Baseline description

D2.1

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D.2.1

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1.2	26/01/17	Adjustments on thermography by ATER Treviso	Exeleria

Executive summary

This report summarizes the results obtained by Exeleria during the different visits in the pilot sites selected, where a process of refurbishment will take place under the DREEAM project approach.

The pilot sites and it visits can be summarized in:

- Padiham: An amount of 107 familiar dwellings in the city of Padiham (United Kingdom) property of Places for People. The visit took place on 8th of February 2016.
- Treviso: The initial pilot site in Treviso (see annex), where two visits have been made, has been changed to another which consists in two multifamily buildings. The building owner of this pilot site is ATER Treviso. The visit took place on 10th of January 2017.
- Landskrona: In the city of Landskrona (Sweden), a total of 5 multifamily buildings property of Landskronahem. The visit took place on 17th of February 2016.

The study focuses on the data gathering of the current situation of the components of the building for a later analysis. The elements subjected to be analysed can be classified in:

- Passive components:
  - Thermographic analysis
  - U-Value analysis
  - Windows
- Active components
  - Heating and DHW production
  - Terminal units
  - Lighting

Some conclusions have been taken after the analysis of all the data obtained during the visit. Of this conclusions is extracted an overview of the most critical situations, from an energetic point of view.

Using these parameters, a simulation analysis has been done. The tool used to do that is the HAP (Hourly Analysis Program) which calculates the energy consumption in the building and that can be compared with the real data obtained from the building owner.

An analysis of sensitivity has been done using the parameters room temperature, U-Value and infiltration showing how a variation of them affects the energy consumption.

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Padiham (UK)

Pilot site

1 Pilot Site overview

1.1 General Description

The purpose of the visit is to evaluate the baseline situation of the building providing the starting point for the renovation DREEAM approach.

This technical baseline will be focus on the gathering of information about:

- **Passive technologies:** The thermal properties of the walls, roof, etc. analysing in which conditions are they currently and the features of the windows.
- **Active technologies:** Identifying every component of the installation of the buildings including electrical parts, heating systems, storage and lighting among other things.

1.2 Buildings Description

The visit took place in the city of Padiham (England) in social housing buildings located in the streets Whitegate Close, Victoria Court and Whitegate Gardens.

Figure 1 Aerial view of the social housing building

From the 107 houses, three types of buildings were examined:

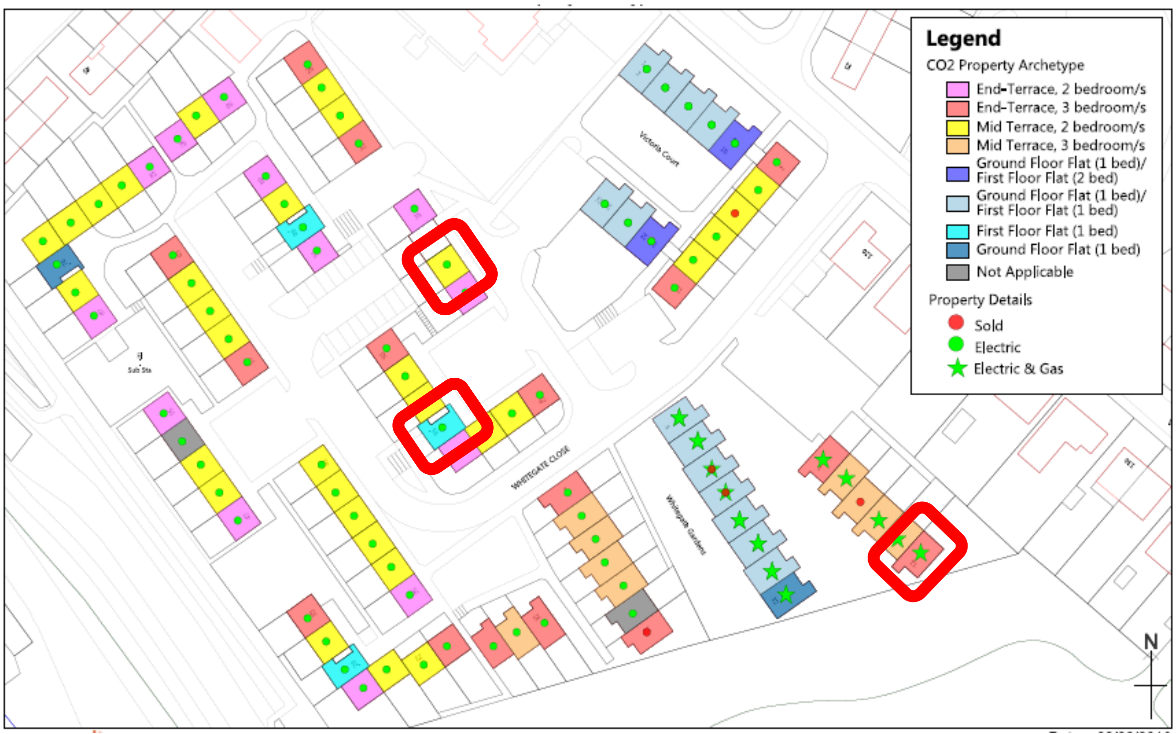


Figure 2 Pilot site map and buildings visited

- A first floor flat with one room (electric): this home was empty so the U-value measurements were taken there. It is located in 50 Whitegate Close and consists in: one room, a living-room, a kitchen, a bathroom, a technic-room and a storeroom. It has a net area of 47,5 m2.

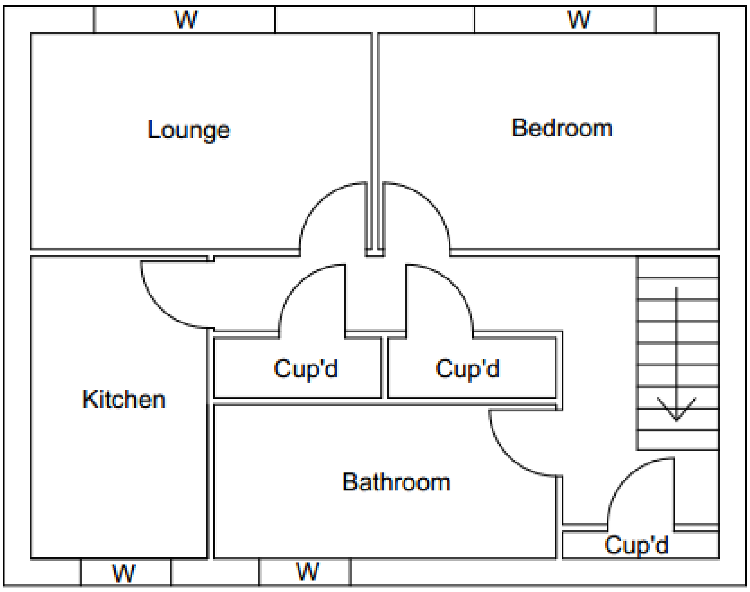


Figure 3 Floor plan:50 Whitegate Close

- A middle terrace with two rooms (electric): Similar construction as the previous one. The thermo graphic analysis has been done in this house. It is located in 38 Whitegate Close and consists in: three rooms, a living-room, a kitchen, a bathroom, a technic-room and a storeroom in two floors. It has a net area of 77,7 m2.

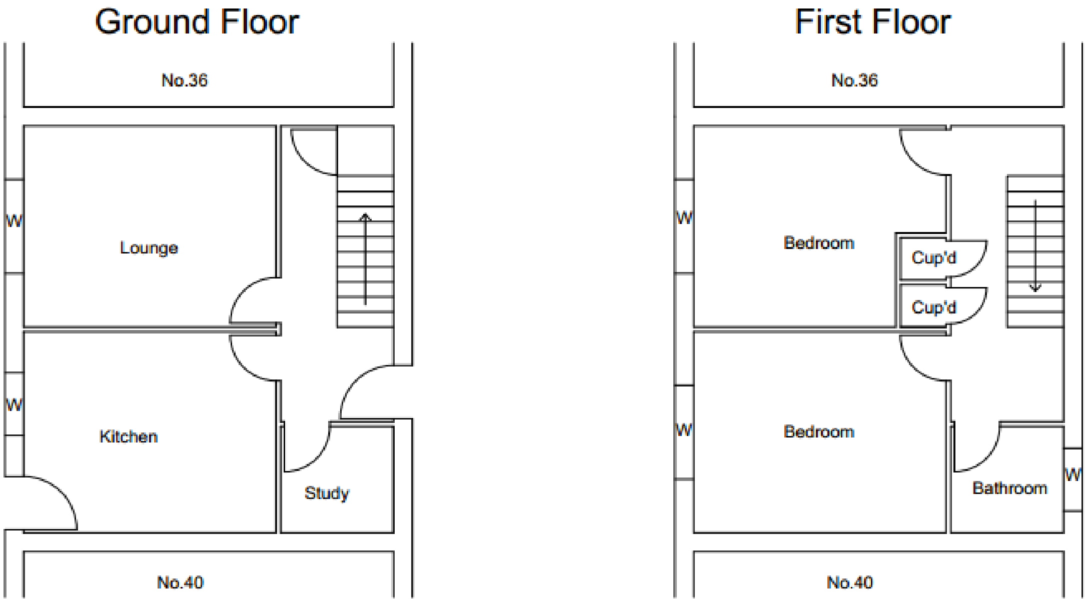


Figure 4 Floor plan:38 Whitegate Close

- End-terrace with three rooms (electric and gas). In this house the Gas powered active technologies has been examined. It is located in 11 Whitegate Gardens and consists in: three rooms, a living-room, a kitchen, two bathrooms, and a technic-room in two floors. It has a net area of 80,8 m2.

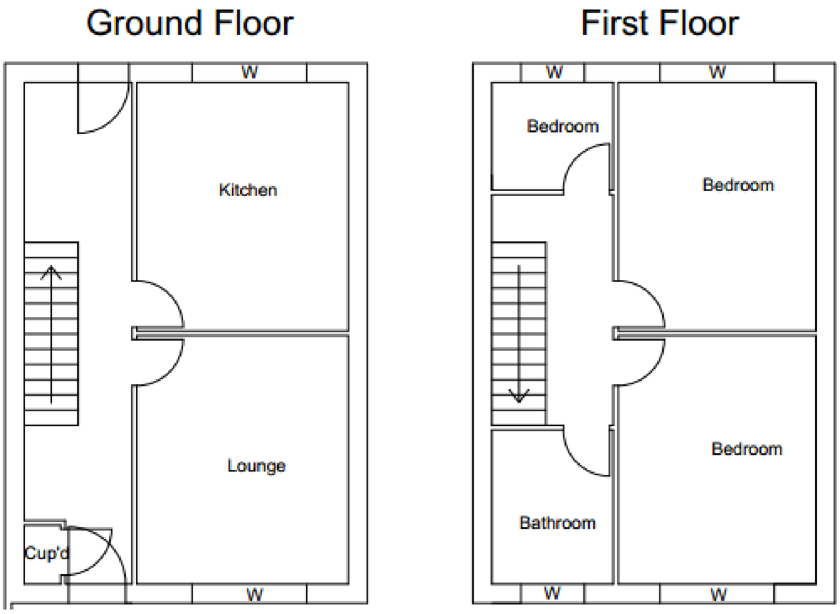


Figure 5 Floor plan:11 Whitegate Gardens

1.3 BO requirements and objectives

To carry out the pilot visit, the collaboration of the building owners is required to allow the other collaborating parts in the visit to gather as much information as possible that can be used after the visit to make a deep analysis about the current situation of the building. For it, Places For People has made available the entry to different flats and technical rooms allowing to make a thermography analysis, to measure the thermal transmission of the passive components and to analyse the active components.

The main objective of the building owner about this visit is to have an understanding of the current situation of their properties. This information must cover the components of the building and the energy consumption of the social housing. It will consist be the first step of the renovation process.

1.4 Information needed

To perform the analysis of the building and compare the data obtained from the measurements it is necessary to have the construction plans which include every information about the typology, orientation, dimensions, components and details of the building.

Places For People has provided the composition of the envelope components, therefore Exeleria can get a comparison between the practical and the theoretical data. Construction plans of the pilot sites visited have been also provided. However, Exeleria has made measurements of the dimensions of one of the buildings.

Another information as construction plans and electrical bills have been provided.

2 On site data gathering

2.1 Pasive components

2.1.1 Thermographic analysis

The detailed information related to the thermographic analysis could be found in the methodology document included in the annexes.

To carry out the thermographic analysis, a minimum thermal conditions for the difference of temperature between indoor-outdoor were necessary.

The temperature inside the building during the thermographic work ranged between 13 and 16 °C. The temperature outside was between 5 and 7 ºC. Which means a difference between 6 and 11 ºC.

After de thermographic analysis in the different parts of the building we can obtain the following conclusions:

There are generally important thermal bridges in the corners of the façades against the outside air. There are big areas with temperatures around 7 – 8 ºC when the rest of the room is around 4º C higher:

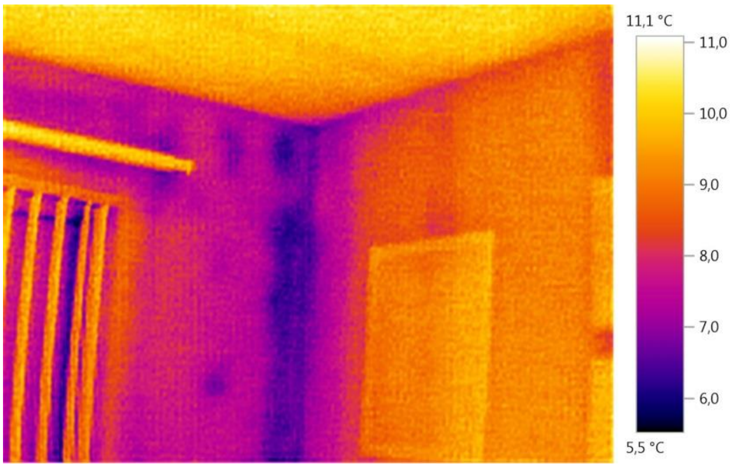


Figure 6 Thermal bridge in a corner

A big presence of humidity can also be observed in most of the walls. There are small random areas with temperatures around 8º C:

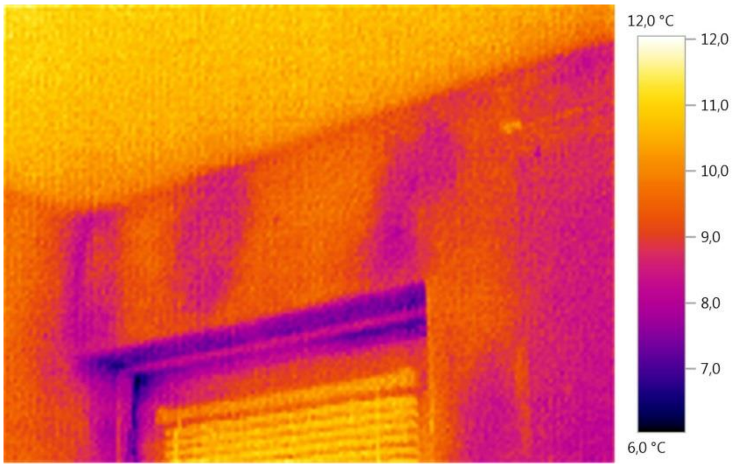


Figure 7 Humidity in the wall

Another example of humidity in other room in the house:

Figure 8 Humidity in the wall

Important thermal bridges can also be observed in windows. There are points with a very low temperature, around 8º C:

Figure 9 Thermal bridge in a window

Regarding the facilities of the building there is no presence of leaks as we can see in the photo:

Figure 10 Pipe inside the wall

In the following photo we can see the gas boiler which is located near another rooms in the house and it has a maximal temperatures of 100º C. The boiler has not an insulated cover.

Figure 11 Gas boiler

Generally, the house presents very bad conditions of insulation and serious humidity problems which implies important constrains regarding the feasible renovation options.

2.1.2 U-Value analysis

The detailed information related to the U-values analysis could be found in the methodology document included in the annexes.

To ensure the accuracy of the measurements the ideal conditions required are:

- Temperature difference (outdoor - indoor) of at least 15 ªC
- External surfaces un exposed to solar radiation

A representative batch within each pilot case based on construction features (num. of bedroom, orientation, m2…) is selected. The equipment for measuring U-values include heat flux meters, thermistor temperature probes and data-loggers.

For the analysis of the building envelope four components of it have been analysed and obtained the currently U-value of them.

The results obtained are:

Number	Component	U-Value obtained [W/m²K]	U-Value calculated [W/m²K]
1	Wall against exterior air	4,676	1,20*
2	Wall against exterior air	1,945	1,20*
3	Floor against exterior air	4,119	3,87
4	Roof against unheated room	1,758	0,58

*There is no evidence of cavity injection

1. Wall against exterior air. This is the wall with windows situated in a room oriented to SW. The results obtained are:

- Temperature difference: 3,7 ºC

- Solar radiation: Not influenced

Date	Time	U-Value [W/m²K]	Tw [ºC]	Ti [ºC]	Hr [%]	To [ºC]
08.02.2016	10:32:42	4,676	7,34	9,59	85,3	5,9

The high U-Value obtained indicates that apparently there is no insulation system on the façade.

