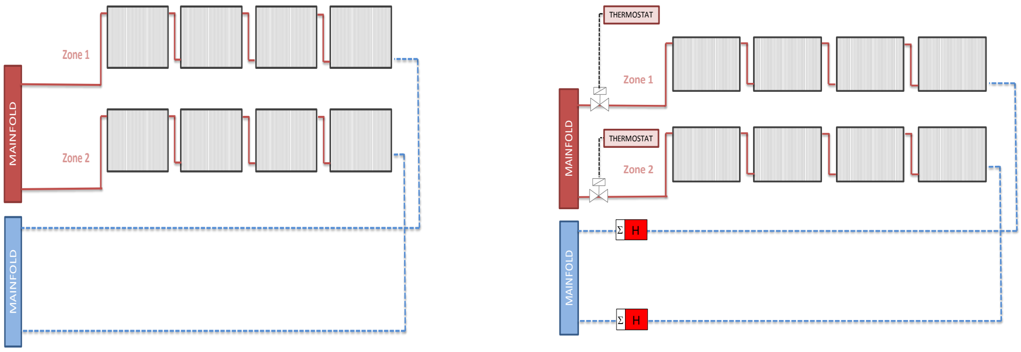


Figure 4.50: Detail of actual and future state of the radiator circuit in each dwelling

Temperature will be regulated from a thermostat that will be installed in each dwelling. Thanks to the installation of this system it will be possible to measure the individual consumption of each dwelling and it will allows to take decisions to each neighbour on monitoring the use of the heating system in your own home. The thermostat is connected to a monitored cutting valve located at the input of each of the dwellings.

The end user will have the ability to decide the comfort temperature, avoiding overheating of the central plants and houses south orientations and west and avoiding actions such as opening windows excess heat addition decide on what are the hours of use of the system depending on their availability, thus avoiding consumption empty homes.

By implementing these measures, demand in each building will be reduced as a result of the reduction of individual demand and thus will reduce the overall demand.

4.5.2 Electrical generation

During the project the installation of a cogeneration equipment to provide thermal and electrical energy for own consumption of district heating network has been proposed.

To design the installation of cogeneration in consumption it is essential to have real information of the thermal and electrical energy demand for with a high enough frequency to discriminate operating hours of each equipment in each specific condition.

This is one of the reasons for having delayed the installation of cogeneration equipment because it still has not been evaluated by the various tools and tasks to be developed throughout the course of the project to determine the best solution for generating electrical energy in a distributed way.

In Spain still auto power consumption has not been regulated but it is envisaged that the government will create a tax toll for the use of the electric network. Thereby the facilities intending to sell its surplus electric power network must pay it. Energy generating facilities that may arise negotiate a net balance that involves the possibility of using electric power network as a permanent storage in the event that energy demand are supplied before the network can be deducted and the final balance with the distribution company's network of electric power.

The project is currently evaluating various strategies for the use of electricity if the integrated heat power generation in order to obtain the best possible performance for all equipment involved in the process of power generation.

To include thermal and electrical storages is being evaluated to optimize energy consumption or the possibility of installing a new electrical distribution network to cover different consumers in different places that allows us to increase the hours of operation in which you can consume the energy produced.

With regard to information on individual electrical energy consumption of each dwelling, is proceeding to replace all energy meters for new ones with communications capability through Power Line protocol using electric power network to transmit and receive information.

This meter replacement is currently being carried out gradually and will be completed this year. We have held meetings with officials from the distributor of electrical energy to raise the meter installation of additional electrical energy but we have been told that this solution is not compatible with your communications infrastructure and can alter the measured data.

The other option we have proposed them is to install a gateway for communication between computers that allow us to access the system that stores consumption logs to collect information required for the project. In the event that we cannot allow the integration of the existing system with the platform referred for the project we could apply consumption data for each individually neighbours but we keep to the frequency and amount of data that we provide.

Figure 4.51: Detail of actual electrical energy meter.

For demand management and energy generation is going to be implemented an advanced control system that is able to optimize each system to obtain the best possible performance at all times. The aim is to find the strategies that are most suitable in different conditions and energy systems.

A meteorological station with temperature sensors, humidity, radiation, wind speed and direction implement a meteorological station with temperature sensors, humidity, radiation, wind speed and direction will be implemented to give us real information about the behaviour of buildings depending on outside weather conditions.

Figure 4.52: Weather stations.

The purpose of this section address several specific improvements in the area of distributed power generation and management of energy demand through innovative and effective solutions for monitoring and home automation control systems and the ongoing optimization of each subsystem using control strategies that allow matching supply and demand.

5 Smart grid interventions and ICT

CITyFiED Smart Grid platform will manage the energy consumption of a district by using ICT technologies for grid management solutions. The objectives of CITyFiED platform is reducing energy demand as far as possible by means of the implementation of innovative and cost effective ICT solutions. This CITyFiED platform will interconnect and manage all the devices and intelligent systems and it will also manage them individually in a hierarchical network.

The figure below shows the Smart Grid and ICT measures that are going to be deployed in the Spanish demo site. There have been defined three levels: District (DEMS), Building (BEMS) and Homes (HEMS). The first one gathers the information at generation and distribution level from the district heating; building level monitors the energy flows for each of the buildings in the Torrelago district; and, finally, homes collects the individual energy consumption at dwelling level. A representative number of homes will also include several enhancements which will give the user greater comfort and a certain improvement in the home energy efficiency, to be measured and compared with the rest of the dwellings which do not include these devices.

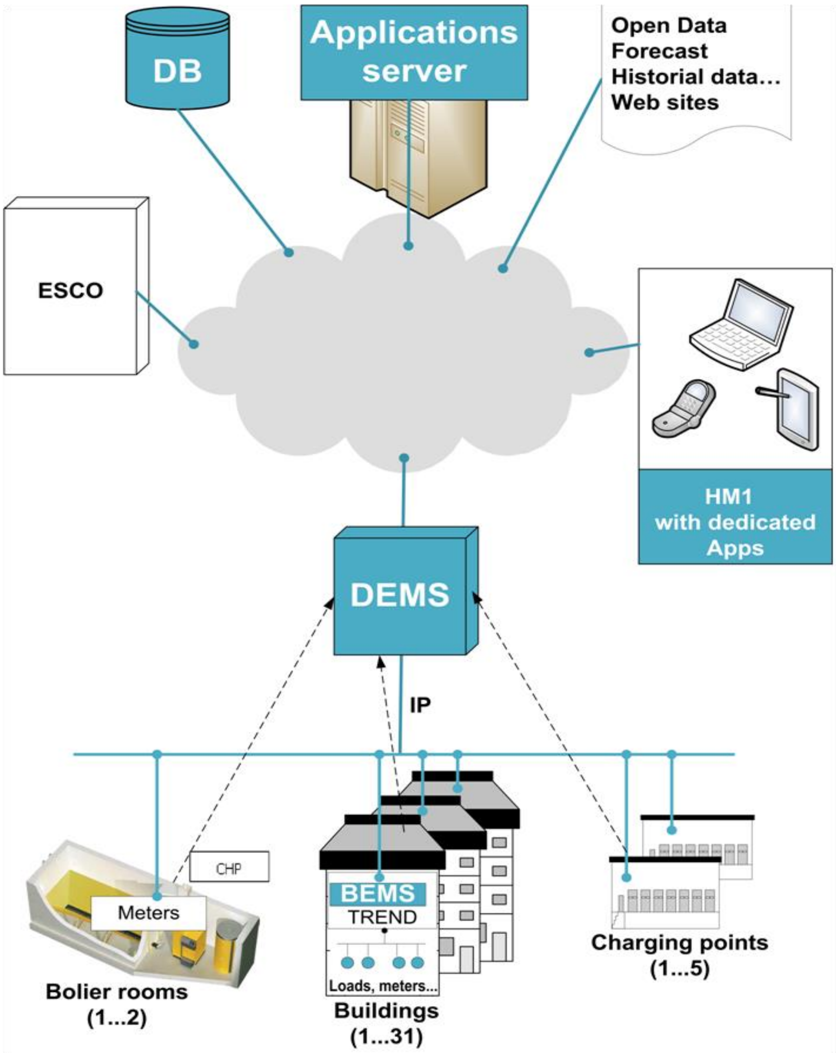


Figure 5.1: Smart Grid and ICT system in Torrelago

The elements/equipment that make part of the Smart Grid and ICT system are listed below:

- Combined Heat and Power (CHP)
- Electrical Vehicles recharging points
- Electricity Smart Meters
- Heat Smart Meters
- Visualization tools
- Monitoring program
- Database system
- Smart Grid Management

5.1 General installation plan for the Smart Grid and ICT

This plan corresponds to the installation of the necessary equipment for the Smart Grid and ICT systems. It is applicable for the installation of the three levels (DEMS, BEMS and HEMS) equipment. The commissioning and tests procedure is described in deliverable D4.7 "Commissioning and test procedure for the Spanish demonstrator".