Figure 12 U-Value analysis of the wall

2. Wall against exterior air. This is a wall with windows situated in a bathroom oriented to NE. The results obtained are:

- Temperature difference: 2,9 ºC
- Solar radiation: Not influenced

Date	Time	U-Value [W/m²K]	Tw [ºC]	Ti [ºC]	Hr [%]	To [ºC]
08.02.2016	11:23:57	1,945	8,08	8,77	89,9	5,9

The relative good U-Value obtained compared with the other wall indicates that there is an insulation system on the façade, apparently injected in a renovation.

Figure 13 U-Value analysis of the wall

3. Floor against exterior air. This is the floor in every room of the flat (first floor flat) against exterior air. The results obtained are:

- Temperature difference: 1,5 ºC
- Solar radiation: Not influenced

Date	Time	U-Value [W/m²K]	Tw [ºC]	Ti [ºC]	Hr [%]	To [ºC]
08.02.2016	11:39:14	4,119	7,29	8,25	86,1	6,8

The high U-Value obtained indicates that apparently there is no insulation system on the floor.

Figure 14 U-Value analysis of the floor

4. <u>Roof against unheated room</u>. This is the roof situated on the first floor against an unheated loft. The results obtained are:

- Temperature difference: 3,4 ºC
- Solar radiation: Not influenced

Date	Time	U-Value [W/m²K]	Tw [ºC]	Ti [ºC]	Hr [%]	To [ºC]
08.02.2016	11:58:26	1,758	9,11	9,61	88,7	6,2

The U-value obtained is similar to the value that this component with a 5 cm layer of insulation (see photo) could have.

Figure 15 U-Value analysis of the wall

2.1.3 Windows

The basic features of the windows can be obtained using the application PRISM@VER 2012 which gives the user the number of layers of glass, their thickness and the length of the cavity between glasses.

Using the application for the windows in the building and in different orientations the conclusion obtained is that the features of the windows are the same for the whole building.

It consist in a double-glazed windows with a cavity between them apparently of gas. The measures of the windows are:

3,5 mm/ 23 mm/ 4,5 mm

Figure 16 Window

2.2 Active components

2.2.1 Heating & DHW production

Depending on the heating and DHW production the pilot houses visited are divided in two different groups:

- Electric: The 100% of the production of energy comes from electricity. For the heating electric radiators are used (see terminal units) and for the domestic hot water production, a small electric boiler with a deposit is installed in every house.

Figure 17 Electric boiler

For the domestic hot water the shower has its own electric resistance:

Figure 18 Electric resistance for the shower

- Electric & gas: There is a system based in a gas boiler for the production of heating and DHW with the help of an electric boiler also for the heating.

The gas boiler is from BAX: FS 601 OF with a output power of 17.58 kW

Figure 19 Gas boiler

The electric boiler is connected to a small storage tank:

Figure 20 Storage tank

The production can be regulated depending on the hours during the day that the tenants prefer and which system is working (hot water, central heating or both of them):

Figure 21 Regulation system

2.2.2 Terminal units

A terminal unit is the part of an installation which receives hot or cool air or water from a centralized system to provide heat or cool on a conditioned area.

The terminal units used are radiators and night storage units.

- Night storage units: The night storage system stores thermal energy during the evening, or at night when base load electricity is available at lower cost, and releases the heat during the day as required.

  There are located one night storage unit per room and the dimensions of it depends on the area to be heated: For example we can find a 1 x 0,65 m in a bedroom and 0,6 x 0,65 m in the kitchen.

Figure 22_Electric radiator

The night storage system stores thermal energy during the evening, or at night when base load electricity is available at lower cost, and releases the heat during the day as required.

In most of the rooms they are located near the entrance despite the optimal location (under the windows).

All radiators have a manual regulation system which regulates the temperature of the room and the overnight charge.

Figure 23 Regulation of the night storage unit

- Gas radiators: Are the elements used in the building to transfer the heat generated by the gas boiler. Depending on the house it can be electric or hot water powered. There are located one radiator per room and the dimensions of it depends on the area to be heated: For example we can find a 1,20 x 0,7 m (26 elements) in a bedroom and 1,1 x 0,9 m (2x22 elements) in the kitchen.

  In most of the rooms they are located under the windows.

  All radiators have a shut-off valve that can interrupt or allow the flow of water flowing through the radiator, and an individual meter that measure the radiator consumption (heat allocator system).

Figure 24 Regulation of the radiator

2.2.3 Lighting

Room lighting can be general, punctual, ambient or decorative. Depending on the lamp:

- Incandescent: a wire filament is heated to a high temperature, by passing an electric current through it. They have a very low efficiency (5%)
- Halogen: is an incandescent lamp that has a small amount of a halogen such as iodine or bromine added. They have a lifetime around 1.500 hours of use.
- Fluorescent: is a low pressure mercury-vapor gas-discharge lamp that uses fluorescence to produce visible light. They are more expensive than incandescent but they have more efficiency and life.
- Low consumption: are also fluorescent lamps adapted to the size, shape and stands of conventional bulbs. They are more expensive but easily to be depreciated with a lifetime between 6.000 and 9.000 hours.
- LED: it is a p–n junction diode, which emits light when activated. LED lamps have a very high efficiency (around 90%) Despite of its high price, they are the best option at long term.

The kind of lamps used in the building and it powers depends on the decision of the tenants. Generally the most used are:

- Incandescent: This kind of lamp is very common for the bedrooms and living-room with power range between 40 and 60 W.
- Halogen: There are some bedrooms with halogen lamps

Figure 25 Halogen lamp

- Fluorescent: This kind of lamp is used for the kitchen and toilets.
- Low consumption lamp: This kind of lamp is barely used in the building.

The consumption of lighting and appliances will be taken into consideration for the baseline analysis but not for the next steps due to the difficulty to establish energy savings measurements because of the variety and number of devices, the behaviour of the user, etc.

3 Simulation analysis

3.1 Hourly analysis program software

The main goals of this simulation are:

- To help to verify that the measured U-values and gathered building information are able to explain the current energy consumption.
- Sensitivity analysis of the different parameters, seeking for those parameters that have influence on energy consumption.
- Feasibility check: This model will be the starting point for the feasibility check to be developed later on.

3.1.1 Introduction

HAP is designed for consulting engineers, design/build contractors, HVAC contractors, facility engineers and other professionals involved in the design and analysis of commercial building HVAC systems.

In addition, HAPs 8760 hour energy analysis capabilities are very useful for green building design. For instance, HAP energy analysis results are accepted by the US Green Building Council for its LEED®1 (Leadership in Energy and Environmental Design) Rating System. Visit the USGBC's website, www.usgbc.org, for more LEED info.

3.1.2 Load calculation

HAP software uses:

- ASHRAE Transfer Function cooling load calculation procedures,
- ASHRAE design heating load calculation procedures, ASHRAE design weather data.
- ASHRAE design solar calculation procedures.

Features:

- Calculates space and zone loads 24-hours a day for design days in each of the 12 months. In doing so it calculates heat flow for all room elements such as walls, windows, roofs, skylights, doors, lights, people, electrical equipment, non-electrical equipment, infiltration, floors and partitions considering time of day and time-of-year factors.
- Performs detailed simulation of air system operation to determine cooling coil loads and heating coil loads and other aspects of system performance 24-hours a day for design days in each of the 12 months.
- Analyses plenum loads.
- Considers any operating schedule for HVAC equipment from 1 hour to 24 hours in duration.

- Permits hourly and seasonal scheduling of occupancy, internal heat gains, and fan and thermostat operation.

On the following figures are displayed some examples of the type of data required in HAP simulation related to design weather inputs but also the outcomes provided by the HAP tool.

Design Parameters:

City Name	Manchester	
Location	United Kingdom	
Latitude	55,4	Deg.
Longitude	2,3	Deg.
Elevation	77,7	m
Summer Design Dry-Bulb	25,0	°C
Summer Coincident Wet-Bulb	17,2	°C
Summer Daily Range	7,6	°K
Winter Design Dry-Bulb	-4,4	°C
Winter Design Wet-Bulb	-6,6	°C
Atmospheric Clearness Number	1,00	
Average Ground Reflectance	0,20	
Soil Conductivity	1,385	W/(m-°K)
Local Time Zone (GMT +/- N hours)	0,0	hours
Consider Daylight Savings Time	No	
Simulation Weather Data	Manchester (TRY)	
Current Data is	2001 ASHRAE Handbook	
Design Cooling Months	January to December	

Design Day Maximum Solar Heat Gains

(The MSHG values are expressed in W/m²)

Month	N	NNE	NE	ENE	E	ESE	SE	SSE	S
January	32,5	32,5	32,5	80,8	231,7	416,6	539,4	633,1	659,9
February	50,7	50,7	68,4	230,2	447,0	596,2	710,3	758,5	772,2
March	70,2	70,2	228,4	424,8	598,8	703,2	749,0	754,0	755,9
April	90,1	196,9	373,6	556,6	654,5	716,1	708,3	673,4	652,7
May	125,5	298,6	484,2	608,9	686,0	690,9	646,6	591,4	560,9
June	167,5	337,7	514,3	621,7	682,1	670,5	614,3	549,9	518,7
July	126,1	304,9	472,1	603,8	667,6	676,8	633,3	576,1	550,8
August	95,7	191,9	368,0	535,0	635,7	688,3	683,5	649,9	632,9
September	73,2	73,2	212,7	380,7	560,6	654,7	717,7	726,9	718,5
October	52,8	52,8	52,8	240,7	406,2	576,6	666,7	723,8	736,8
November	32,9	32,9	32,9	69,1	240,5	398,6	537,7	617,7	638,2
December	24,1	24,1	24,1	30,1	154,7	312,6	440,5	532,7	555,0
Month	**SSW**	**SW**	**WSW**	**W**	**WNW**	**NW**	**NNW**	**HOR**	**Mult**
January	621,7	550,9	404,0	248,4	63,7	32,5	32,5	134,0	1,00
February	759,8	707,9	593,5	447,3	238,4	67,6	50,7	299,1	1,00
March	761,9	756,5	708,9	585,6	432,9	217,0	70,2	478,8	1,00
April	674,5	705,6	716,0	666,1	551,3	384,4	189,5	620,4	1,00
May	591,4	643,3	687,6	687,4	606,5	485,0	295,4	703,9	1,00
June	549,5	607,5	663,0	681,4	628,5	509,7	348,8	731,1	1,00
July	576,3	625,0	668,8	672,4	601,8	475,6	302,9	701,0	1,00
August	652,0	680,6	689,9	641,6	530,3	372,3	184,8	614,1	1,00
September	727,6	718,6	655,7	560,2	379,1	212,5	73,2	458,4	1,00
October	721,5	675,5	576,2	414,7	237,8	57,3	52,8	293,2	1,00
November	619,9	533,6	403,9	232,8	75,3	32,9	32,9	132,5	1,00
December	533,4	437,0	316,6	139,8	32,4	24,1	24,1	79,5	1,00

Mult. = User-defined solar multiplier factor.

Figure 26 Design weather data

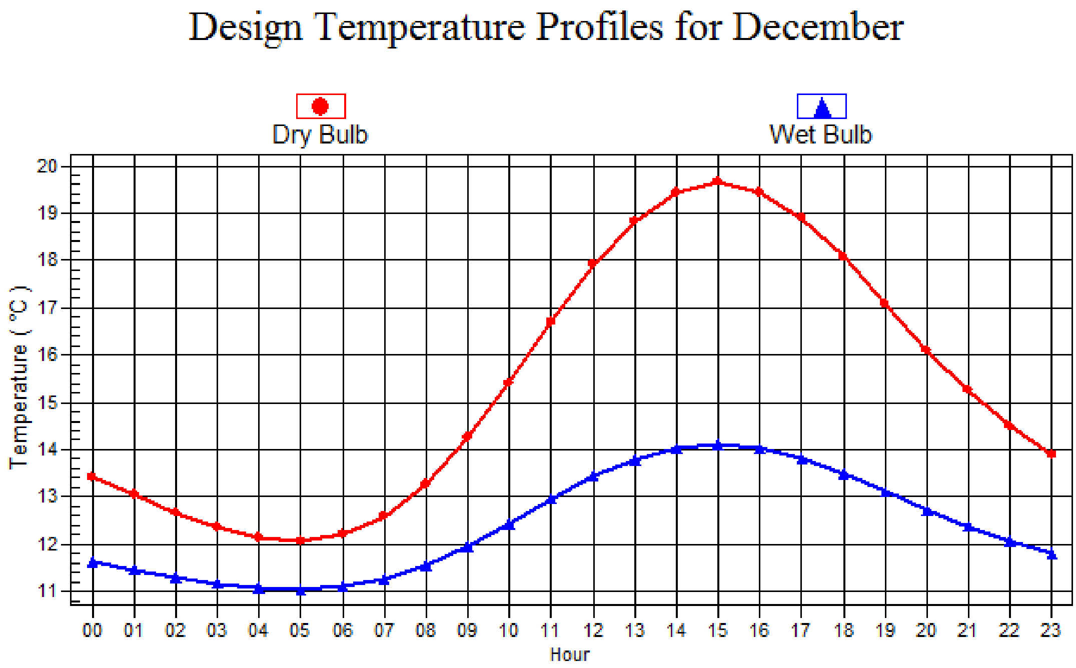


Figure 27 Example of December daily temperature

3.1.3 Simulation approach in Padiham

- 50 Whitegate Close

  In order to extract conclusions the house with electricity as energy source where the U-values have been taken have been modelled and simulated.

  According to the dimensions measured in the first flat (floor area, ceiling height, walls and windows dimensions, etc.) the simulation has been done.

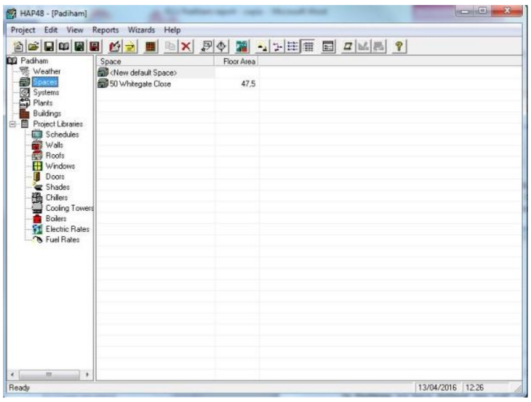


Figure 28 Space definition

In Padiham we have defined one wall composition for the walls against outside oriented to NE, SW one for the floor against outside, one for the ceiling and one for the windows. In this first approach we have estimated the occupancy of 3 people in the flat due to there are two rooms (parents with a children). According to the information gathered during the visit we also assume 8 W/m^2 for lighting and 6 W/m^2 for electrical equipment.

Ventilation parameters are really significant in residential sector to assess the energy demand (Heating and Cooling) at the buildings. In Padiham according to the construction type we have estimated an infiltration of 0,75 ACH (Air Changes per Hour) which means an intermediate level of infiltration.