Diagram

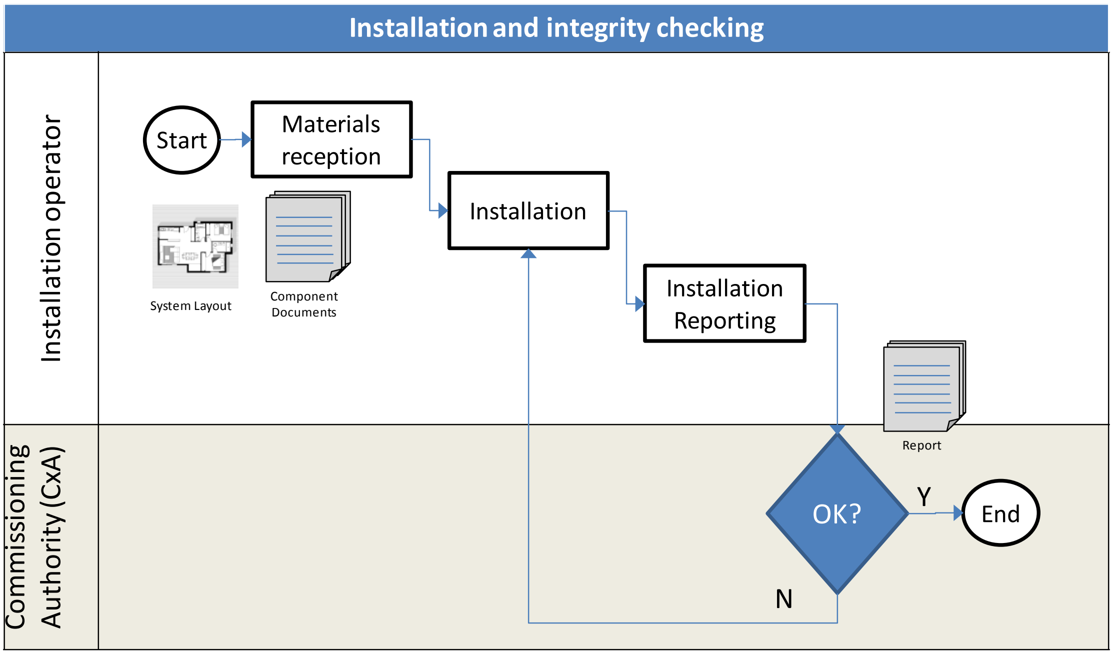


Figure 5.2: Installation plan and integrity checking diagram

Description of activities

As it is shown in the figure above, the planned activities related to the installation are:

- Reception of materials needed for the installation of the equipment, checking if the systems are in a good conditions to be installed (they have no dents, no signs of oxidation; they are also labelled with material features, etc.). These systems must undergo a conformity check according to the details contained in the drawings (a record can be set for each of the received equipment).
- Wiring and systems installation following the wiring diagrams of available items. The weight of this activity depends on whether the equipment is going to be or not wired (power supply, data, etc.). The system to be installed in homes, for example, follows a Plug & Play scheme and is wireless.
- Reporting of the installation: After the installation, the installer will register that the installation is consistent with the defined requirements.

The validation of the system is via a check-list that reviews whether all the features of the facility have been carried out properly and according to the provided installation drawings, following the rules established for this type of installations and by a reception recording that shows that all systems are OK and that they have been installed according to the manufacturer's recommendations.

Inputs/Outputs

The inputs for this plan are:

- Documents of the equipment to be installed (manuals, instructions, etc.).
- Layout of the equipment installation.

The outputs of this plan are:

- Recording of the installation.
- Validation checklist.

Participants

The participants in the development of this equipment installation plan are the following ones:

- The person responsible for the equipment installation, who is in charge for validating that the installation, is being carried out according to the standards.
- The installation technician who will be in charge of receiving and verifying materials, installing the equipment according to the proposed installation layout and registering that the installation has followed the indicated guidelines.

5.2 Combined Heat and Power (CHP)

It is planned to prioritize and increase the use of this technology because has a high performance and can contribute to the objectives of the project. We try to increase as much as possible the hours of operation of cogeneration equipment. For this reason the cogeneration system will be use to supply a part of DWH system since is greater demand hours operation. Next figure shows the operation strategy after the implementation of this technology into the grid. The first thermal power required by the installation will be provided by the CHP system. At the moment that this requirement is more than the power that could be provided by the cogeneration system, biomass boilers begin to produce. If the sum of CHP and biomass boilers power isn´t enough, natural gas boilers begin to produce too.

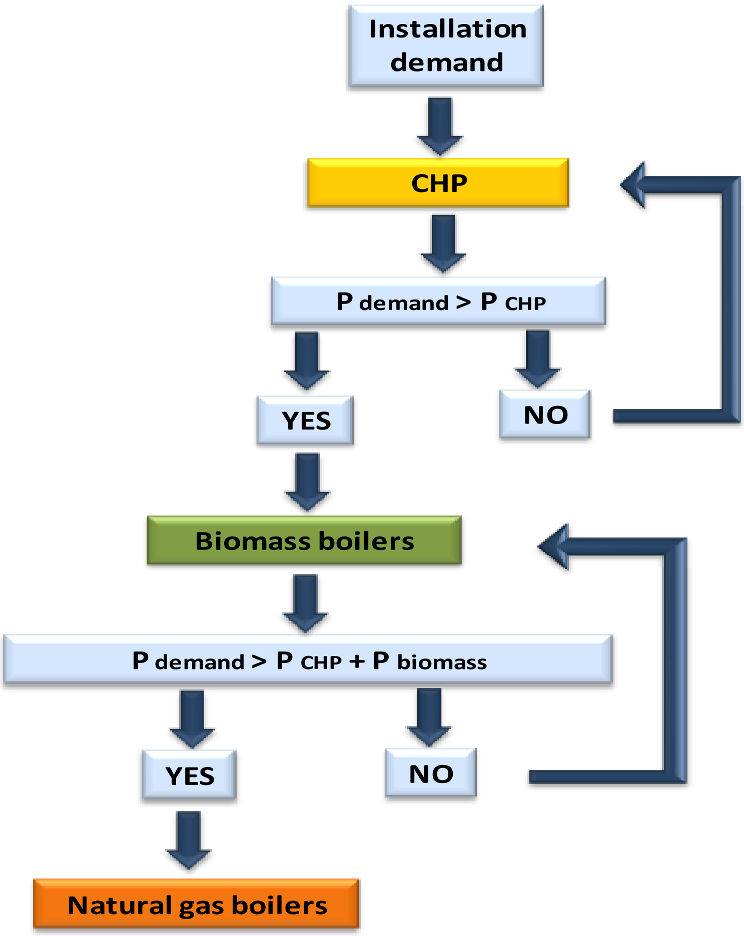


Figure 5.3: Operation strategy

Electrical Vehicles recharging points

Around Torrelago district there are five parking areas, highlighted in the figure below. In each of them, different charging points for electric vehicles and electric bicycles will be installed.

This actuation is fully aligned with the mobility plans of both Laguna and Valladolid municipalities, been both included in the metropolitan area, in which smart and sustainable mobility between both cities is endorsed.

Figure 5.4: Recharging points for Electrical Vehicles
(Source: DoW)

Although the manufacturer and model of the Electrical Vehicles recharging point has not being selected yet (the Figure below shows one of the equipment that are being analysed), the main installation steps are very similar for all of them.

Figure 5.5: Fagor Electronics' recharging points

These are the main steps for the installation of an Electrical Vehicles recharging point:

- **Pedestal:**
    - Site preparation: The installer can use a prefabricated anchor or make his according to the pattern described in the manual.
    - Concrete base: The base can be prefabricated or made on site using concrete formwork.

  - An electrical conduit sized properly for the type of electrical cable used shall be installed in a way that it brings the electrical cables in the centre of the anchor.
  - The dimension of the top of the base and the position of the anchor shall be determined according to the specific charging station configuration.
  - Base installation: It is the installation of the main structure over the concrete base. It depends on the type of base: single, double, quadruple or wall.

- **Connection:** the wires have to be pulled to proceed with the connection as shown on the drawings described in the manual.
- **Front panel & base cover installation**
- **Installation of charging station head on its base**
- **Installation of a connector module**
- **Preliminary tests & commissioning:** this phase is explained in deliverable D4.7 “Commissioning and test procedure of the Spanish demonstrator”.

5.3 Electricity Smart Meters

The installation of those meters in homes and buildings is out of the scope of this deliverable. Iberdrola [4], one of the Spanish utilities, has installed Smart Meters in Torrelago dwellings and buildings. In principle, they are a new line of meters, with capabilities of third part access that can inform about inhabitants’ real time consumption. Some negotiations have being carried with them to allow CITyFiED project to access that data.

It is envisaged that the project monitoring platform can provide to each neighbour power consumption data to assist in the task of awareness of the need to reduce energy expenditure.

These profiles will be able to provide more energy consumption information to citizens to enable them to adjust their energy demand and thus reduce consumption.

To the knowledge of these specifics perhaps have to make an authorization for each neighbour because he is the owner of the energy consumption data.

5.4 Heat Smart Meters

In the district Torrelago demonstrator thermal energy counters will be installed to monitor all energy flows from generation to consumption in each dwelling.

The energy counters will be implemented in each boiler, in each subsystem of each substation and each dwelling.

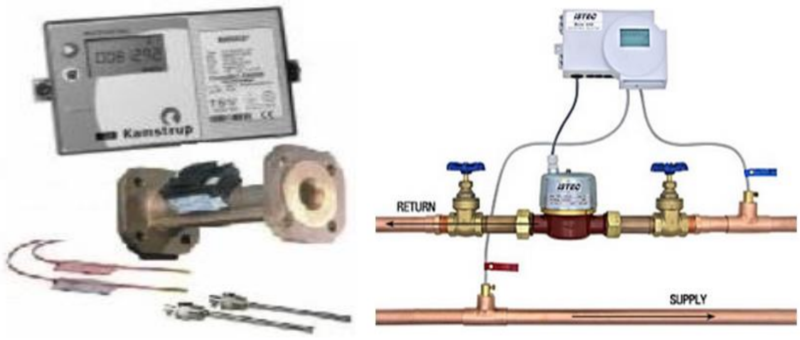


Figure 5.6: Thermal energy meters
(Source: http://www.kamstrup.com, http://www.istec.-corp.com)

Therefore consider that it will have sufficient information at all levels to assess the losses and get optimize the performance of the entire installation.

5.5 Visualization tools

User HMI Interfaces will provide management information such as home status and data, consumptions historical and trending, external agents' incoming information (utilities price), etc. over an Internet platform and extensible under user demand to different platforms: TV, PC, tablets and Smart phones. The interfaces will show dashboard like graphics that will help users decide on consumption issues, receive alerts trigger by unnecessary waste of energy or allow users to communicate with home devices remotely among other functions. Thus, users will program devices to run on off-peak hours, switch energy providers or receive alerts under demand on a switch light that was forgotten on.

All the information needed about visualization tools (description, functionality, interface, etc.) is going to be found in D2.14 "Report on the actual experience from the demo sites as well as experiences and results found in literature, how to visualize results, communicate information to citizens and influence their attitude about local production of renewable energy (electricity from photovoltaic)".

5.6 Monitoring program

The main objective of this program is to gather data from different sources in order to provide CITyFiED with the necessary information (KPI) to validate the energy approaches implemented in the project. To do that, besides the data gathered from the three levels described above, open source information will be collected. The monitoring system will also empower the different agents by providing them with information and tools that supports their energy consumption decisions. To that end, some of the dwellings will install additional equipment for the monitoring of the electrical appliances and comfort parameters. This equipment, by Current Cost, includes Monitor/Energy Manager P with temperature sensor, transmitter, IAM plug sensors and internet connection module. A more detailed description is provided in the following table:

Device	Description	
Monitor/Energy Manager P		1 Manager per dwelling.
Transmitter		1 transmitter per dwelling. Its jaw is encircled and clamped around the mains wire for overall consumption monitoring.
IAM (Individual Appliance Monitor) Plug Sensor		4 IAMs Plug sensors per dwelling to measure up to 4 appliances.
Netsmart internet module		1 Netsmart internet module per dwelling to connect the manager to Internet.
Temperature Sensor		Additional temperature sensor per dwelling for measuring the temperature of comfort in another room.

Figure 5.7: Monitoring equipment to be installed at homes
(Source: http://www.currentcost.com/products.html)

All the issues related to the monitoring infrastructure and program are out of the scope of this deliverable and will be described in a specific deliverable of T4.4 “Monitoring programme definition” named D4.13 “Monitoring program of the Spanish demonstrator” and due to month 17. That includes the installation and commissioning of the above mentioned equipment.

5.7 Database system

The proposed database system at district level will manipulate and securely store the data for years, providing useful, globally-accessible information. This information will be accessed by the Energy Management System (EMS) that will share information gathered and analyzed from the three levels management systems. Microsoft Azzure [5] will be the Cloud service that will be used for this proposed.

As this Database is an important element of the Monitoring system, it will be detailed within deliverable D4.13 “Monitoring program of the Spanish demonstrator”.

5.8 Smart Grid Management

Smart Grid strategy concept is similar to the monitoring one as they use the same ICT infrastructure to achieve their aim. The installation and commissioning of this infrastructure is, therefore, described within D4.13 “Monitoring program of the Spanish demonstrator”.

Interoperable communication protocols and data models will be used to make connection with the District and the Building Manager and the ESCO.

The Home Manager will also be able to communicate with the building controller and with the ESCO. That will allow the seamless integration of the home level energy management with the community level energy management and above. The whole home behaves as an active node of the Smart Grid answering the energy demand indications automatically. The energy management software module will be able to operate integrating different electric loads and taking into account both the economic and technical indications from the utilities and the users’ priorities. The objective is to provide recommendations to residents based on their consumption habits taking into consideration the peaks and valleys offered by energy service providers, as well as KPIs and density of users. In this way, the capacity to design an algorithm that launches customized recommendations to residents depends on their appliance usage avoiding sending the same recommendations to every user at the same time.

6 Private procurement processes

6.1 End-users acceptance

The retrofitting works are currently being carried out in Torrelago. From the beginning of the project until the present time, the end-users' acceptance can be described as good. The residents themselves decided to get involved in CITyFiED and, as shown in the following paragraph, their impressions about the project are good.

6.1.1 Residents votes and contracts with companies

Before the beginning of CITyFiED, the residents of Torrelago expressed their interest and acceptance of the project by means of votes taken by both Communities of Owners. More detailed information about this issue can be found in D4.1 "Technical definition of the Spanish demo Site (Laguna de Duero, Valladolid, Spain)" [1].

On the one hand, on 15th June 2013, the Community of Owners of Phase I celebrated an Extraordinary General Meeting, aiming at discussing and voting the approval or rejection of the CITyFiED project. The owners were informed by mail about the result of the voting 15 days after the Extraordinary General Meeting. 245 people (172 attendees and 73 by delegation) took part in Extraordinary General Meeting, being the result of the voting 235 votes in favour; 6 votes against and 3 abstentions. Spanish regulation allows to change the vote within a period of 3 months after Extraordinary General Meeting, and it should be highlighted that no one from the Community of Owners of Phase I changed its approval vote to a rejection vote.