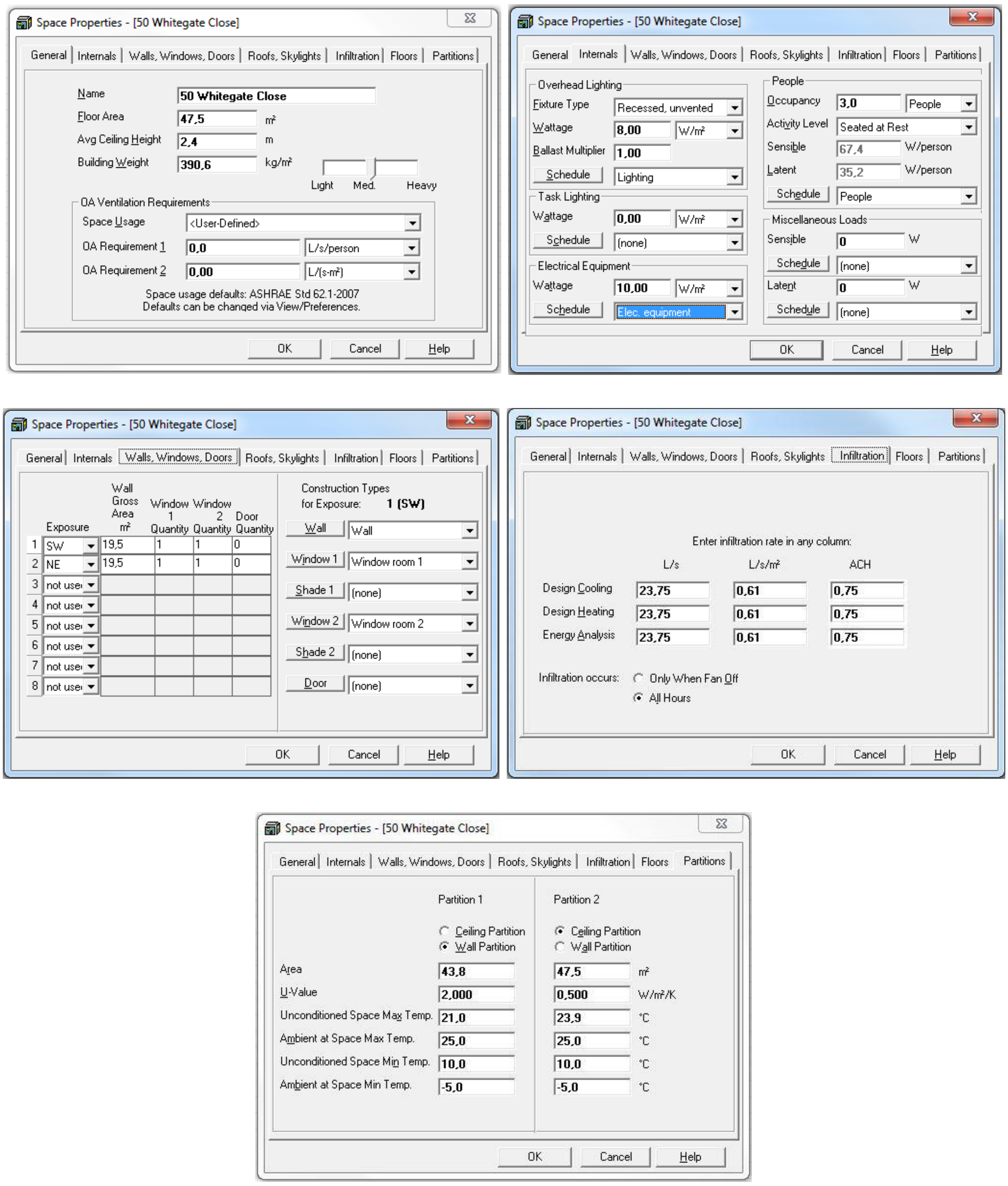


Figure 29 Spaces definition

In the next figures we have the wall and windows defined as well as an example of the type of input required by the tool:

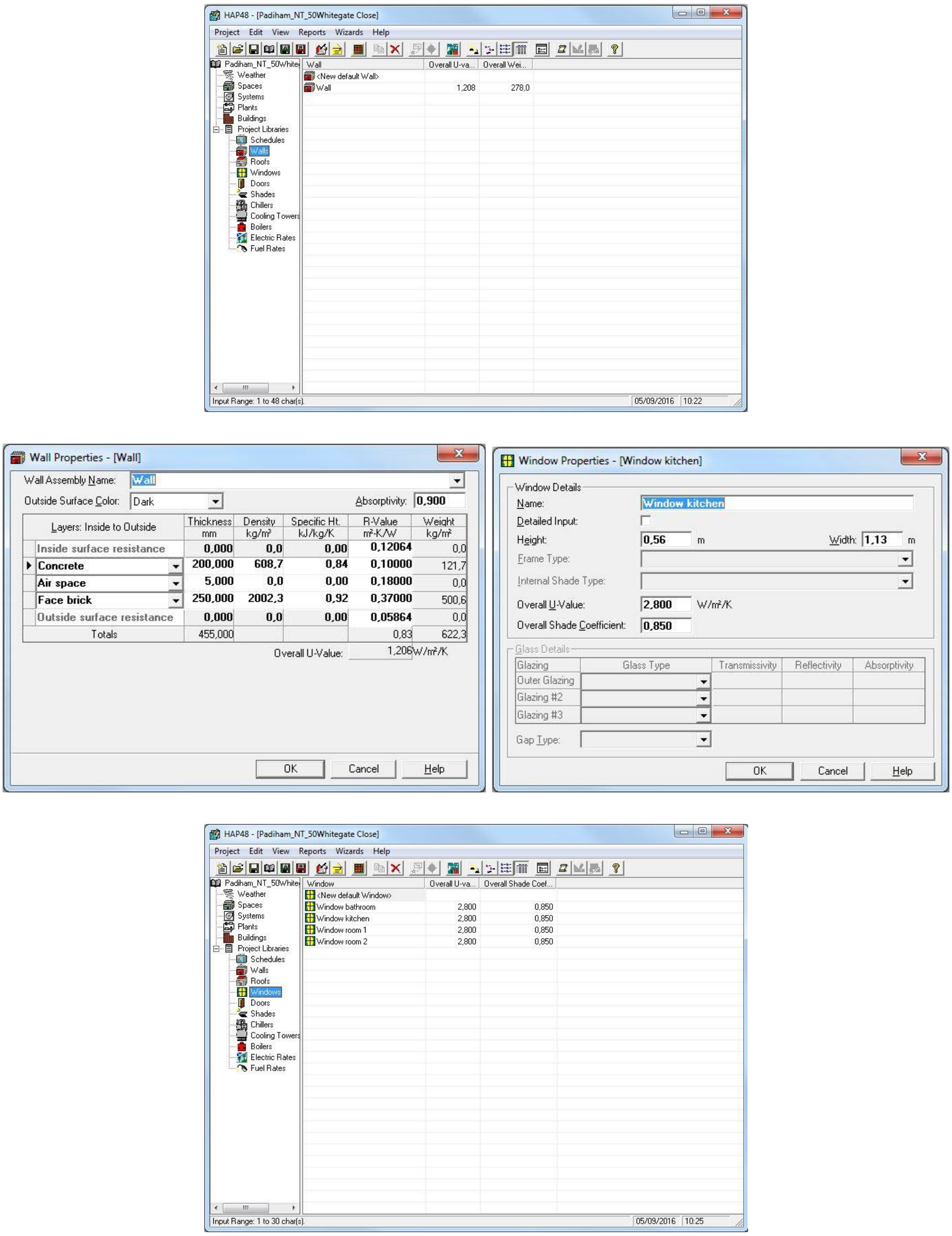


Figure 30 Wall and windows definition

While defining a space, information about the construction of walls, roofs, windows, doors and external shading devices is needed, as well as information about the hourly schedules for internal heat gains. This construction and schedule data can be specified directly from the space input form (via links to the construction and schedule forms), or alternately can be defined prior to entering space data. In this first approach we have define three different schedules: one for the electrical equipment, one for heating and one for lighting.

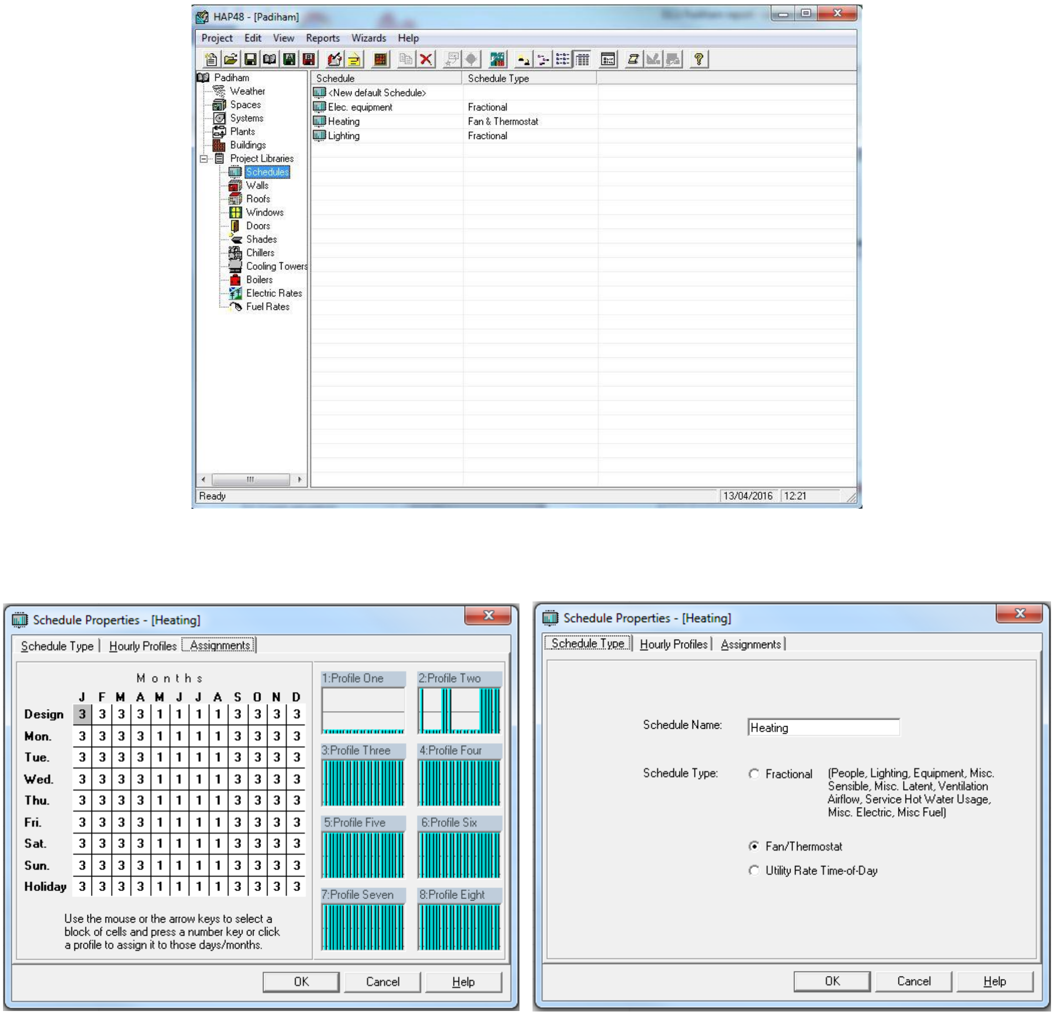
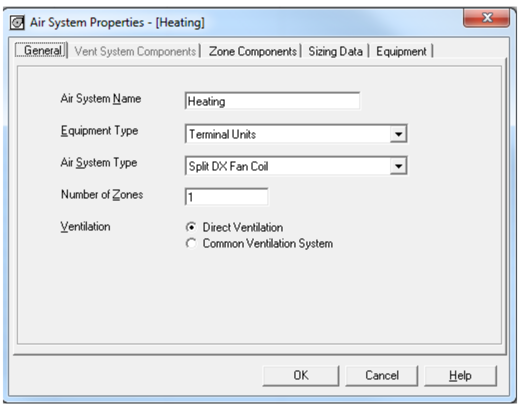
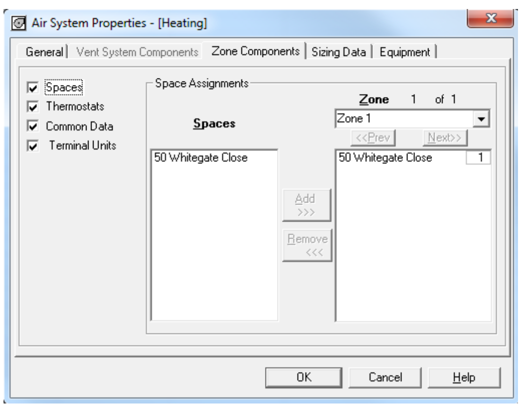


Figure 31 Schedule definition

In Padiham we have electric radiators as terminal units (heating system) so the design supply temperature must be quite close to 55 ºC. Heating T-stat Set points is 21ºC.





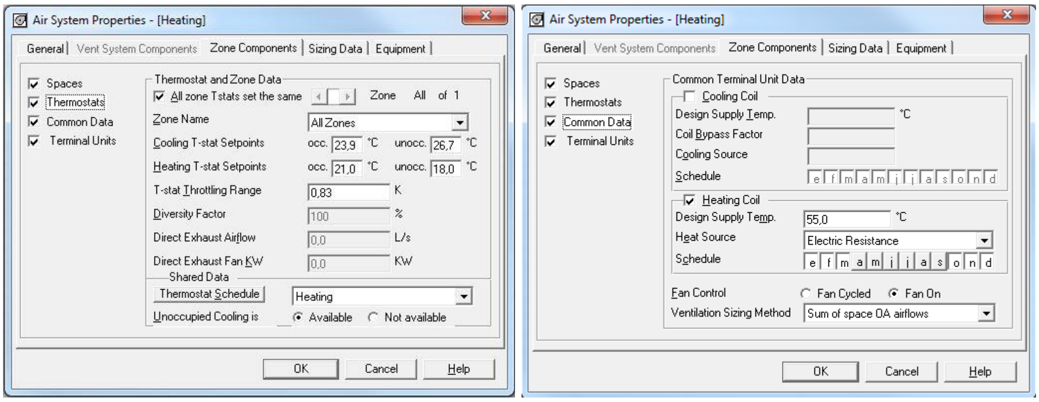
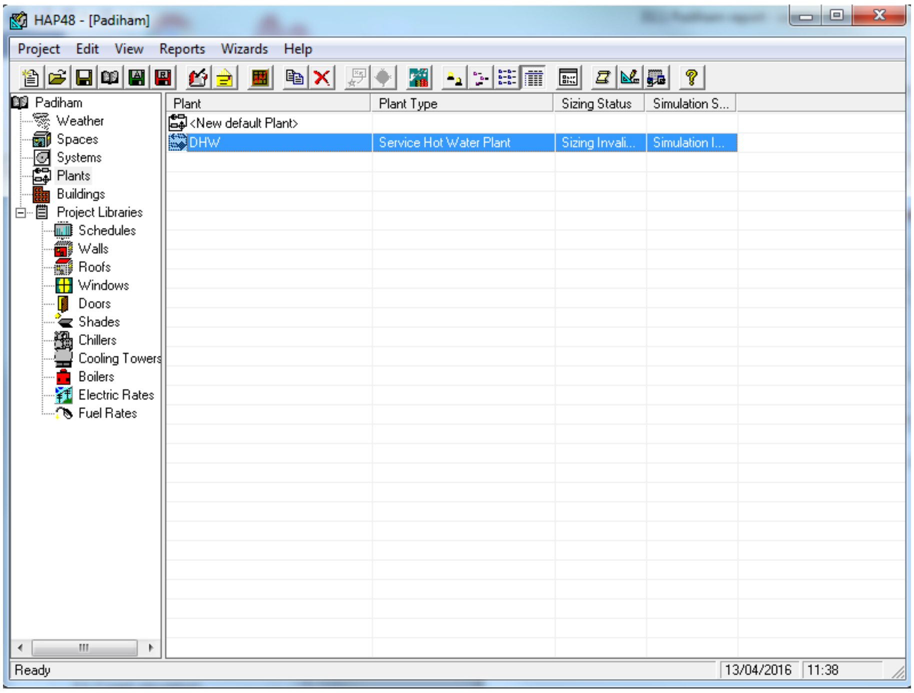


Figure 32 System definition



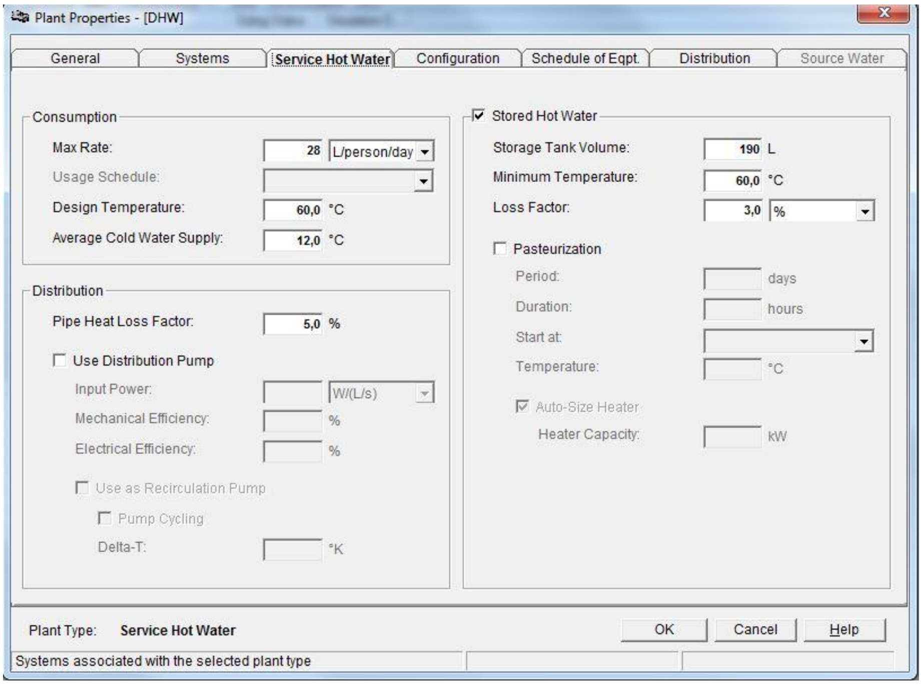
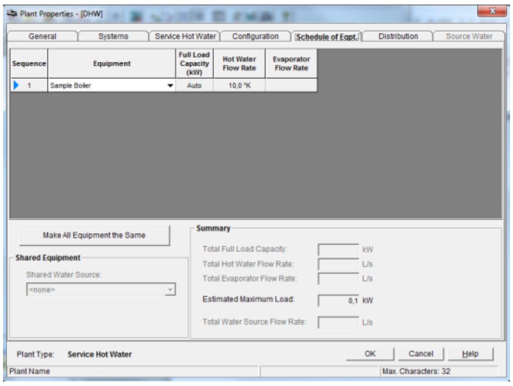
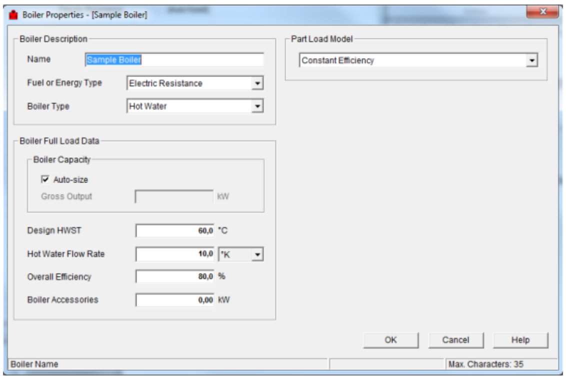


Figure 33 Plant definition

The Domestic Hot Water plant has been simulated taking into account 28 l/person/day, distribution losses of 5% and a design temperature of 60ºC.