On the other hand, on 22th June 2013, the Community of Owners of Phase II celebrated an Extraordinary General Meeting, aiming at discussing and voting the approval or rejection of the CITyFiED project. The owners were informed by mail about the result of the voting 15 days after the Extraordinary General Meeting. 392 people took part in Extraordinary General Meeting, being the result of the voting 295 votes in favour; 71 votes against and 6 abstentions (Figure 2.55). Spanish regulation allows changing the vote within a period of 3 months after Extraordinary General Meeting, and it should be highlighted that no one from the Community of Owners of Phase II changed its approval vote to a rejection vote.

Finally, on September 2013, the private contracts between both Communities of Owners and DAL and 3IA were signed. Afterwards, several informative meetings between the residents and DAL and 3IA were organized in order to solve the end-users' doubts.

6.1.2 Questionnaires

For the time being, the end-users' acceptance of the CITyFiED project has been evaluated by means of the distribution of a questionnaire between the residents of Torrelago. More information about its purpose, structure and contents can be found in D4.1 “Technical definition of the Spanish demo Site (Laguna de Duero, Valladolid, Spain)” [1].

Section IV of this questionnaire is devoted the residents’ acceptance of the CITyFiED project. About this issue, 70.9 % of the residents who answered to the questionnaire (8.5% of all dwellings and 9.4 % of the inhabited ones) said that “they think that they have received sufficient and adequate information about the CITyFiED project”, whereas 22.8 % of residents disagreed with this statement and 6.3 % did not provide any information.

When asked whether they have some cause for dissatisfaction or concern regarding the CITyFiED project, 63 % of the residents did not expressed any concern, and the 37% expressed their concern regarding the next issues: worry about the project being finally a burden on their finances; concern with a lack of information about the project; worry about the aging of the materials and/or possible need of expensive maintenance; concern with the slowness of the works or of the project; worry about the lattices of the balconies not being refurbished; worry about the strict adherence to deadlines, budgets and materials; doubts about the quality of the refurbishment materials being used.

6.2 Licenses and permits

In this section the different procedures and requirements for obtaining permits and licenses are described, as well as the needs of technical projects.

6.2.1 Buildings retrofitting

In Spain, a different number of administrative processes are necessary depending on the type of construction intervention. It is necessary to consider that it cannot work on the project if appropriate permits are not defined as well as the responsibilities of stakeholders. This involves: installers, construction, scaffolding, materials and agents. Therefore, to begin work has performed an exhaustive documentation.

Building permit was obtained before the construction on any building began. This permit is compulsory for any work carried out on an existing building; change exterior appearance, modify the volume, or where extra finish will be created.

There are two types of building permits:

- Permit for minor works: walls, terraces and appearance.
- Permit for major works: new buildings, alterations, and demolitions.

To obtain a building permit for works, you need simply request a permit at Laguna de Duero Town Hall. Normally this should include a description of the work to be undertaken and an estimation of the costs. This so that taxes can be calculated. The tax ICIO is paid at the beginning of the job and is normally calculated at around 4 % of the construction cost.

Building permit

To obtain a building permit for major works is necessary at least to have the sign of three professionals to the application:

- Technical dossier (project definition) created by an architect registered in the Spanish architecture college.
- A technical architect (surveyor), normally chosen by the architect. The technical architect is the site manager in official control of the building site.
- A builder.

The *building permit* to start working is granted by the Laguna de Duero Town Council. Once the municipal architect approves the project, the promoter requires *opening the workplace.*

Figure 6.1. Licensing process

The steps for carrying out the necessary documentation for the license during almost a year, by the large amount of documentation to perform because the design is global for 31 blocks, were:

1. Knowing the purpose of the project, with reference to the Consortium by the values and calculations made for the grant of the EU. There are some indicators of energy savings achieved with the final building permit for the comfort of the end user
2. Talk to the presidents of both Communities of Owners to bring positions and have a notion of the weaknesses observed in the blocks they manage.
3. Search the plans residential district. We search Torrelago City Council and had the original projects of the 80s.
4. Check the plans found in the town hall with existing blocks. By not match the measures, nor design, it was decided to draw all blocks (31). For example, garages appear drawn or *brise-soleil* windows that were never executed.
5. Draw the residential district level situation, plan, elevation and section in situ checking measures.
6. Design the proposal that met the conditions of existing buildings.

7. Definition of the best facade constructive solution for energy savings.
8. Drafting the basic and execution project.
9. The documents comprising the project delivered with the competent authorities in rehabilitation were:

Technical Project	Documents
1. Report	Descriptive memory
- 1.1. Descriptive Report	01. Agents. 02. Background Information. 03. Description of the project. 04. Performance of Buildings
- 1.2. Constructive Memory	01. Structure. 02. Envelope System. 03. Finishing Design. 04. Urban plan.
- 1.3. Spanish Technical Building Code	01. Report SE. Structure. 02. DB-SI.2. Fire regulations. 04. DB-HS.1. Salubrity. 05. DB-HE.1. Energy regulations.
- 1.4. Annexes	01. Quality Control Plan. 02. Waste management. 03. Noise Law of Valladolid. 04. Restoration, regeneration and urban renewal. 05. Deadline for execution of the work.
2. Plans	For Phase 1: blocks 01 to 07.
3. Measures and Budget	Cost of the project.
4. Report of Conditions	This involves: installers, construction, scaffolding, materials and agents.
5. Annexe	Health and Safety Study

Table 6.1: Technical project content

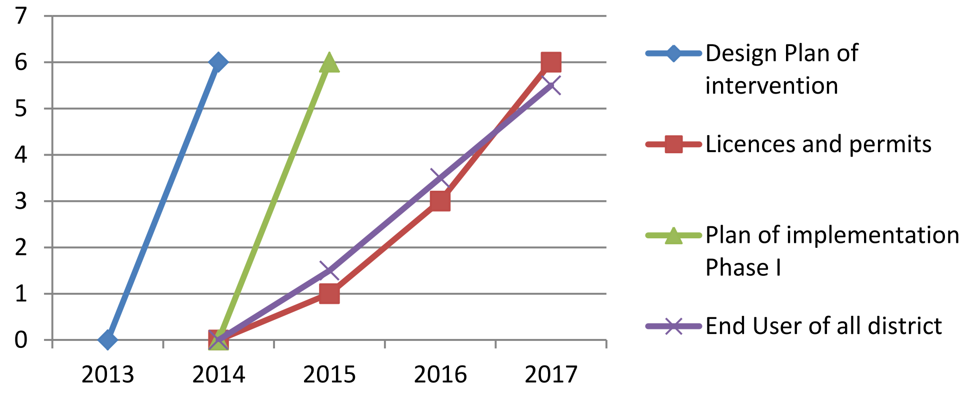


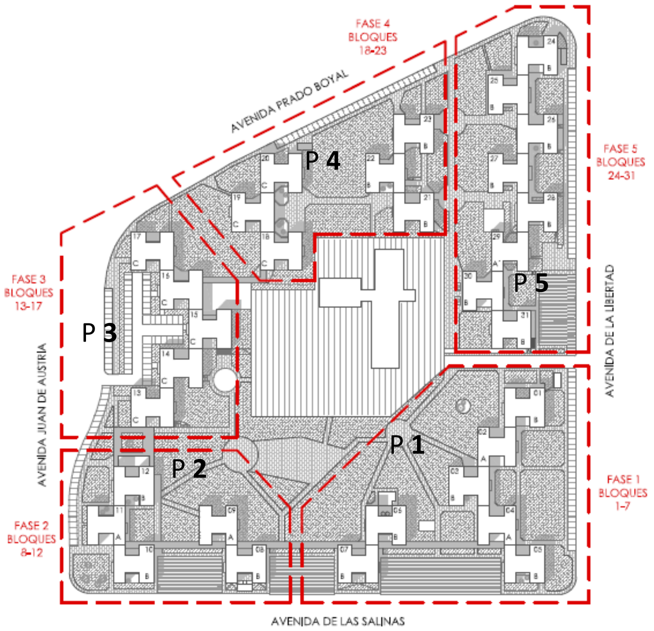
Figure 6.2. Deadline for Project on retrofitting buildings

Summary	Plan of implementation
Design plan of intervention	Architect team. September 2013 - May 2014
Licences	Laguna de Duero Town Council. May - June 2014
Construction works Phase 1 (blocks 1-7)	August 2014 - April 2015

Table 6.2: Plan of implementation of building retrofitting

10. This was developed by a multidisciplinary technical team of engineers, surveyors and architects.
11. Load calculations facade, land register use, and infographics are needed to show the proposal to tenants.
12. The required licenses are related to several factors. The demo of Torrelago is a residential district with a number of identifying characteristics.