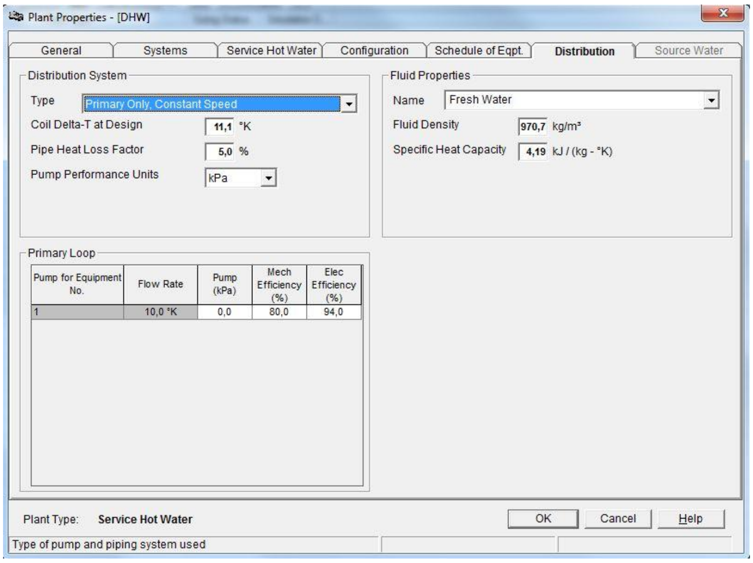


Figure 34 Plant definition

In our simulation a boilers that provide DHW has been defined with a deposit tank estimated in 190 l.

In the following figures we have the results that comes from the simulation tool. On one hand the energy consumption related to DHW which it is really similar throughout the year as it is possible to observe in the figure 32, on the other hand the heating consumption as figure 33 displays there is no energy demand related to heating consumption during summer time.

Monthly Simulation Results for DHW

Padiham_50WGC_Current
Exeleria

01/13/2017
10:05

Plant Simulation Results (Table 1):

Month	Service HW Load (kWh)	HW Storage Tank Losses (kWh)	SHW Piping Losses (kWh)	Plant Heating Load (kWh)	Boiler Output (kWh)	Boiler Input - Electric (kWh)	Boiler Misc. Electric (kWh)
January	335	230	5	352	352	370	0
February	303	208	5	318	318	335	0
March	335	230	5	352	352	370	0
April	324	222	5	341	341	359	0
May	335	230	5	352	352	370	0
June	324	222	5	341	341	359	0
July	335	230	5	352	352	370	0
August	335	230	5	352	352	370	0
September	324	222	5	341	341	359	0
October	335	230	5	352	352	370	0
November	324	222	5	341	341	359	0
December	335	230	5	352	352	370	0
Total	**3947**	**2707**	**59**	**4144**	**4144**	**4362**	**0**

Monthly Simulation Results for DHW

Padiham_50WGC_Current
Exeleria

01/13/2017
10:07

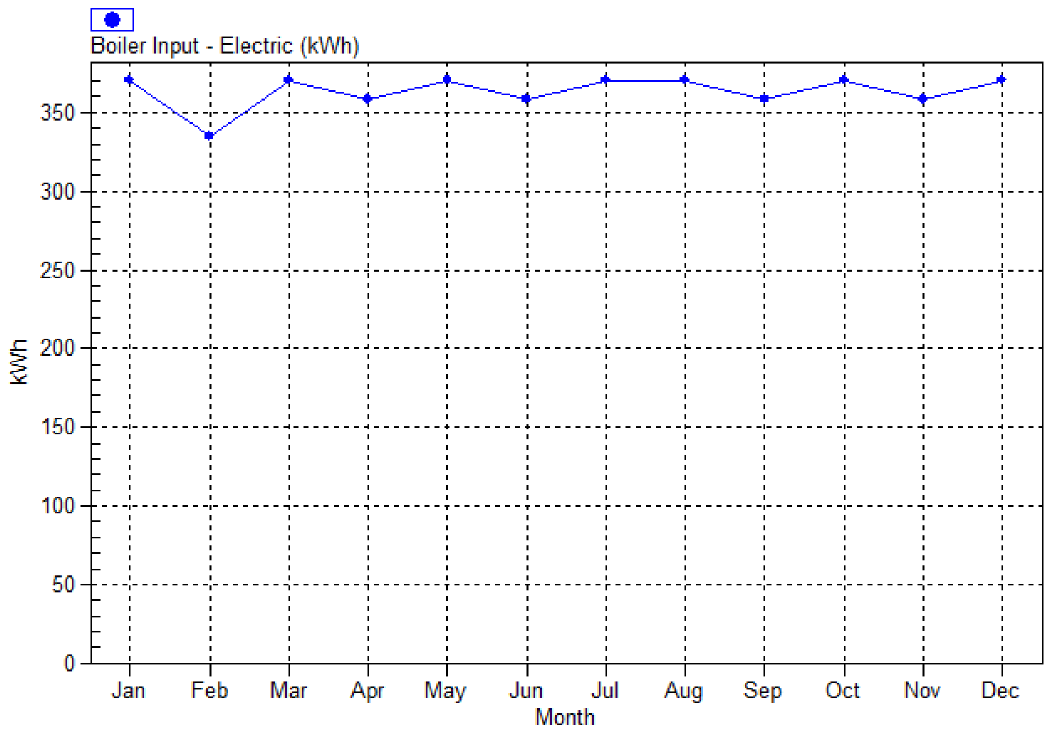


Figure 35 DHW simulation results- 50 Whitegate Close

Monthly Simulation Results for Heating

Project Name: Padiham_50WGC_Current 01/13/2017
Prepared by: Exeleria 01:06

Air System Simulation Results (Table 1) :

Month	Terminal Heating Coil Load (kWh)	Terminal Heating Coil Input (kWh)	Terminal Fan (kWh)	Lighting (kWh)	Electric Equipment (kWh)
January	1743	1743	0	64	137
February	1349	1349	0	57	124
March	1238	1238	0	64	137
April	0	0	0	62	133
May	0	0	0	64	137
June	0	0	0	62	133
July	0	0	0	64	137
August	0	0	0	64	137
September	0	0	0	62	133
October	633	633	0	64	137
November	1027	1027	0	62	133
December	1346	1346	0	64	137
Total	**7337**	**7337**	**0**	**749**	**1612**

Monthly Simulation Results for Heating

Project Name: Padiham_50WGC_Current 01/13/2017
Prepared by: Exeleria 01:06

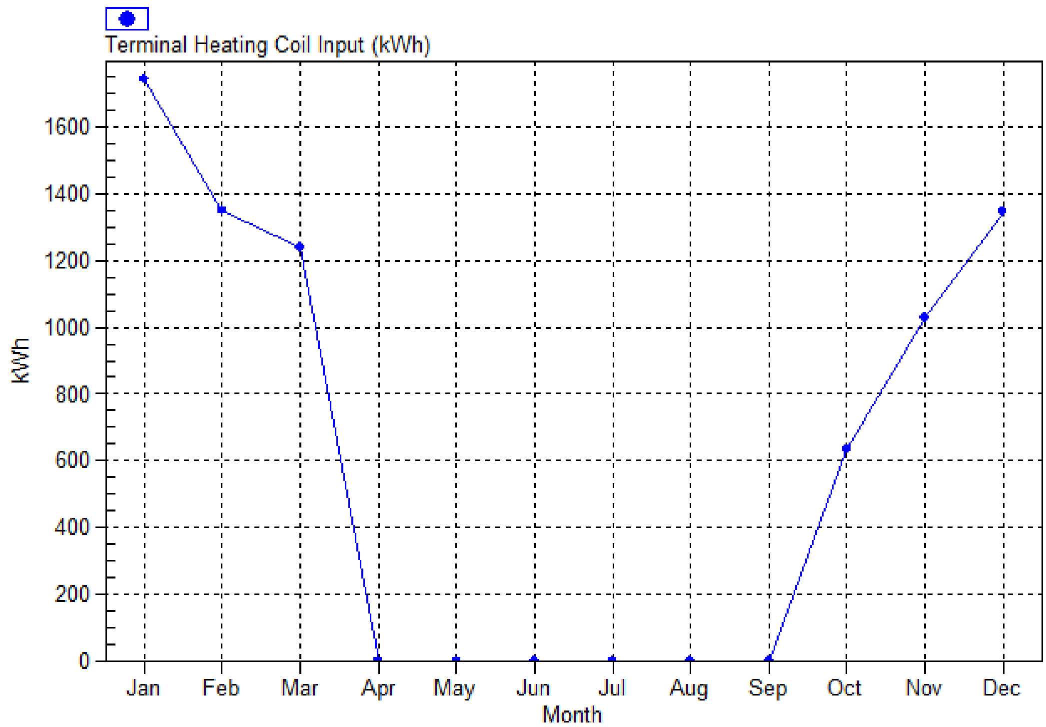


Figure 36 Heating system simulation results- 50 Whitegate Close

- 38 Whitegate Close

  The same previous procedure has been done for the building located in 38 Whitegate Close obtaining the following results:

Monthly Simulation Results for DHW

Padiham_38WGC_Current 01/13/2017
Exeleria 10:15

Plant Simulation Results (Table 1):

Month	Service HW Load (kWh)	HW Storage Tank Losses (kWh)	SHW Piping Losses (kWh)	Plant Heating Load (kWh)	Boiler Output (kWh)	Boiler Input - Electric (kWh)	Boiler Misc. Electric (kWh)
January	367	230	7	385	385	405	0
February	331	208	6	348	348	366	0
March	367	230	7	385	385	405	0
April	355	222	6	373	373	392	0
May	367	230	7	385	385	405	0
June	355	222	6	373	373	392	0
July	367	230	7	385	385	405	0
August	367	230	7	385	385	405	0
September	355	222	6	373	373	392	0
October	367	230	7	385	385	405	0
November	355	222	6	373	373	392	0
December	367	230	7	385	385	405	0
Total	**4317**	**2707**	**77**	**4533**	**4533**	**4772**	**0**

Monthly Simulation Results for DHW

Padiham_38WGC_Current 01/13/2017
Exeleria 10:15

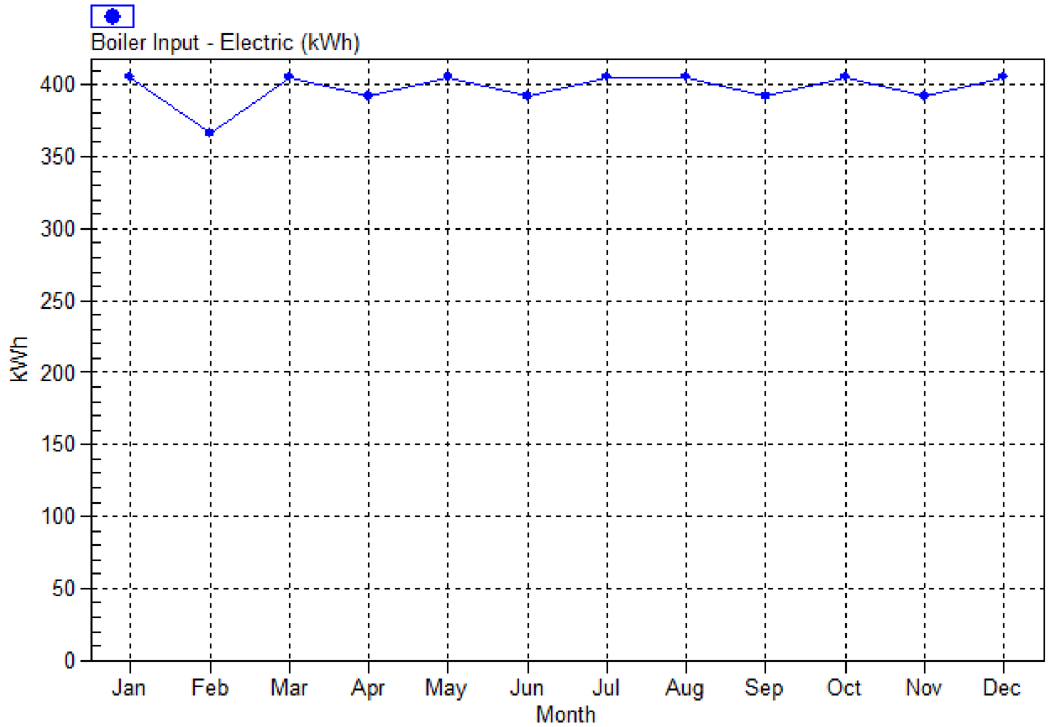


Figure 37 DHW simulation results- 38 Whitegate Close

Monthly Simulation Results for Heating

Project Name: Padiham_38WGC_Current 01/13/2017
Prepared by: Exeleria 12:01

Air System Simulation Results (Table 1) :

Month	Terminal Heating Coil Load (kWh)	Terminal Heating Coil Input (kWh)	Terminal Fan (kWh)	Lighting (kWh)	Electric Equipment (kWh)
January	2437	2437	0	145	205
February	1841	1841	0	131	186
March	1640	1640	0	145	205
April	0	0	0	140	199
May	0	0	0	145	205
June	0	0	0	140	199
July	0	0	0	145	205
August	0	0	0	145	205
September	0	0	0	140	199
October	769	769	0	145	205
November	1401	1401	0	140	199
December	1871	1871	0	145	205
Total	**9960**	**9960**	**0**	**1709**	**2420**

Monthly Simulation Results for Heating

Project Name: Padiham_38WGC_Current 01/13/2017
Prepared by: Exeleria 12:01

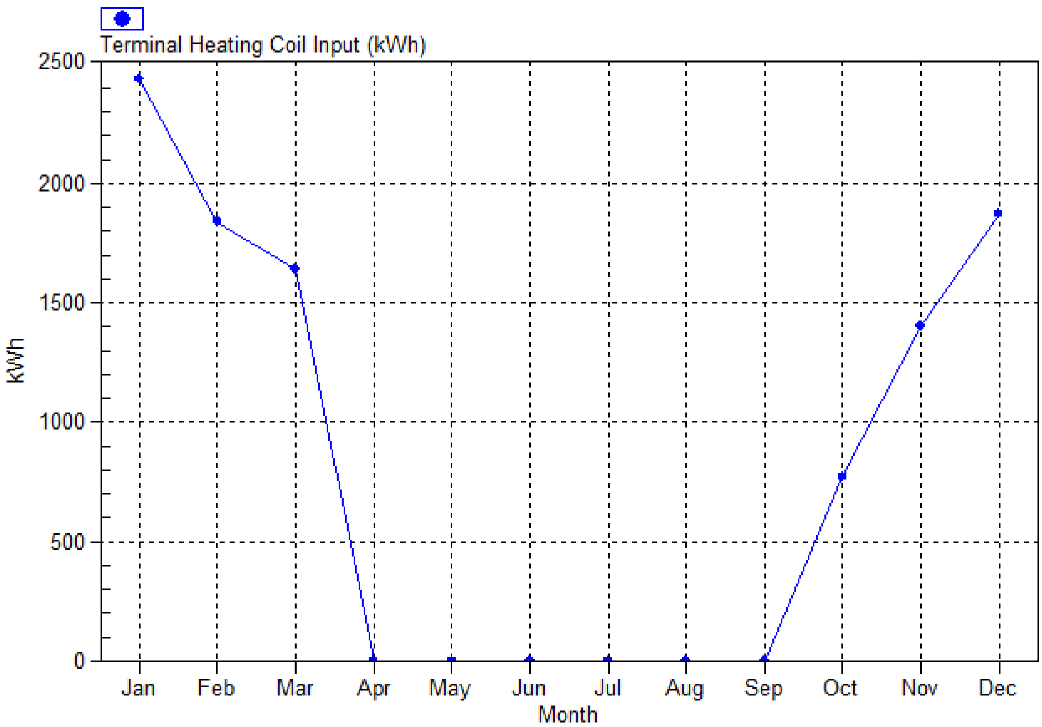


Figure 38 Heating system simulation results- 38 Whitegate Close

- 11 Whitegate Gardens

  The same previous procedure has been done for the building located in 11 Whitegate Gardens. The differences comparing with the other flats are the gas source and more external walls (end-terrace archetype). The following results are obtained:

Monthly Simulation Results for DHW

Padiham_11WGG_Current
Exeleria

01/13/2017
12:12

Plant Simulation Results (Table 1):

Month	Service HW Load (kWh)	HW Storage Tank Losses (kWh)	SHW Piping Losses (kWh)	Plant Heating Load (kWh)	Boiler Output (kWh)	Boiler Input - Electric (kWh)	Boiler Misc. Electric (kWh)
January	370	230	7	389	389	409	0
February	335	208	6	351	351	370	0
March	370	230	7	389	389	409	0
April	358	222	6	376	376	396	0
May	370	230	7	389	389	409	0
June	358	222	6	376	376	396	0
July	370	230	7	389	389	409	0
August	370	230	7	389	389	409	0
September	358	222	6	376	376	396	0
October	370	230	7	389	389	409	0
November	358	222	6	376	376	396	0
December	370	230	7	389	389	409	0
Total	**4361**	**2707**	**79**	**4579**	**4579**	**4820**	**0**

Monthly Simulation Results for DHW

Padiham_11WGG_Current
Exeleria

01/13/2017
12:16

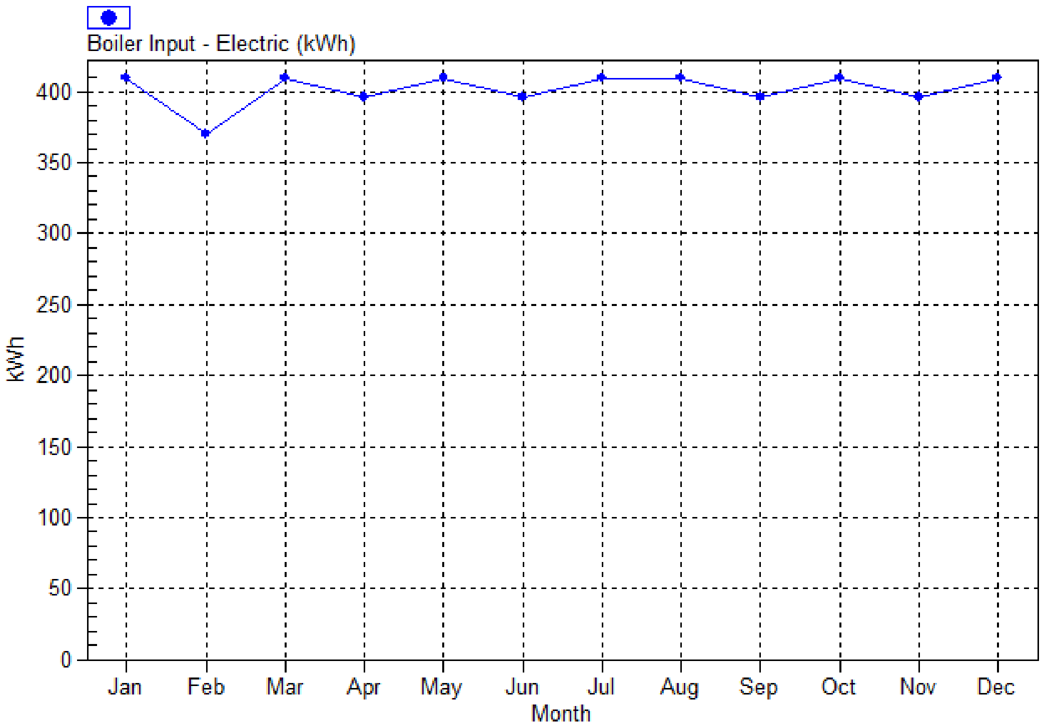


Figure 39 DHW simulation result - 11 Whitegate Garden

dreeam

Monthly Simulation Results for Heating

Padiham_11WGG_Current
Exeleria

01/13/2017
12:17

Plant Simulation Results (Table 1) :

Month	Heating Coil Load (kWh)	Plant Heating Load (kWh)	Boiler Output (kWh)	Boiler Input - Propane (kWh)	Boiler Misc. Electric (kWh)	Primary Water Dist. Pump (kWh)
January	2829	2829	2829	3536	0	0
February	2111	2111	2111	2638	0	0
March	1826	1826	1826	2283	0	0
April	0	0	0	0	0	0
May	0	0	0	0	0	0
June	0	0	0	0	0	0
July	0	0	0	0	0	0
August	0	0	0	0	0	0
September	0	0	0	0	0	0
October	864	864	864	1080	0	0
November	1639	1639	1639	2049	0	0
December	2196	2196	2196	2746	0	0
Total	**11465**	**11465**	**11465**	**14331**	**0**	**0**

Monthly Simulation Results for Heating

Padiham_11WGG_Current
Exeleria

01/13/2017
12:17

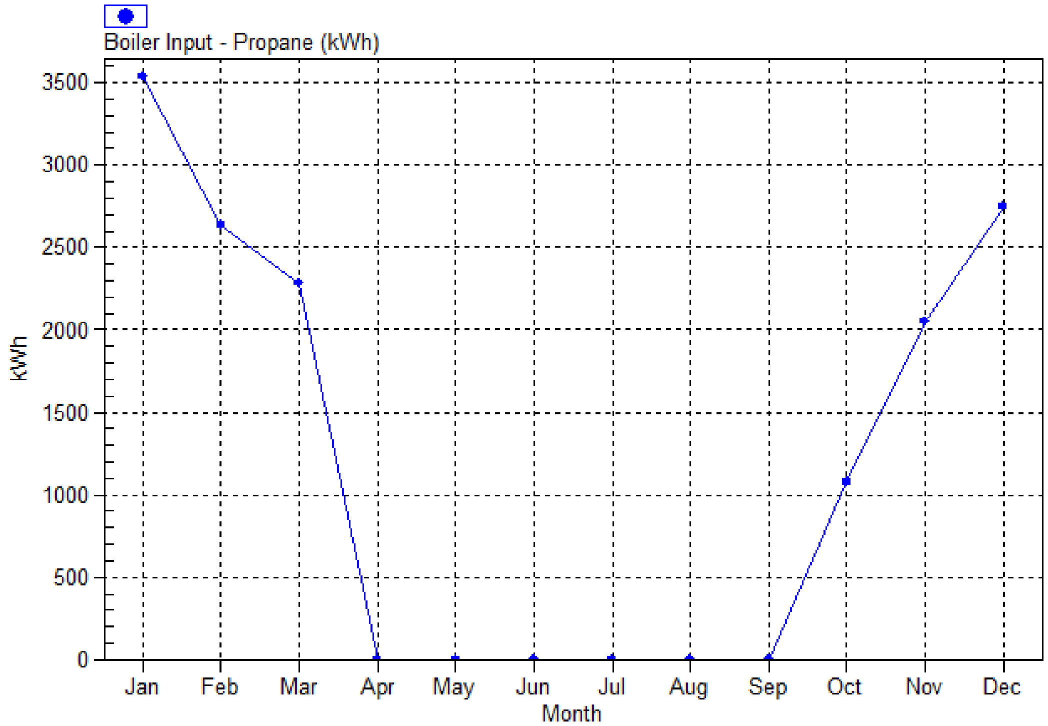


Figure 40 Heating system simulation result - 11 Whitegate Garden

3.2 Analysis of sensitivity

After the simulation analysis with the HAP tool, the following parameters have been modified to see how they affect to the result of the consumption. The building located in 50 Whitegate Close is selected for the analysis of sensitivity:

3.2.1 Room temperature

For the current analysis calculated before, it has been considered a room temperature of 22 ºC while heated. An increment and a decrease of 1 ºC on this temperature has been modified and checked the variation on the heating energy demand.

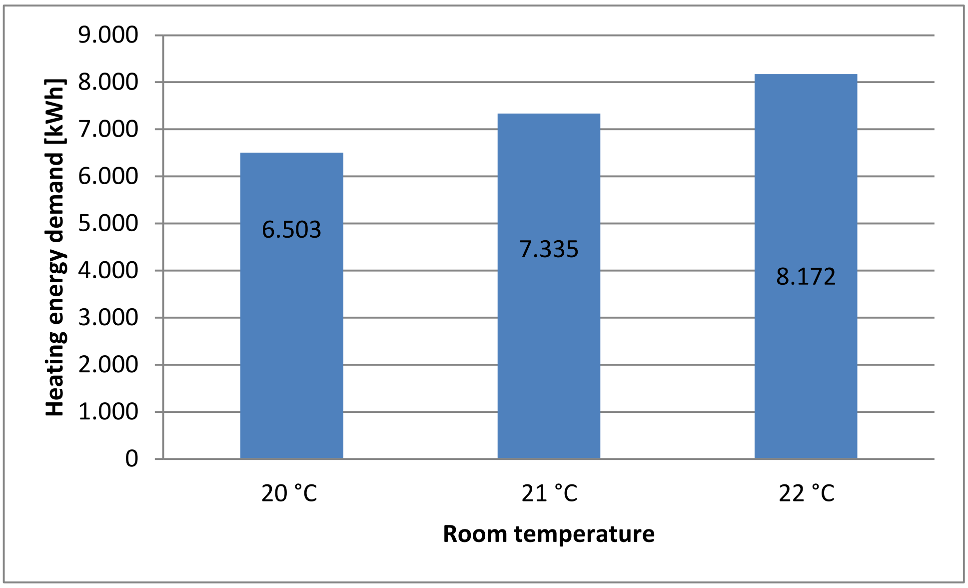


Figure 41 Heat energy demand in relation to room temperature

The variation in percentage produced is:

Temperature	Heating energy demand [kWh]
-1 ºC	-11,3 %
21 ºC	7.335
+1 ºC	+11,4 %

3.2.2 U-Value

In the following analysis the U-Values measured during the first visit are compared with the values obtained in the calculation.

- Wall against the outside. The calculated value for the simulation 1,2 W/m²K and a worse one of 2,8:

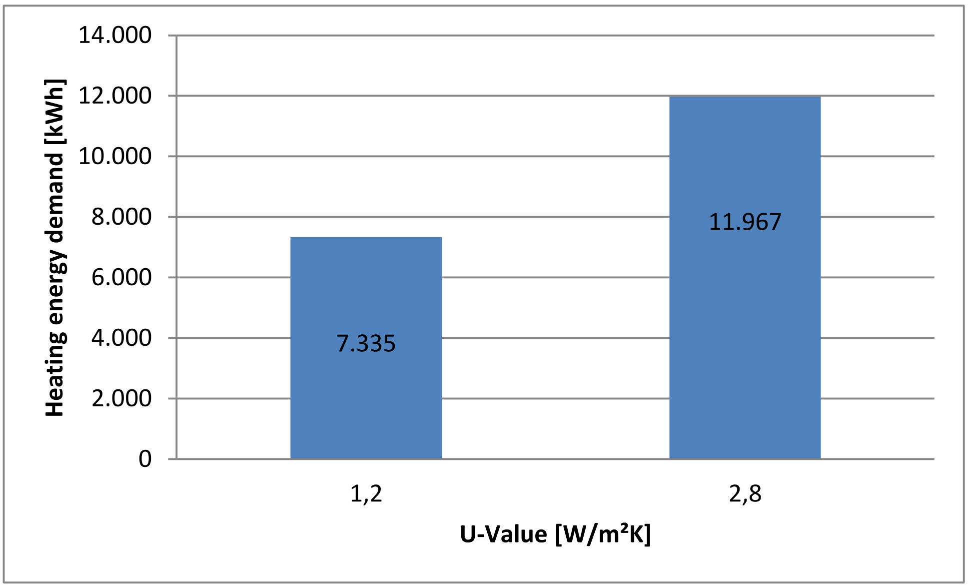


Figure 42 Heat energy demand in relation to the U-Value

There is a double demand for the measured value.

- Roof against and small unheated loft. The U-Value measured is 1,758 and the calculated for the simulation 0,58 W/m²K:

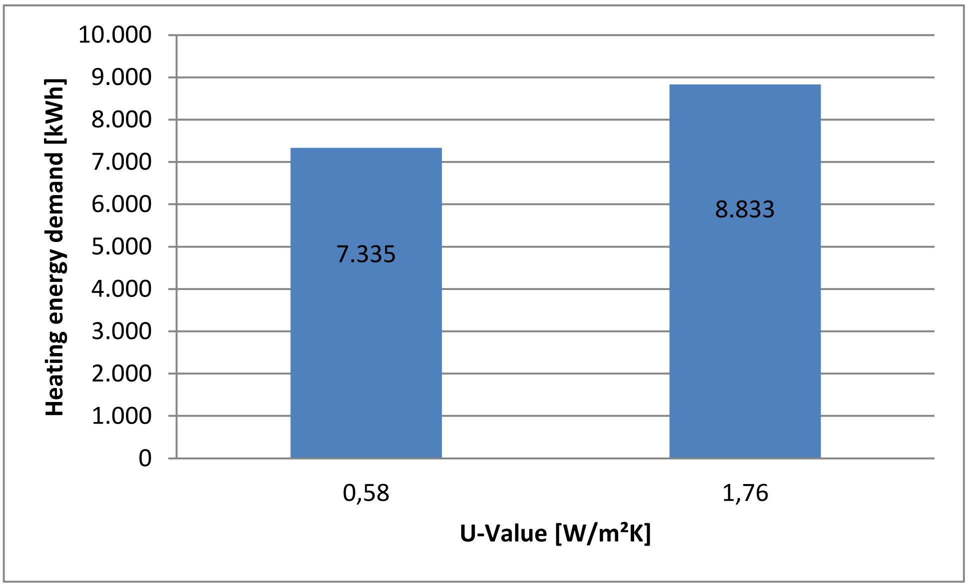


Figure 43 Heat energy demand in relation to the U-Value

There is a 24 % higher demand for the measured value.

- Floor against the outside. The highest U-Value measured is 4,119 and the calculated for the simulation 3,87 W/m²K:

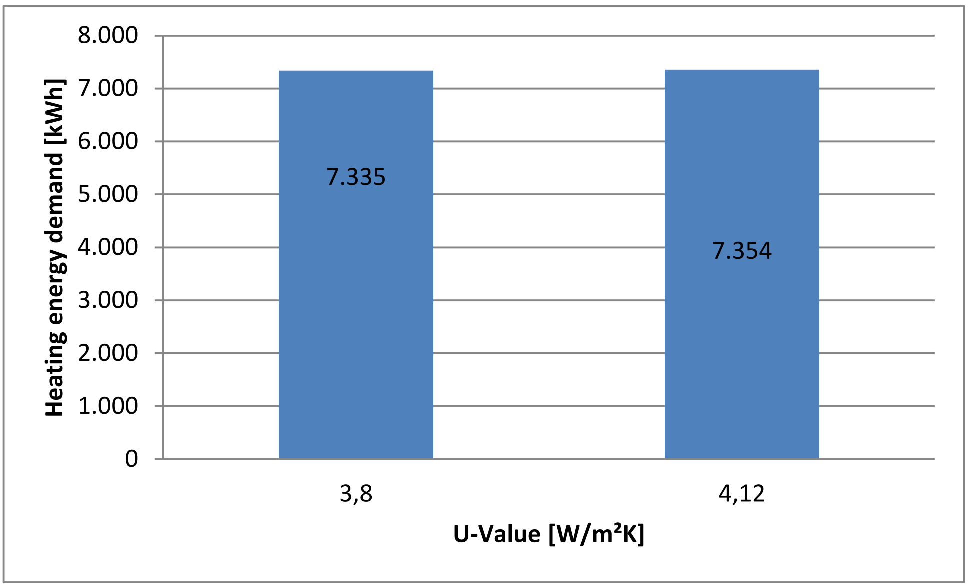


Figure 44 Heat energy demand in relation to the U-Value

There is the same demand for the measured value.

- All the values together.

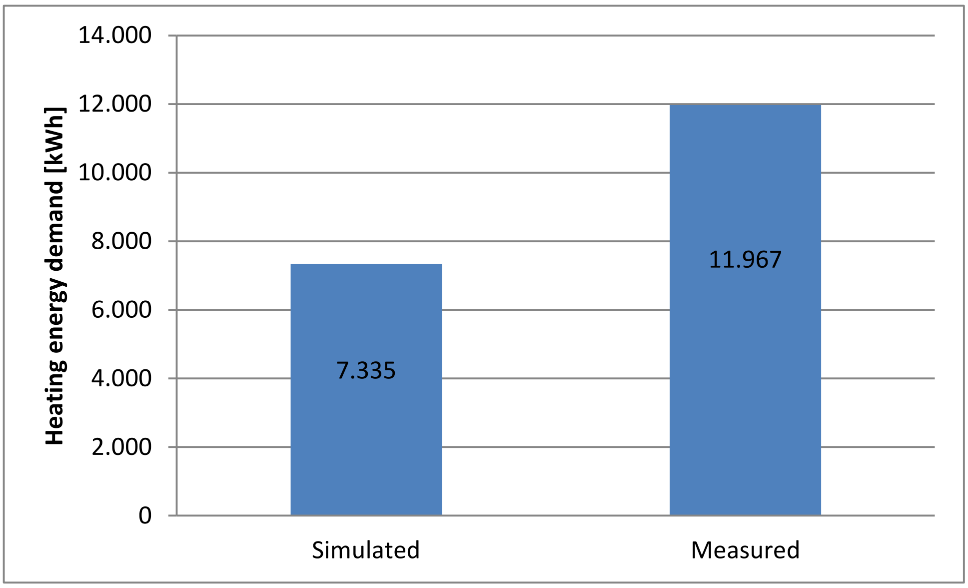


Figure 45 Heat energy demand in relation to the U-Value

There is a 63,1 % higher demand for the measured values.