    The joint intervention in question consists of two neighbouring communities privately owned which were built in stages between 1978 and 1981. The Community of Owners of Phase I is composed by 12 blocks and Community of Owners of Phase II by 19 for the case of building block in height of about 43 meters. It will be over 12 heights above ground level, aimed at local and entrance to housing, which remains largely transparent on pillars, which allows passage to the communal garden. Each building has an H-shaped plan that binds at least one other and sometimes two nearby typologies, organized into 4 apartments of 100 m^2 becoming 48 neighbours within a total of 1,488 dwellings. The facades of different measures are red envelope forming the ceramic blocks to respond to more than 4,000 residents.
13. By the size of the work was necessary to divide the implementation plan in five phases.



Community of Owners of Phase I:

Phase 1: blocks 01 to 07

Phase 2: blocks 08 to 12

Community of Owners of Phase II:

Phase 3: blocks 13 to 17

Phase 4: blocks 18 to 23

Phase 5: blocks 24 to 31

Figure 6.3: Plan of Phases of our intervention and licenses

6.2.2 District heating renovation

Permits required for legalization and installation of a biomass heating system are the same as for a conventional system (gas, diesel, LPG) and are granted by the competent authority of the Comunidad Autónoma de Castilla y León, complying with all regulations at national and local level.

Regulation

Royal Decree 1027/2007 of 20 July (RITE) [6] , were the Regulation of Thermal Installations in Buildings was approved, has joined biomass, which previously faced some problems in the legalization of facilities because it wasn´t considered as fuel. Certain points of interesting biomass heating systems have been incorporated:

- With regard to the minimum requirements in energy performance heat generators (IT 1.2.4.2.1: Energy efficiency requirement in terms of generation of heat and cold) when biomass is used as fuel, the instantaneous minimum performance shall be 75% at full load. If solid bio fuels are used, it shall indicate that performance for the boiler-combustion system for 100% of the maximum power. Furthermore, it must indicate the performance and the feed water temperature of set-combustion system boiler when biomass is used, the maximum power demand the heating system or the hot water system.
- If there is a power fractionation, the installation will be following the IT 1.2.4.1.2.2 (Heat generation: Fractionation power).
- Within the safety of the heating system, fed systems with solid bio fuels must comply with the IT 1.3.4.1.1 (Characterization and quantification of safety requirement : Terms

of heat and cold, i.e. interruption of system operation combustion and the flashback, a system of heat dissipation residual boiler and resulting bio fuel introduced before the interruption of system operation, etc.

- To comply with the dimension of the boiler room shall met the IT 1.3.4.1.2.5 (Characterization and quantification of safety requirement: Self-contained heat generation).
- For storage of solid bio fuels it must accomplish the standards in the IT 1.3.4.1.4 (Characterization and quantification of safety requirement: Storage of solid bio fuels). The place of storage may be inside or outside the building for only for this use, and accordingly there will be some rules or other.
- The maintenance and use cited in the IT 3. On the premises fed with solid bio fuel should check the status of storage fuel , opening and closing the collapsible container , cleaning ash , visual control of the boiler, checking and cleaning , if necessary, circuit boiler smoke flues and fireplaces and review of the security elements .

Building permit

The works that modify common elements of the building, their security , especially the structure or introducing a surge in it or affecting the general location of ducts sanitation, ventilation , or the appearance of the facades and roofs of buildings, license require major work.

Its processing involves the payment of fees for the provision of municipal services and the amount is set by the council .The type of work to be done determines the required documentation in the municipality and, above all , the type of project that is to be drafted by a technician with a qualification .

It requires a project written by a senior architect and be submitted in the municipalities with the corresponding association certificate.

- **Tax on Construction, Installation and Works (ICIO):** It is mandatory to settle the tax Building and Construction (ICIO) levied on the making of the work. The amount is determined by the municipality and is usually a certain percentage of the operating budget. No work should be started without obtaining the relevant building license and have paid the taxes and fees. It is desirable to have a copy of both in the work with which justifies its legality before a possible inspection. These two actions are the responsibility and obligation of the promoter of the work. If the sponsor delegates the management contractor, you will have to require delivery of the completed and approved together with the supporting documents for payments before authorizing the start of construction documentation.
- **Canon of landfill:** The dumping of waste generated in the work should be done in an authorized landfill and it is therefore necessary to pay the fee of release. Normally, the contractor is responsible for this process; this cost must be reflected in the budget.

- **Authorization for the occupation of public roads:** If the circumstances of the work required having a space in the street for downloading materials or accommodating a container for debris, you must request prior authorization from the municipality, providing a plane with the installation situation and indicating the period occupancy expected.

6.2.3 Electrical generation

The legalization processes for installing energy production of electricity for self-consumption with zero injection is the same as the process to legalize any reception facility.

Basically, it consists of the presentation of the technical documentation of the installation to a control entity and after verifying that the entity is properly recorded and sealed copy of the person concerned certifying that the system has been legalized.

The installation of cogeneration equipment for electric power production requires, as a single procedure, the license application municipal minor work. The system requires no request connection point or other technical analysis by the distribution company.

In assembling the system all technical requirements specified in the Technical Building Code and the Low Voltage Electrical Regulations were respected.

The documentation required for legalization of the cogeneration system will be:

- The request instance.
- The bulletin installer.
- Line diagram of the system.
- Basic memory or project visa depending on the inverter power installed:
    - For systems with less than 10kW is enough with specification.
    - For projects with more than 10 kW executive projects requires visa. Both memory as the installation project shall specify the procedure used by the system to avoid feeding in defining the equipment for that function.

The instantaneous consumption is self-generating electric power and at the same time consuming. This particular form of power generation is increasing significantly despite the current law in some countries like Spain, because it is precisely this form of electricity generation that allows generation facilities licensed as an electrical installation either. This simplifies and reduces the cost of managing the installation of consumption to the authorities, so that makes legislatively equivalent to other electricity generator.

Here are the steps in the process of legalization shown:

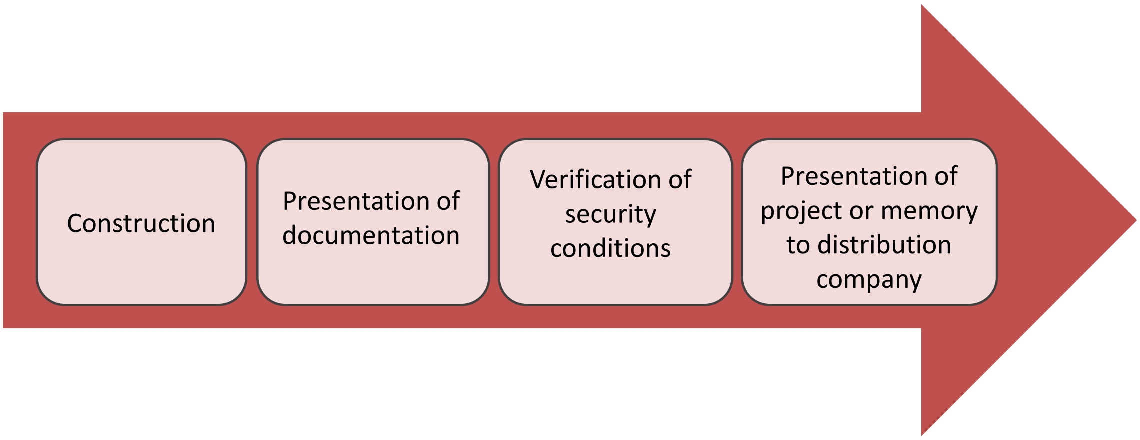


Figure 6.4. Planning of the electrical intervention and licenses

6.2.4 Smart grid interventions and ICT

The 2012/27/EU Energy Efficiency Directive (RITE) [6] establishes a set of binding measures to help the EU reach its 20% energy efficiency target by 2020. All the member states are required to use energy more efficiently at all stages of the energy chain from its production to its final consumption. Its publication was on 14 November 2012 and it entry into force on 4 December 2012 and the article 9 is referred to the requirements on metering: Individual heat/cool/hot water consumption meters in multi-apartment buildings - 31/12/2016.

- Final customers of electricity, natural gas, district heating, and district cooling and domestic hot water are provided with competitively priced individual meters that accurately reflect the final customer's actual energy consumption and that provide information on actual time of use (introduced by article 13, Directive 2006/32/EC [7]).
- In the energy efficiency directive the above point is also extended to final customers residing in multi-apartment and multi-purpose buildings with a common central heating/cooling/hot water system. Meters should be installed before 31 December 2016.
- In the case of multi-apartment or multi-purpose buildings that are supplied by heating or cooling or hot water from external sources, Member States must ensure that a meter is installed at the heat exchanger or the point of delivery to the building. These meters must be installed before 5 June 2014.
- Individual meters for each apartment or unit in such building are installed by 31 December 2016 where technically feasible and cost-efficient: If the installation of individual heat meters is not technically feasible or not cost-efficient, accurate heat cost allocators must be installed for each radiator.
- This article imposes an unconditional requirement to provide individual meters (not heat cost allocators) in cases where a new connection is made in a new building or where a building undergoes a major renovation.

- Member States are required to inform the Commission of the technical conditions and economic thresholds or other criteria under which they justify that it would not be technically feasible or cost-effective to comply with their obligations. In the case of multi-apartment and multi-purpose buildings where it is found technically feasible and cost-effective to install individual heat meters but the final customers already have heat cost allocators, then by 31 December 2016 Member States must ensure that individual heat meters are installed. However, it can be assumed that the existence of heat cost allocators is a factor that would normally affect the cost-benefit calculation for the use of individual heat meters.

Technically feasible

- It can be assumed that individual metering of heat consumption in multi-apartment buildings is technically possible when the installation of individual meters would not require changing the existing in-house piping for hot water heating in the building.
- If the hot water used for heating enters and leaves individual apartments at several points, the use of individual heat meters is less likely to be technical feasible or cost-efficient.
- In such buildings, measurements of individual heat consumption can be carried out by means of individual heat cost allocators.

Cost-efficiency of individual metering

- Member States can compare the costs of the installation and maintenance of the meters/heat cost allocators with the benefits for end consumer: Various studies indicate that the range of savings due to the introduction of individual metering and billing based on actual consumption of heat often reach 30% in comparison to systems without individual metering and with billing based on flat rates (e.g. per m2).
- EED does not provide a definition of a multi-apartment or multi-purpose building. However, a multi-apartment building could be understood as a building with at least two apartments and a multi-purpose building could be understood as a building occupied by at least two entities that need to share between themselves the bill for the energy purchased.
- Where multi-apartment buildings are supplied from district heating or cooling Member States may introduce transparent rules on the allocation of the cost of thermal or hot water consumption in such buildings to ensure transparency and accuracy of accounting for individual consumption.
- Where appropriate, such rules shall include guidelines on the way to allocate costs for heat and/or hot water that is used as follows:
    - Hot water for domestic needs
    - Heat radiated from the building installation and for the purpose of heating the common areas (where staircases and corridors are equipped with radiators).
    - For the purpose of heating apartments.

6.3 Selection of equipment and installers

Once defined the work that it is going to be make in the installation, budget will be request to different companies and these budgets provided will be compared. The choice of the equipment and installers that will execute the works should not be limited to the financial offer, since there are other issues to contemplate and check like quality of equipment, service of the suppliers, delivery time or previous experience available to suppliers.

The set of requirements is specified in the contract specification so that from them all offers will be evaluated. The evaluation will be based on evaluation method that has been specified the in the contract. From the evaluation of the different proposals the equipment and the installers will be chosen.

6.3.1 Buildings retrofitting

Supply Company

Once started the selection process to find the best company to develop the project implementation are considered a number of factors:

- Experience in this type of work, ETICs solution on façade.
- Technical characteristics installing materials.
- Financial offer.

The supply companies selected were: Mapei [8], Weber [9] and Baumit [10]. Finally, Mapei was the chosen company. It was elected with a system installation of all constructive solution of ETICS according to a series of characteristics: DITE and European Technical Approval where there are information about the selection of materials with specific features, how the proper installation, assessment tests and trials for security as a supplier. Find in the Annex 4 the following information among other abovementioned for ETICs system:

- Mechanical resistance and stability
- Safety in case of fire
- Hygiene, health and environment
- Safety in use
- Protection against noise
- Energy saving and thermal insulation

Installers

Regarding installation of the building system company ISTA [11] was chosen. It is responsible for special workers in construction with experience in high scaffolding and ETICs, scaffolding hiring, sheets window so no water and maintenance courses and training of workers for successful implementation.

Follow the instructions of the foreman, according to the licensed project.

Characteristic provided	Supply Company		
	MAPEI	WEBER	BAUMIT
Work with ETICs	x	x	x
- Work with all the constructive solution	x	x	x
- Multifamily block work	x	x	x
- Material tested	x	x	x
- Experience	International	International	National
- Work of great magnitude	x	x	x
EPS thickness	8 cm	8 cm	8 cm
- EPS density 15-20 Kg/m^3	x	x	x
- Installation according to ETAG 004	x	x	x
Finish characteristics	Without mold	Without mold	Without mold
- Colour finish	Own	Own	Own
- Grain finish	Thin	Thin	Thin
- Facade finishes	standardized	standardized	standardized
- Self-cleaning facade	x	x	x
Product	Mapetherm	Weber Therm	Austrotherm
- Confort characteristics	x	x	x
- Good maintenance	x	x	x
- Product delivery	Fast	Fast	Fast
- Material supply capacity	Good	Good	In Advance
Financial offer	First	Second	Third

Table 6.3: Plan of Phases of our intervention and licenses

The existing wall is added as a solution Thermal Insulation System for Exterior composed. EPS insulation plates 15 to 20kg/m^3 density and 80mm. thick, received one-component cementations adhesive mortar sand, synthetic resins and special additives and mechanical anchors; according to characteristics of the ETAG No. 004 ETA installed according to the company that supplied.

6.3.2 District heating renovation

In the selection of equipment that will form part of each installation it must take into account a number of factors that determine the duration and quality of the refurbishment work.

After defining the main trades in which it is possible to divide the work done it is necessary to make a request process of the economic supply and the associated technical resources that are offered for use in each task. In addition to assessing the technical and economic feasibility of each offer, the responsible staff must consider the difficulty that can have each task and evaluate the experience in similar work.

Then the comparison process conditions for the choice of heat generation equipment that best fit the needs of the project are shown.

Characteristic	Biochamm	Binder	Viessmann
Offer reference	104/2013 RO	4-120526	140101A
Type of boiler	Mobile power system	Mobile power system	Mobile power system
General characteristics			
Power	1000 + 2500 kW	840 + 3000 kW	950+1250+1250 kW
Power system grid	Included	Included	Included
Boiler	Yes	Yes	Yes
Automated system pipe cleaning	Yes	Yes	Yes
Automatic ash removal (oven and multicyclone)	Yes / Clarify	Yes	Yes
Ash collection container	Excluded	Yes	Yes
Silo Dosing	Si	Unnecessary	Unnecessary
Economizer	Excluded	Excluded	Unnecessary
System pressure compressor	Clarify	No	Yes
Multicyclone	Yes	Yes	Yes
Bag Filter	No	No	No
PLC	Yes	Yes	Yes
Electrical wiring of motors, and fans and signs to Control box and CCM	No	Yes / Clarify	No
Frequency Converters	Yes	Yes	Yes
Fan primary, secondary and induced air shot	Yes	Yes	Yes
Cranes and Lifting Systems	No	No	No
Painting and heat insulation pipes	Clarify	No	Unnecessary
Spare parts	No	-	Excluded
Open fireplace	Yes	Excluded	Excluded
Staff training	Yes	Yes	Yes

Characteristic	Biochamm	Binder	Viessmann
Buffer stores	No	No	No
Energy meters	No	No	No
Boiler feed pumps	Yes	No	No
Primary pumps	No	No	No
Installation and commissioning	Yes	Yes	Yes
Maintenance Manual	Yes	Yes	Yes
Biomass			
% Humidity	35%	31-50%	25-45%
Heating power	2.500 Kcal/Kg		2700 kW/h
Granulometry	G50	G100	G50
Technical qualities			
Performance	86,0%	85,5%	90,0%
Electrical consumption	75 CV	Request	Request
Availability	90%	Request	1 h
Operation cost	Request	Request	Request
Noise			
Noise	<85 Db	Request	<90 Db
Emissions			
SO_2	<200 mg/Nm3	Request	<200 mg/Nm3
CO	<250 mg/Nm3	118mg/m3	<650 mg/Nm3
Nox	<500 mg/Nm3	135mg/m3	<400 mg/Nm3
COV	<50 mg/Nm3	< 5mg/m3	Request
Particulates	<30 mg/Nm3	< 79mg/m3	<225 mg/Nm3
Delivery			
Equipment supply plan	Factory delivery in 4-5 months. Total time indicated in 6-7 months, including transport and assembly	3-4 months	3 months
Financial offer	First	Third	Second

Table 6.4: Boilers features comparison

6.3.3 Electrical generation

For electrical work, several offers from various companies in the sector with which we usually work were evaluated.