3.2.3 Infiltration

For the current analysis calculated before, it has been considered an infiltration of 1 air change per hour. An increment or decrease of it modify the heating energy demand:

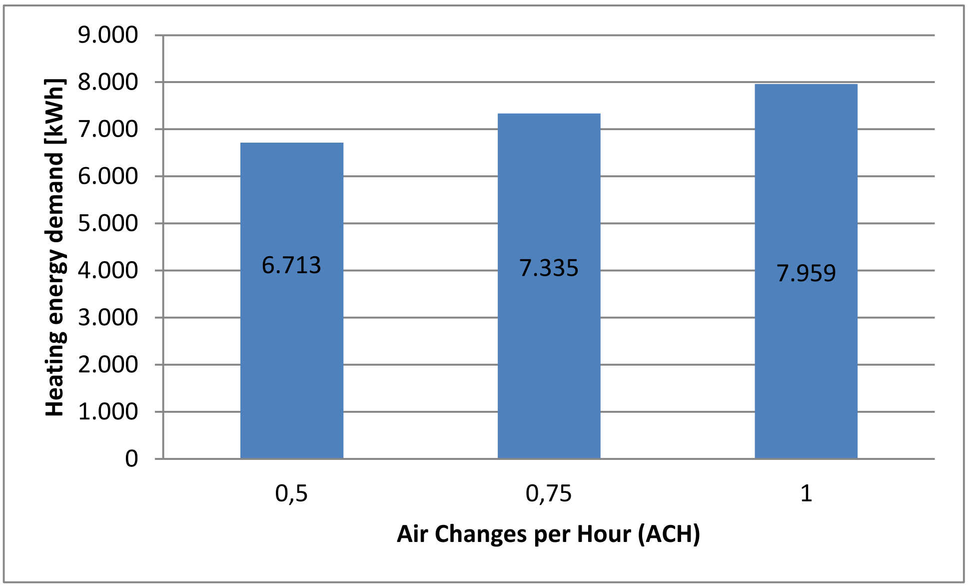


Figure 46 Heating energy demand in relation to the infiltration

Air Changes per Hour (ACH)	Heating energy demand [kWh]
0,5	-8,4 %
0,75	7.335
1	+8,5 %

A discussion on how to use for this simulation analysis is done in the conclusions section.

3.2.4 Overview

Parameter	Heating energy demand [kWh]	Percentage
Temperature -1 ºC	6.503	-11,3 %
Temperature +1 ºC	8.172	+11,4 %
Worse U-Values	11.967	+63,1 %
ACH from 0,75 to 0,5	6.713	-8,4 %
ACH from 0,75 to 1	7.959	+8,5 %

4 Summary and conclusions

4.1 Passive Components

4.1.1 Thermographic analysis

From the thermographic analysis we can get the conclusion that generally, the conditions of the insulation in the building are not favourable and do not allow a minimal thermal comfort for the daily life in the dwelling. A significant amount of thermal bridges have been found in different parts of the construction: walls, roof, windows, etc. All the components of the envelope must be supervised.

Due to the high presence of moistures, a deeper analysis of it was applied in order to have a better understanding of them and about possible solutions to this problem. A report of this analysis is attached here (see damp report).

4.1.2 U-Value analysis

Generally, the values obtained are very high (over 4,00 W/m^{2}K) and it can be possible that those values are wrong measured. The possible reasons of the high values could be:

- Non ideal measurement conditions because temperature difference were below 15 ºC (similar outside and inside temperature)
- Humidity during the measure due to the rain.

Considering these values there is an important heat loss through the walls and floor that increases significantly the energy consumption of the building.

In accordance with this discrepancy, in the simulation have been selected the calculated U-Values. Below the table with the U-values analysed (bolded the selected for simulations):

		U-Value [W/m²K]		
Number	**Component**	**Obtained**	**Calculated**	**Construction year average (BPIE)**
1	Wall against exterior air	4,676	**1,20***	1,80
2	Wall against exterior air	1,945	**1,20***	1,80
3	Floor against exterior air	4,119	**3,87**	1,20
4	Roof against unheated room	1,758	**0,58**	0,90

*There is no evidence of cavity injection

4.1.3 Windows

The results obtained show that the windows have apparently a good state of insulation due to the wide cavity (aprox. 23 mm) between the two glasses. Moreover, the existence of a gas between them imply a lower U-Value of the window.

For the analysis, a value of 2,8 W/m^{2}K has been selected.

4.2 Active Components

4.2.1 Heating & DHW production

The boilers seems to be very old. That means that they have a very low efficiency, which implies a higher demand of primary energy comparing with the current boilers in the market. It can be also observed that the pipes are not good isolated in some cases, therefore, there are important heat losses through them.

The electrical system for the shower is an efficient way to produce hot water in the same moment as the consumption and also to reduce the loses produced during the transport of it.

4.2.2 Terminal units

In the case of the radiators in the houses that use gas, the control of the heating depends on the user which can switch on or switch off it depending on their thermal comfort (not on the room temperature or the outside temperature). This system is not very efficient from an efficiency point of view.

4.2.3 Lighting

There are installed a significant number of lamps that suppose a waste of energy comparing with the newest kind of lamps as LED or low consumption lamps. The use of lamps with a high nominal power in a dwelling increase significantly the power consumption considering the total amount and the number of hours they are working.

4.3 Simulation analysis

4.3.1 Results obtained

The total consumption of the house is the sum of all the loads: heating, DHW, lighting and electric equipment. This is not possible to compare the simulated consumption with a real consumption due to the lack of this information. However, the energy consumed in a social house can be lower than the standard. Despite this a comparisons based on SAP results for the homes is shown below:

- 50 Whitegate Close

Consumption = 7.335 + 4.362 + 749 + 1.616 = 14.062 kWh year

In relation with the area of the flat (47,5 m^2):

Simulation ratios:

- Heating final energy: 154 kWh/m2
- Heating primary energy: 308 kWh/m2
- Total primary energy (heating, DHW, lighting): 592 kWh/m2

SAP ratios:

- Total primary energy (heating, DHW, lighting): 689 kWh/m2

The energy certificate shows a similar value as the energy demand simulated.

- 38 Whitegate Close

Consumption = 9.567 + 5.662 + 1.709 + 2420 = 19.358 kWh year

In relation with the area of the flat (77,6 m^2):

Simulation ratios:

- Heating final energy: 123 kWh/m2
- Heating primary energy: 246 kWh/m2
- Total primary energy (heating, DHW, lighting): 499 kWh/m2

The EPC of the building is not available. Therefore a comparison is not possible. However, the value obtained is similar to de SAP of 50 Whitegate Close.

- 11 Whitegate Gardens

Consumption = 14.331 + 4.820 + 1.274 + 2.061 = 22.486 kWh year

In relation with the area of the flat (80,8 m^2):

Simulation ratios:

- Heating final energy: 177 kWh/m2
- Heating primary energy: 195 kWh/m2
- Total primary energy (heating, DHW, lighting): 397 kWh/m2

The EPC of the building is not available. Therefore a comparison is not possible.

4.3.2 Analysis of sensitivity

A sensitivity analysis has been done showing the influence of changes in the most relevant parameters.

- Room temperature

  An increment or a decrease of 1 ºC on the room temperature produces a variation around 11,3 % in the heating energy demand. A temperature of 21 - 22 ºC during the day ensures a minimum of habitability conditions.

  It can be considered that the temperature vary from one room to another. For example, in the bathroom can exceed this temperature to 23 °C and the rooms that are not usually used up to 18 °C.

  To heat the building with a room temperature above 22 ºC implies a significant waste of energy.

- U-Value

  The variation produced in the case of the wall against outside is very significant (the U-Value measured is in some cases the double as the one selected for the analysis) For the other components there is not a big variation. After the analysis of all of the components together with a better U-Value it is shown the importance of having a good insulation system.

  Using the U-Values calculated which are similar to the one selected from the year construction, which are in most of the cases much better than the measured, the heating energy demand obtained is around the half than the one calculated with the U-Values measured.

- Infiltration

  Through the analysis of the infiltrations in the building, it can be shown that they have an important impact not only in the comfort of its users but also in the level of energy efficiency of the building. It is obvious that when the outside temperature is low, have an income of cold air inside the building increases the heating energy demand.

  As we can see in the Figure 46, a small increment in in the value of air changes per hour produces a significant higher heating energy demand. For example the heating energy demand from 0,5 to 0,75 air changes per hour is increased a 8,5%.

Treviso (IT)

Pilot site

5 Pilot Site overview

5.1 General Description

The purpose of the visit is to evaluate the baseline situation of the building providing the starting point for the renovation DREEAM approach.

This technical baseline will be focus on the gathering of information about:

- **Passive technologies:** The thermal properties of the walls, roof, etc. analysing in which conditions are they currently and the features of the windows.
- **Active technologies:** Identifying every component of the installation of the buildings including electrical parts, heating systems, storage and lighting among other things.

5.2 Buildings Description

The visit took place in the city of Treviso (Italy) in social housing buildings located between the streets Francia and Borgo Furo di Santa Bona

Figure 47 Aerial view of the social housing building

The two buildings have identical construction features but different orientation

Figure 48 Pilot site map and buildings visited

Each building has 6 floors of living spaces and in the basement there is a storage room. The triangular shape of the building allows it to have a high exterior surface.

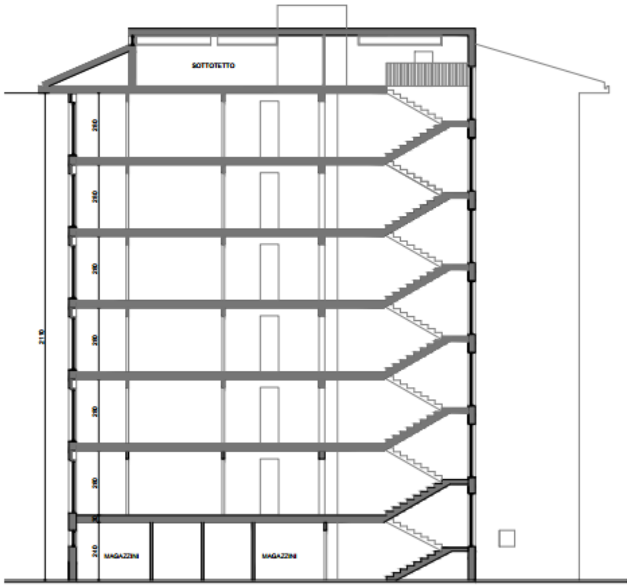


Figure 49 elevation plan

There are 3 dwellings per floor of 82,3 m^2 each. The dwelling consist 3 rooms, a living room, a kitchen, a bathroom, a toilet and a hall. In the next figure it can be shown an example of one of the flats:

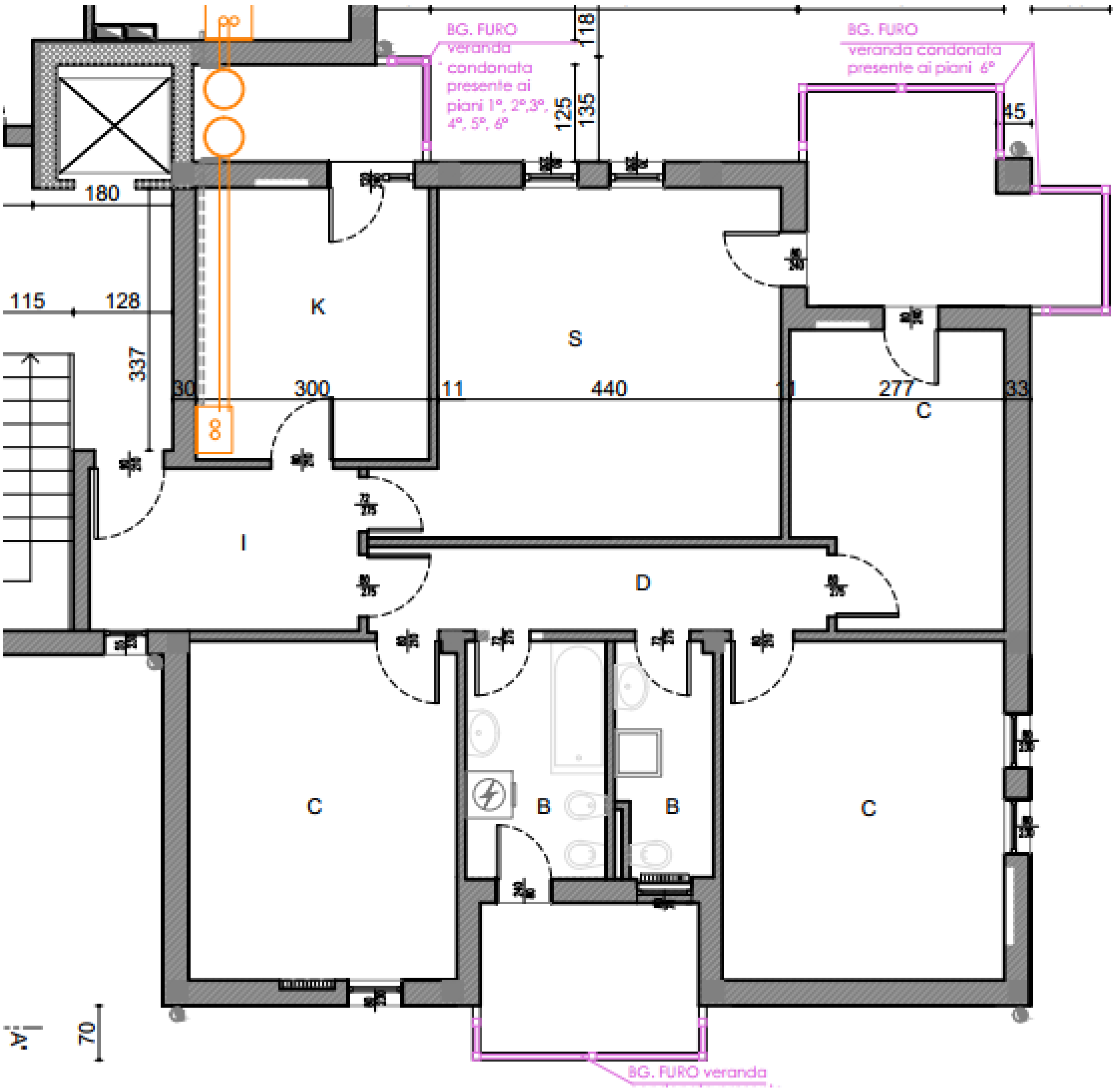


Figure 50 Floor plan of one dwelling

The total amount of dwellings in each building is 18.

5.3 BO requirements and objectives

To carry out the pilot visit, the collaboration of the building owners is required to facilitate to gather as much information as possible that can be used to make a deep analysis about the current situation of the building. For it, ATER Treviso has made available the entry to different flats and technical rooms allowing to make a thermography analysis, to measure the thermal transmission of the passive components and to analyse the active components.

The main objective of the building owner about this visit is to have an understanding of the current situation of their properties. This information must cover the components of the building and the energy consumption of the social housing. It will consist be the first step of the renovation process.

5.4 Information needed

To perform the analysis of the building and compare the data obtained from the measurements it is necessary to have the construction plans which include every information about the typology, orientation, dimensions, components and details of the building.

ATER Treviso has provided all the construction drawings that allow Exeleria to get a deep study of the building.

This information includes:

- Building spaces Lay-out
- Elevation drawings
- Energy Performance Certificates of some dwellings
- Envelope components detailed description
- Heating & DHW technical drawings (central production systems schemes)
- Energy consumptions of the central heating & DHW systems for the whole building

6 On site data gathering

6.1 Pasive components

6.1.1 Thermographic analysis

The detailed information related to the thermographic analysis could be found in the methodology document included in the annexes.

To carry out the thermographic analysis, a minimum thermal conditions for the difference of temperature between indoor-outdoor were necessary.

The temperature inside the building during the thermographic work ranged between 16 and 18 °C. The temperature outside was between 5 and 7 ºC. Which means a difference between 10 and 11 ºC.