The criteria considered for the award of responsibility for electrical works were mainly credibility to deadlines according to the technical and human resources arise to perform each job.

Of course we took into account technical and economic reasons but exerted more pressure on the decision of the contractor's quality and experience provided in this type of work.

Given that the work is conducted in facilities of inhabited buildings must ensure that the impact on the quality of the neighbours is minimized. For this reason it is easier to perform tasks with a local company who knows the facilities and be more agile and effective in legalizing them.

Therefore for the work of installation of new electric power generating equipment intend to accomplish with the same company that has performed the electrical and control wiring reform district heating network works.

6.3.4 Smart grid interventions and ICT

With regard to the work to implement smart grid interventions are evaluating various installers that offer experience in installing and maintaining such systems.

The decision will have to be agreed with the other partners involved in the task because you have to take into account the constraints posed by each approach the task.

A key feature that should have the installer smart grid systems is to be close to the neighbours to facilitate the work of installation, configuration and maintenance of the equipment.

7 Planning

7.1 End-users commitments

From the beginning of CITyFiED project, the residents of the Spanish demo site agreed on some social, economic and technical commitments to be taken into account before and after the intervention in their district.

First of all, it was decided to include all dwellings of Torrelago district into the frame of CITyFiED project. By joining CITyFiED project, the residents pledged themselves to reduce the energy demand and GHG emissions and to increase the use of renewable energy sources in their district.

Then, the residents committed to respect the contracts signed with the companies 3IA and DAL. They agreed to collaborate during the development of retrofitting works and to pay the heating fees established.

Finally, the Spanish Technical Building Code [2] indicates the need to include instructions for use and maintenance of the building and its facilities between the documentation to be delivered to the owners of the buildings after the retrofitting. The Spanish Technical Building Code [2] also makes it mandatory for users to use and maintain the building following the above mentioned instructions.

In the case of the Spanish demo site, instructions for use and maintenance of the building and its facilities will provide guidance on ventilation by residents, use of heating and advisable windows in case of replacement.

7.2 Buildings retrofitting

The implementation plan is developed in 5 phases with corresponding 5 licenses granted by the Laguna de Duero Town Council. It was started by the Community of Owners of Phase I, go in line with the installation of biomass company DAL. Thus tenants have a double response on the one hand with ETICS facade insulation and on the other hand with the district heating.

The implementation schedule is divided in 5 phases to develop the project of buildings retrofitting until 2017:

- Phase 1: from June 2014 to December 2014 to finish 7 blocks.
- Phase 2: from January 2015 to July 2015 to finish 5 blocks.
- Phase 3: from August 2015 to December 2015 to finish 5 blocks.
- Phase 4: from January 2016 to August 2016 to finish 6 blocks.
- Phase 5: from September 2016 to September 2017 to finish 8 blocks.

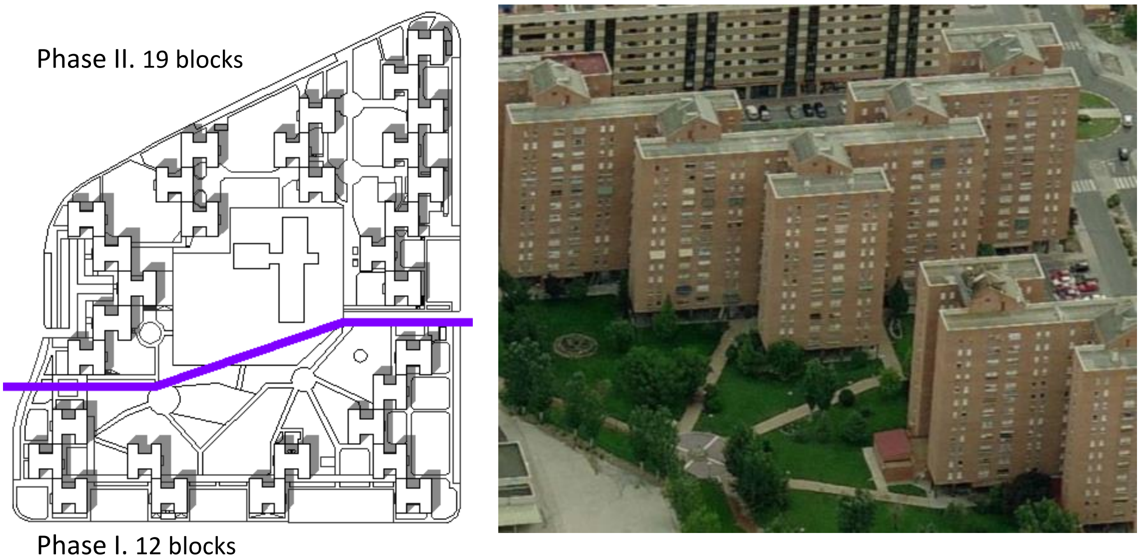


Figure 7.1: Plan of Community of Owners of Phases I

The implementation is performed progressively in blocks when the temperature conditions permit.

Building Retrofitting Plan	Initial plan	Deviation plan
Phase 1 (7 blocks)	5 months	8 months
- Blocks 01 to 07	June 2014 - December 2014	June 2014 - April 2015
Phase 2 (5 blocks)	7 months	5 months
- Blocks 08 to 12	January 2015 - July 2015	April 2015 – September 2015
Phase 3 (5 blocks)	4 months	4 months
- Blocks 13 to 17	August 2015 - December 2015	September 2015 – January 2016
Phase 4 (6 blocks)	7 months	7 months
- Blocks 18 to 23	January 2016 - August 2016	February 2016 – September 2016
Phase 5 (8 blocks)	12 months	11 months
- Blocks 24 to 31	September 2016 - September 2017	October 2016 – September 2017

Table 7.1: Initial Plan intervention and Deviation plan

The facades have a plan in progress as the ETICS projected construction system. The control of its implementation is divided by block, name of the façade (from A to the L in a total of 12 block facades) and the rate of implementation. So each facade develops and it is divided into three levels according to:

- 40% with insulation EPS.
- 35% with layers of mortar. It´s needed 15 days of drying the layer applied last.
- 25% to the final finish colour.

It must be considered for the implementation plan that the facade products cannot be applied at temperatures below 5 degrees or above 35.

CÓDIGO	UD	largo	alto	superficie	colocación placa EPS + tacos 40 %	mortero+malla+ mortero 35%	imprimación + mortero de acabado 25%	TOTAL
Bloque 1								
a	1	22,32	34,99	780,98	0,4	0,35	0,2	95%
b					medianera			
c	1	5,85	34,99	204,69	0,4			40%
d								0%
e	1	5,85	34,99	204,69	0,4	0,35		75%
f	1	8,26	34,99	289,02	0,4	0,35		75%
g	1	22,38	34,99	783,08	0,4	0,35		75%
h	1	8,26	34,99	289,02	0,4	0,35		75%
i	1	5,85	34,99	204,69	0,4	0,35		75%
j								0%
k	1	5,85	34,99	204,69	0,4	0,35		75%
l	1	6,9	34,99	241,43	0,4	0,35	0,125	88%

Figure 7.2: Implementation example of the construction system on the facade of block 1

Planning deviation

There is currently a delay in the implementation of Phase 1 due to weather conditions. Work was almost unable on the facades from December 2014 to February 2015 because there was not sufficient degree heat to apply the products. The supply company of the mortar, primed and finish required conditions have not been fulfilled in Laguna de Duero. This delay is intended to solve in the spring and autumn where there are no extreme temperatures and can apply the products

7.3 District heating renovation

A restricted procedure in which all providers submit an application for participation will continue, but in the end only participate suppliers who have been invited after a selection process, each of these providers will submit its own bid.

The acquisition Process may take several months and after that a time to make the contract specifications is needed.

In all European territory there are some rules applied to purchases whose value exceeds a certain limit Direct contracting can only be made if the value of the purchase is low or in certain circumstances.

The processes of execution of the work have been separated into 6 phases:

- Phase 1: It was executed the works that do not affect the operation of the initial boiler room. Land where was going to be the boiler room was cleaned and after that, this surface was excavated
- Phase 2: It was started with the civil works. It was proceeded to dismantle the boiler room of Community of Owners of Phase I and the dismantling of existing chimneys. It began to build the structure of the new boiler room and also proceeded to the implementation of necessary sanitation facility.
- Phase 3: In this phase the equipment was installed. Because of heavy equipment of the boiler room such as boilers, cyclones or augers, they were introduced, and placed in its final position using a crane. After that, the ceiling was built. The installation of the pipes that connect the boiler room in Community of Owners of Phase II with the new biomass generation system.
- Phase 4: Piping and installation of all mechanical elements of the boiler: Installation of boilers and their different elements, piping hydraulic, electrical and control wiring and installation of electrical and control panels.
- Phase 5: connecting the new room with substations was performed. Besides its connection hydraulic, electrical and control circuits.
- Phase 6: The current phase in which is immersed installation. It has made the commissioning and being made different tests to verify proper operation.

District Heating Plan	Start Date	End Date
Building license	16/06/14	18/06/14
- Implantation in work	17/06/14	18/06/14
Civil Works	19/06/14	22/09/14
- Previous demolitions, turnouts and guide wall	19/06/14	04/07/14
- Supporter wall	07/07/14	31/07/14
- Crown beam	01/08/14	13/08/14
- Excavating biomass room	29/07/14	08/08/14
- Slab and outside wall	11/08/14	20/08/14
- Mounting roof slab	21/08/14	22/08/14
- Boiler room	25/08/14	22/09/14
- Stairs	25/08/14	29/08/14
- Corrugated sheet metal	01/09/14	09/09/14
- Hydraulic block walls	01/09/14	04/09/14
- Internal works Silo	01/09/14	05/09/14
- Doors, Stairs (emergency) and locksmith	03/09/14	22/09/14

District Heating Plan	Start Date	End Date
District Heating	23/07/14	20/08/14
- Supply pipes	24/07/14	24/07/14
- Trench excavation	23/07/14	31/07/14
- Installing pipe: welding and testing	25/07/14	07/08/14
- Filling and compaction	08/08/14	13/08/14
- Sidewalk urbanized area Phase II	14/08/14	20/08/14
Electric works biomass room	08/12/14	12/12/14
- Ditch	08/12/14	10/12/14
- Wiring	11/12/14	12/12/14
Substations	11/09/14	15/10/14
- Reception of 12 units	11/09/14	11/09/14
- Deposits and interconnection mechanical mounting hydraulic towers	12/09/14	15/10/14
Fireplaces	01/07/14	21/10/14
- Phase I (Outdoor installation)	17/10/14	21/10/14
Mounting of boilers and mobile floor	26/09/14	13/11/14
- Reception silo gates	29/09/14	29/09/14
- Reception boilers, screws and other	03/10/14	03/10/14
- Mechanical Installation (Viessmann)	06/10/14	14/10/14
- Mechanical installation hydraulic circuits	26/09/14	13/11/14
Electricity and control	10/09/14	19/12/14
- Boiler room	15/10/14	21/11/14
- - Reception electrical panel	29/10/14	29/10/14
- - Electrical and instrumentation wiring boiler	15/10/14	21/11/14
- Room Substations	10/09/14	19/12/14
- - Reception electrical panel	16/10/14	19/12/14
- - Electrical wiring and control	24/11/14	28/11/14
- Commissioning Boilers 1,2,3	19/06/14	19/06/14
- Substation Commissioning 1-6	08/12/14	15/12/14
- Substation Commissioning 7-12	16/12/14	22/12/14

Table 7.2: Planning of the interventions

7.4 Electrical generation

The installation of cogeneration module planning is divided into six phases, with a total duration of 18 days. The start phase is the mounting of the CHP motor. After that the exhaust system will be installed. Then, the gas pipe will be connected to the motor.

Following this phase, it will be the installation and assembly motor lubrication system. After this step, the electric motor connection and finally the start-up. The days that last the different phases can be seen in the Gantt diagram.

		May																	
Total CHP installation	**18 days**	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Mounting the CHP motor	5 days																		
Installation of exhaust system	5 days																		
Connecting the gas pipe to the motor	3 days																		
Installation and assembly motor lubrication system	3 days																		
Electric Motor Connection	3 days																		
Start-up	10 days																		

Table 7.3: CHP Gantt diagram

7.5 Smart grid interventions and ICT

The following task that is associated to Monitoring programme should finish before M17 (August 2015).

	Time situation		
Task	**In progress**	**Pending**	**Finished**
Data selection from sources	X		
Data base design		X	
Platform selection: cloud service type selection		X	
Data collection/consumption technology selection		X	
Design of visualization tools			X

Table 7.4: Time situation of the smart grid interventions and ITC

8 Conclusions

The residential district Torrelago consists of 31 blocks of buildings whose characteristics are described in D4.1 “Technical definition of the Spanish demo Site (Laguna de Duero, Valladolid, Spain)”. The aim of the implementation plan of the Spanish demonstrator is to accomplish the CITyFiED project objectives. The main objective is to reduce the energy demand, so greenhouse gas emissions will be decreased. To achieve savings in energy efficiency a series of measures were carried out on this residential district, achieving savings in energy costs, introducing greater use of renewable energies and allowing greater control on the installation.

Initially, it consisted of two separate phases, each one with a DH powered by natural gas boilers. These two facilities are to be joined in one with several energy sources providing heating power. It was also carried out the construction of a boiler room that feed the new district heating by the use of three biomass boilers. It was also decided to maintain the original natural gas boiler room DH2 as support for the moments when biomass boilers were not enough.

It was also proceed to the construction of 12 new exchange substations and the installation of a cogeneration system which will use the electricity produced in the different elements of the biomass boiler room and thermal energy in the heat network. In a near future it will be held individualization of consumption such that each neighbour can decide their own comfort temperature.

The installation of a Building Management System was also carried out to improve the control system of the installation by recording a series of variables from the boiler room and from different substations, getting as a result the improvement of the installation performance.

Users of dwellings only can regulate the temperature of their homes manually through the radiator valves. A measure of energy saving and efficiency to be implemented is the installation of wireless thermostats for each user to manage comfort conditions required.

One side a façade retrofitting renovation strategy was carried to obtain a reduction of the thermal demand of buildings. Initially, the building façades were made of brick cavity walls and were closed by ceramic lattices in some parts. Therefore it was decided to place an ETICS solution that will be attached to the exterior wall of the buildings and that is composed by 8 cm of expanded polystyrene sheet for insulation (EPS) fixed by adhesive mortar and mechanical anchors, all covered by 1.5 cm mortar layer. This solution gets to reduce the transmissibility coefficient from 1.36 to 0.34 W/m^{2}K.

9 Annexes

Annex 1: Basic and execution project of retrofitting of the façades of 7 residential blocks in Torrelago district (Laguna de Duero, Valladolid)

Annex 2: Basic and execution project of boiler room container building and biomass tank in Torrelago district (Laguna de Duero, Valladolid)

Annex 3: Project of thermal heat supply facilities with a biomass plant in Torrelago district (Laguna de Duero, Valladolid)

Annex 4: European Technical Approval for ETICs system

10 References

[1] CITyFiED Consortium. (2014). D4.1: Technical definition of the Spanish demo Site (Laguna de Duero, Valladolid, Spain)

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