After de thermographic analysis in the different parts of the building we can obtain the following conclusions:

There are generally no important thermal bridges in the dwellings. The joint between the window and the wall shows that is correctly sealed. However, the line between the wall and the ceiling is around 1 ºC less:

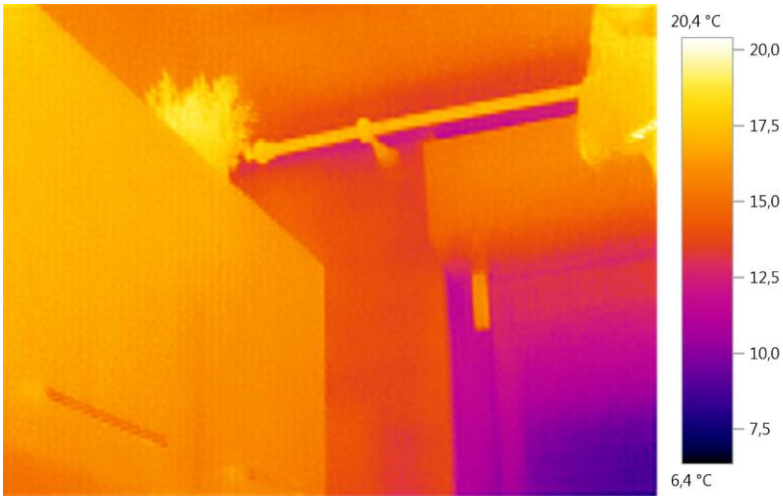


Figure 51 Thermal image of the window

The wall correspond to the kitchen where U-Value measurement has been also taken:

Figure 52 Thermal image in the kitchen

Another example of it:

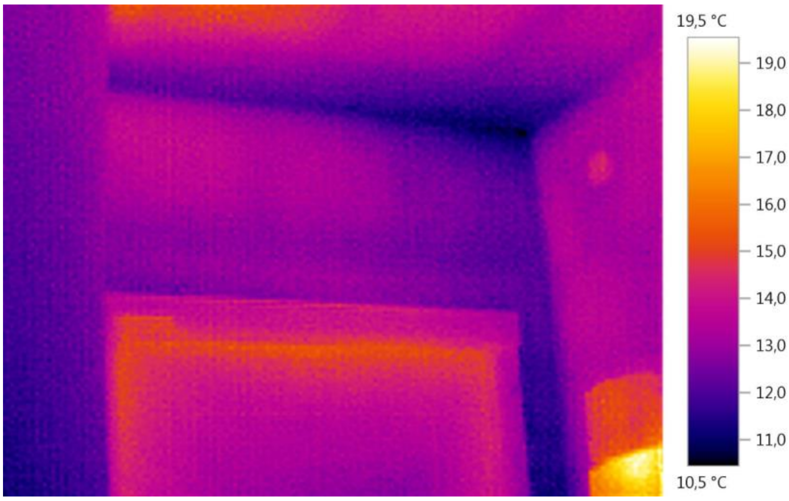


Figure 53 Thermal image in wall with window

There are no significant pipe loses in the heating distribution through the radiators and the hot water is correctly circulated though the device:

Figure 54 Thermal image of a radiator

In the terrace (unheated space) it can be found an small thermal bridge in the corner where the temperature is 2,7 ºC against around 5 ºC in the wall or in the ceiling:

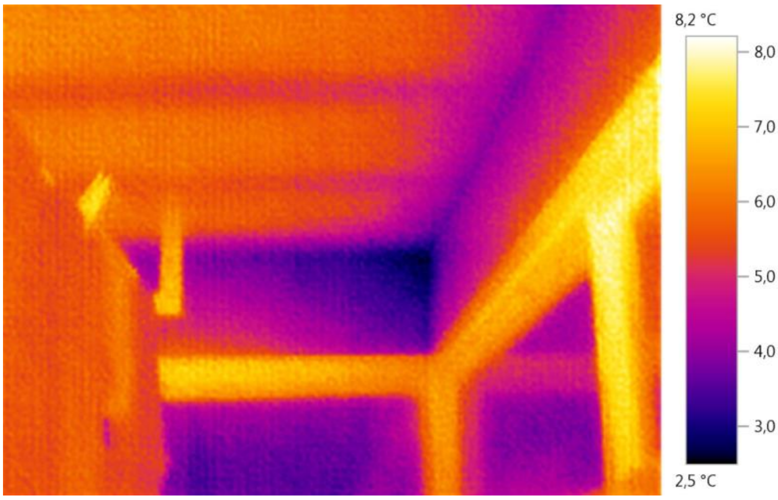


Figure 55 Thermal bridge in terrace

Figure 56 Pipe inside the wall

In the following photo we can see the facade in good condition:

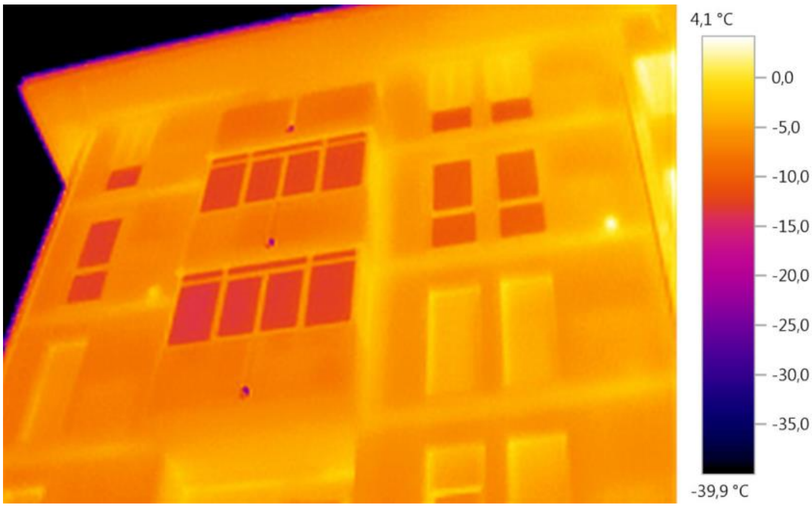


Figure 57 Façade

In the dwelling where the themographic anlaysis has been made there is no presence of moistures. However, according with the interviews with the tenants, some buildings have problems with it, probably due to the lack of a ventilation system.

Generally, there is no presence of leaks of energy in the heating or significant differences in the envelope components. In some dwellings there are problems with moistures.

6.1.2 U-Value analysis

The detailed information related to the U-values analysis could be found in the methodology document included in the annexes.

To ensure the accuracy of the measurements the ideal conditions required are:

- Temperature difference (outdoor - indoor) of at least 15 ªC
- External surfaces un exposed to solar radiation

A representative batch within each pilot case based on construction features (num. of bedroom, orientation, m2…) is selected. The equipment for measuring U-values include heat flux meters, thermistor temperature probes and data-loggers.

For the analysis of the building envelope four components of it have been analysed and obtained the currently U-value of them.

The results obtained are:

Number	Component	U-Value obtained [W/m²K]
1	Wall against exterior air	0,990
2	Wall against exterior air	1,096
3	Double window	2,353

5. Wall against exterior air. This is the wall with windows situated in the kitchen oriented to NE. The results obtained are:

- Temperature difference: 15,93 ºC
- Solar radiation: Not influenced

Date	Time	U-Value [W/m²K]	Tw [ºC]	Ti [ºC]	Hr [%]	To [ºC]
10.01.2017	10:38:19	0,990	14,97	17,02	54,7	1,10

The high U-Value obtained indicates that apparently there is a low insulation system on the façade.

Figure 58 U-Value analysis of the wall

6. Wall against exterior air. This is a wall with windows situated in a room oriented to SE. The results obtained are:

- Temperature difference: 15.26 ºC
- Solar radiation: Not influenced

Date	Time	U-Value [W/m²K]	Tw [ºC]	Ti [ºC]	Hr [%]	To [ºC]
10.01.2017	11:27:36	1,096	13,89	16,06	54,60	0,80

The similar U-Value obtained compared with the other wall indicates that they have the same composition.

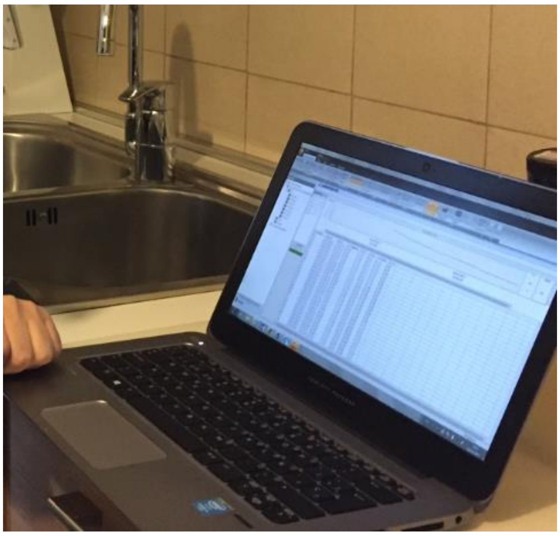


Figure 59 Data analysis in the software

7. Double window. The U-Value calculated is the total of the system of two windows. The results obtained are:

- Temperature difference: 10,6 ºC
- Solar radiation: Not influenced

Date	Time	U-Value [W/m²K]	Tw [ºC]	Ti [ºC]	Hr [%]	To [ºC]
10.01.2017	11:08:35	2,353	11,3	15,98	55,3	0,7

Figure 60 U-Value measurement device and probe

6.2 Active components

6.2.1 Heating & DHW production

The heat and the domestic hot water (DHW) is produced by the central heating system. It consists in a conventional gas boiler per dwelling which can heat water above its initial temperature. This hot water is used for many activities that include cooking, cleaning, bathing, and space heating.

The gas boiler is located in the kitchen of each dwelling as we can see in the following floor plan:

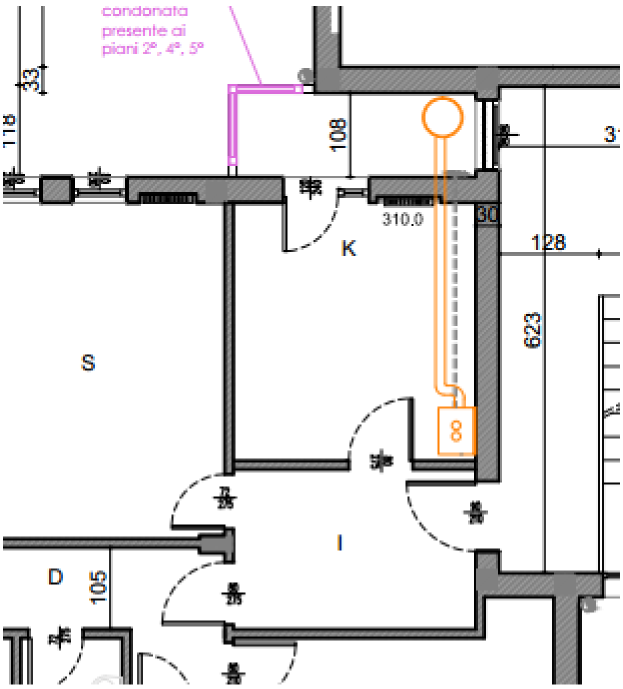
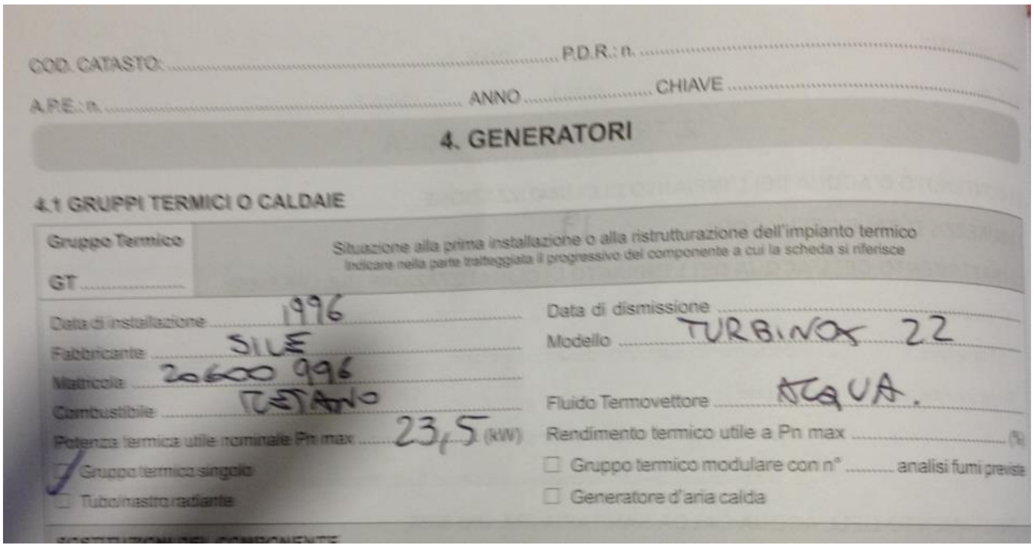


Figure 61 Boiler location

The boiler installed in the dwellings correspond to the model TURBINOX 22 by SILE which has maximum power of 23,5 kW:

Figure 62 Gas boiler

According to the information provided by ATER the boilers are installed in the year 1996, which means, they are very close to the end of its useful life.



COD. CATASTO: .... P.D.R.: n. ....

A.P.E.: n. .... ANNO .... CHIAVE ....

4. GENERATORI

4.1 GRUPPI TERMICI O CALDAIE

Gruppo Termico GT ....

Situazione alla prima installazione o alla ristrutturazione dell'impianto termico
Indicare nella parte tratteggiata il progressivo del componente a cui la scheda si riferisce

Data di installazione 1996

Fabbricante SILE

Matricola 20600 996

Combustibile METANO

Potenza termica utile nominale Pn max 23,5 (kW)

☑ Gruppo termico singolo

☐ Tubo/nastro radiante

Data di dismissione ....

Modello TURBINOX 22

Fluido Termovettore ACQUA.

Rendimento termico utile a Pn max .... (%)

☐ Gruppo termico modulare con n° .... analisi fumi previste

☐ Generatore d'aria calda

Figure 63 Form of the boiler

To protect the closed circuit of the heating and DHW production system, an expansion vessel is also necessary. In this case an expansion vessel of 7,5 l is installed:

Figure 64 Expansion vessel

6.2.2 Terminal units

A terminal unit is the part of an installation which receives air or water from a centralized system acting on the conditions of a conditioned area.

The terminal units found in the building are:

- <u>Radiators:</u> Are the elements used in the building to transfer the heat generated by the gas boiler. There are one radiator per room and the dimensions of it depends on the area to be heated: For example we can find a 1 x 0,6 m in the living room and 0,3 x 0,6 m in the bathroom.

Figure 65_Electric radiator

All radiators have a shut-off valve that can interrupt or allow the flow of water flowing through the radiator.

- Air conditioning: It is a cooling/heating air device for individual room based on a direct expansion system that also filter, at some extent, the air pollution. Air conditioning is not installed in every flat because it is a decentralised system under the decision of the tenant.

Figure 66 Air conditioning system

6.2.3 Lighting

Room lighting can be general, punctual, ambient or decorative.

Depending on the lamp:

- Incandescent: a wire filament is heated to a high temperature, by passing an electric current through it. They have a very low efficiency (5%)
- Halogen: is an incandescent lamp that has a small amount of a halogen such as iodine or bromine added. They have a lifetime around 1.500 hours of use.
- Fluorescent: is a low pressure mercury-vapor gas-discharge lamp that uses fluorescence to produce visible light. They are more expensive than incandescent but they have more efficiency and life.
- Low consumption: are also fluorescent lamps adapted to the size, shape and stands of conventional bulbs. They are more expensive but easily to be depreciated with a lifetime between 6.000 and 9.000 hours.
- LED: it is a p–n junction diode, which emits light when activated. LED lamps have a very high efficiency (around 90%) Despite of its high price, they are the best option at long term.

The kind of lamps used in the building and it powers depends on the decision of the tenants. Generally the most used are:

- Incandescent: This kind of lamp is very common for the bedrooms and living-room with power range between 40 and 60 W.
- Halogen: There are some bedrooms with halogen lamps
- Fluorescent: This kind of lamp is used for the kitchen and toilets.

- Low consumption lamp: This kind of lamp is barely used in the building.

The consumption of lighting and appliances will be taken into consideration for the baseline analysis but not for the next steps due to the difficulty to establish energy savings measurements because of the variety and number of devices, the behaviour of the user, etc.

7 Simulation analysis

7.1 Hourly analysis program software

The main goals of this simulation are:

- To help to verify that the measured U-values and gathered building information are able to explain the current energy consumption.
- Sensitivity analysis of the different parameters, seeking for those parameters that have influence on energy consumption.
- Feasibility check: This model will be the starting point for the feasibility check to be developed later on.

7.1.1 Introduction

HAP is designed for consulting engineers, design/build contractors, HVAC contractors, facility engineers and other professionals involved in the design and analysis of commercial building HVAC systems.

In addition, HAPs 8760 hour energy analysis capabilities are very useful for green building design. For instance, HAP energy analysis results are accepted by the US Green Building Council for its LEED®1 (Leadership in Energy and Environmental Design) Rating System. Visit the USGBC's website, www.usgbc.org, for more LEED info.

7.1.2 Load calculation

HAP software uses:

- ASHRAE Transfer Function cooling load calculation procedures,
- ASHRAE design heating load calculation procedures, ASHRAE design weather data.
- ASHRAE design solar calculation procedures.

Features:

- Calculates space and zone loads 24-hours a day for design days in each of the 12 months. In doing so it calculates heat flow for all room elements such as walls, windows, roofs, skylights, doors, lights, people, electrical equipment, non-electrical equipment, infiltration, floors and partitions considering time of day and time-of-year factors.
- Performs detailed simulation of air system operation to determine cooling coil loads and heating coil loads and other aspects of system performance 24-hours a day for design days in each of the 12 months.
- Analyses plenum loads.
- Considers any operating schedule for HVAC equipment from 1 hour to 24 hours in duration.

- Permits hourly and seasonal scheduling of occupancy, internal heat gains, and fan and thermostat operation.

On the following figures are displayed some examples of the type of data required in HAP simulation related to design weather inputs but also the outcomes provided by the HAP tool.

Design Parameters:

City Name .... Venice
Location .... Italy
Latitude .... 45,5 Deg.
Longitude .... -12,3 Deg.
Elevation .... 5,8 m
Summer Design Dry-Bulb .... 30,6 °C
Summer Coincident Wet-Bulb .... 23,3 °C
Summer Daily Range .... 9,1 °K
Winter Design Dry-Bulb .... -5,0 °C
Winter Design Wet-Bulb .... -7,1 °C
Atmospheric Clearness Number 1,00
Average Ground Reflectance 0,20
Soil Conductivity .... 1,385 W/(m-°K)
Local Time Zone (GMT +/- N hours) .... -1,0 hours
Consider Daylight Savings Time .... No
Simulation Weather Data .... Venice (IWC)
Current Data is .... 2001 ASHRAE Handbook
Design Cooling Months .... January to December

Design Day Maximum Solar Heat Gains

(The MSHG values are expressed in W/m²)

Month	N	NNE	NE	ENE	E	ESE	SE	SSE	S
January	52,1	52,1	52,1	179,0	417,1	575,5	716,3	772,6	788,1
February	67,4	67,4	123,0	357,7	545,1	704,9	769,4	782,9	784,5
March	84,2	84,2	285,5	492,4	663,2	734,4	757,9	721,5	700,2
April	101,1	205,9	422,3	593,1	683,8	716,9	669,1	595,9	554,6
May	113,0	318,5	491,5	638,4	689,8	671,6	585,8	487,8	435,0
June	151,2	355,1	517,5	646,7	679,7	645,3	547,0	437,9	383,4
July	116,6	312,1	493,7	627,3	668,8	657,4	574,5	475,1	425,7
August	106,6	194,2	412,6	568,0	664,7	689,9	647,0	575,9	537,7
September	87,3	87,3	270,5	447,7	623,9	704,4	727,3	698,1	671,7
October	69,6	69,6	122,6	334,5	535,0	663,0	746,2	762,9	753,8
November	52,6	52,6	52,6	196,5	395,7	583,2	694,3	753,6	767,6
December	45,2	45,2	45,2	119,7	350,2	514,9	669,9	739,7	759,8
Month	**SSW**	**SW**	**WSW**	**W**	**WNW**	**NW**	**NNW**	**HOR**	**Mult**
January	774,2	711,3	589,3	406,7	198,6	52,1	52,1	316,2	1,00
February	787,3	774,5	702,3	555,0	345,4	132,0	67,4	478,0	1,00
March	720,9	751,6	748,3	647,4	503,8	273,1	84,2	628,3	1,00
April	593,5	661,6	714,1	692,0	592,9	405,0	215,1	737,1	1,00
May	485,1	582,0	666,5	695,5	631,7	500,6	316,0	795,5	1,00
June	433,0	545,9	635,6	685,5	633,1	530,0	347,8	811,3	1,00
July	469,1	572,0	646,8	681,4	614,0	497,9	309,5	789,6	1,00
August	573,2	638,0	688,4	667,5	572,0	394,2	211,6	726,5	1,00
September	698,2	726,9	708,2	621,1	456,7	269,9	87,3	602,8	1,00
October	760,5	741,2	671,1	527,7	342,6	105,4	69,6	466,0	1,00
November	750,4	697,5	581,7	400,7	191,7	52,6	52,6	310,6	1,00
December	735,1	663,6	532,4	342,0	135,8	45,2	45,2	248,0	1,00

Mult. = User-defined solar multiplier factor.

Figure 67 Design weather data

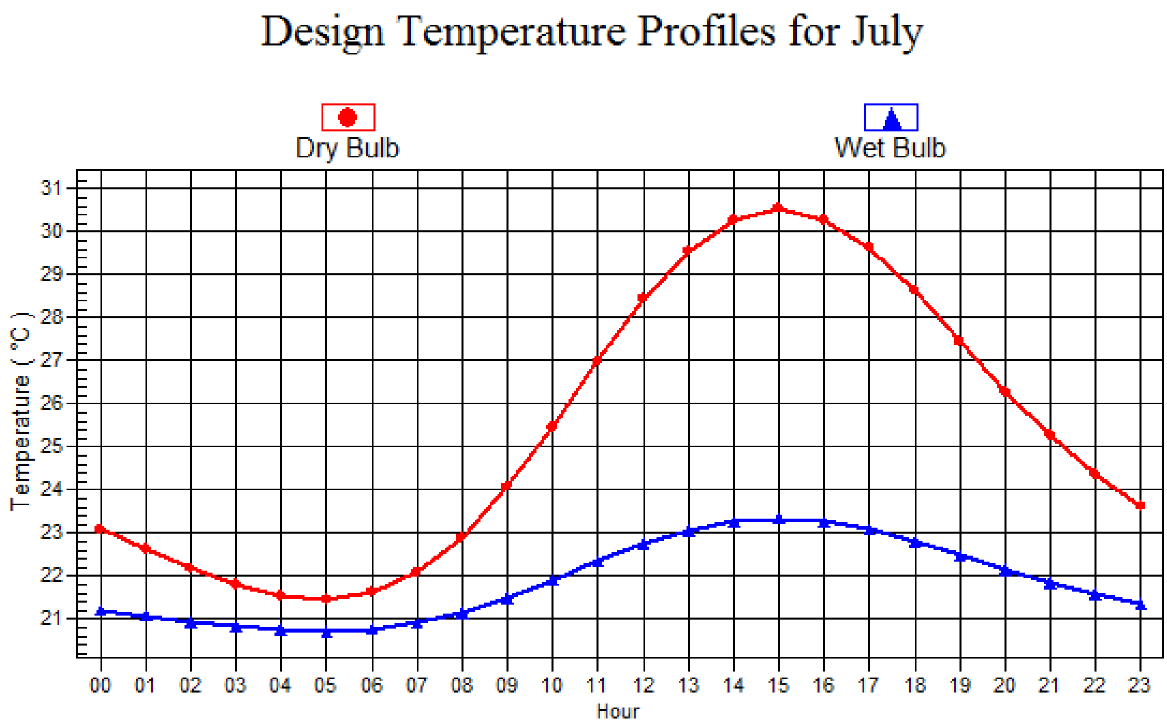


Figure 68 Example of December daily temperature

7.1.3 Simulation approach in Treviso

One of the two buildings has been simulated defining each floor as an space made up by 3 dwellings. Later, the energy simulation of the other building is obtained rotating the first one till have the same orientation.

According to the dimensions described in the architectural plans provided by ATER (floor area, ceiling height, walls and windows dimensions,etc.) the spaces have been defined.

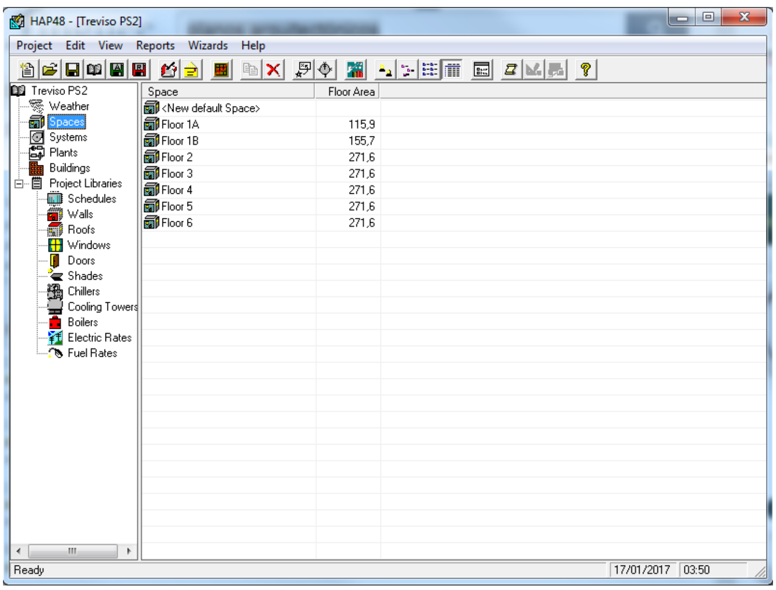


Figure 69 Space definition

According to the data obtained during the measures, it has been described only one type of wall for all the orientations, one for the floor, one for the ceiling and one for the windows. In this first approach we have estimated the occupancy between 2 and 3 people per dwelling due to the information gathered of the tenants. For the case of lights and electrical equipment, we also assume 5 W/m^2 for lighting and 4 W/m^2 for electrical equipment, based on the visit.

Ventilation parameters are really significant in residential sector to assess the energy demand (Heating and Cooling) at the buildings. In Padiham according to the construction type we have estimated an infiltration of 0,5 ACH (Air Changes per Hour) which means an intermediate level of infiltration.

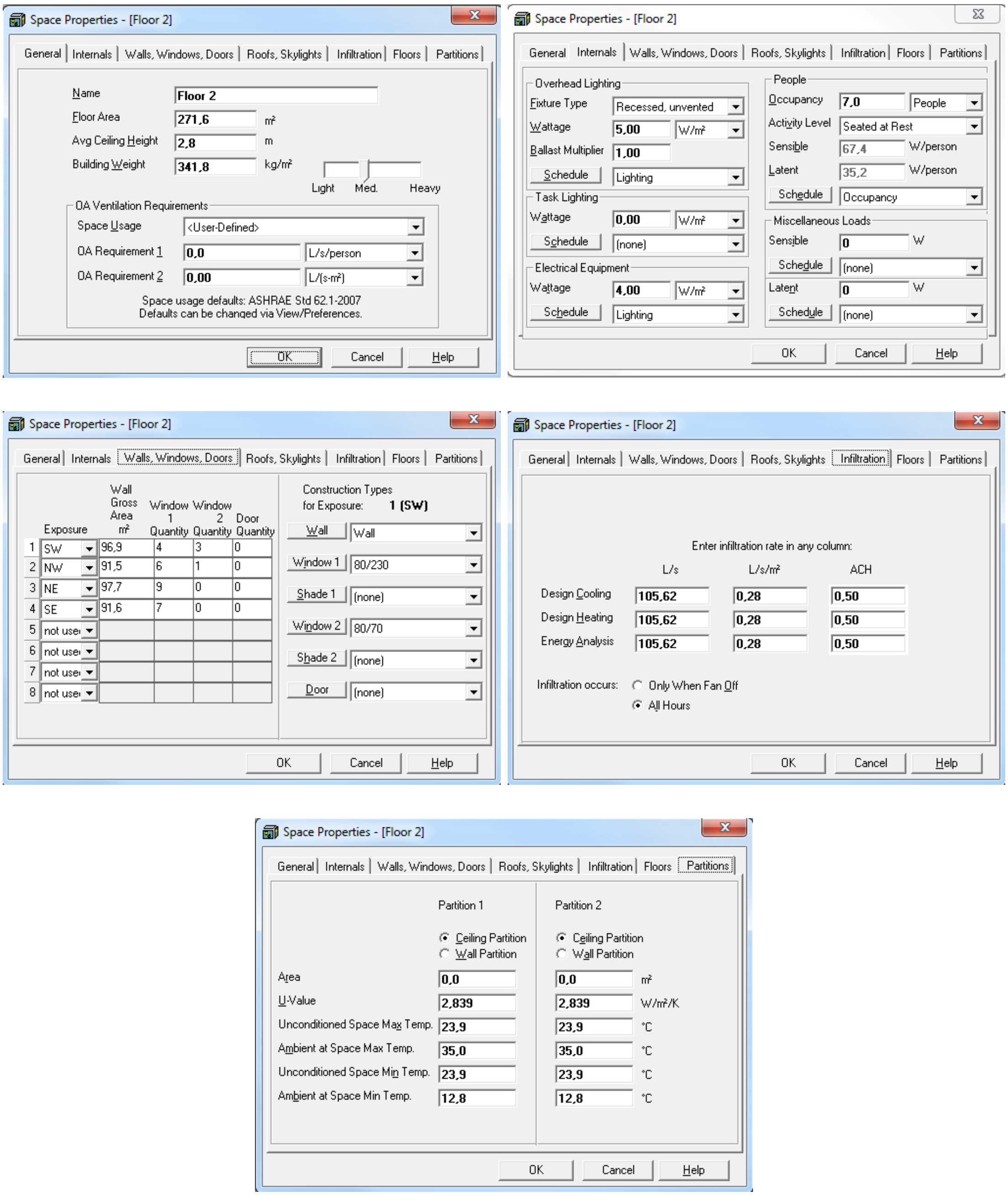


Figure 70 Spaces definition

In the next figures we have the wall and windows defined as well as an example of the type of input required by the tool:

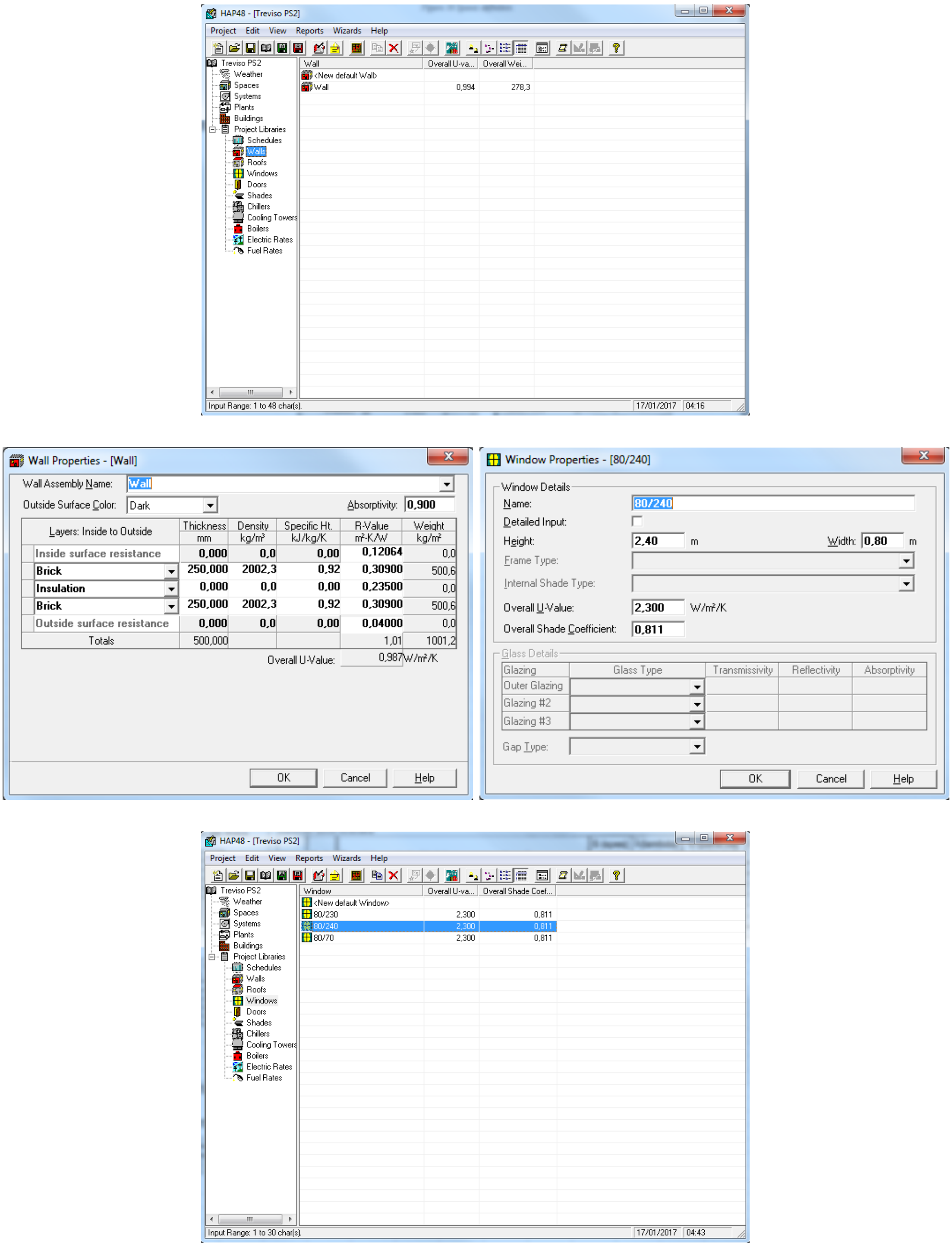
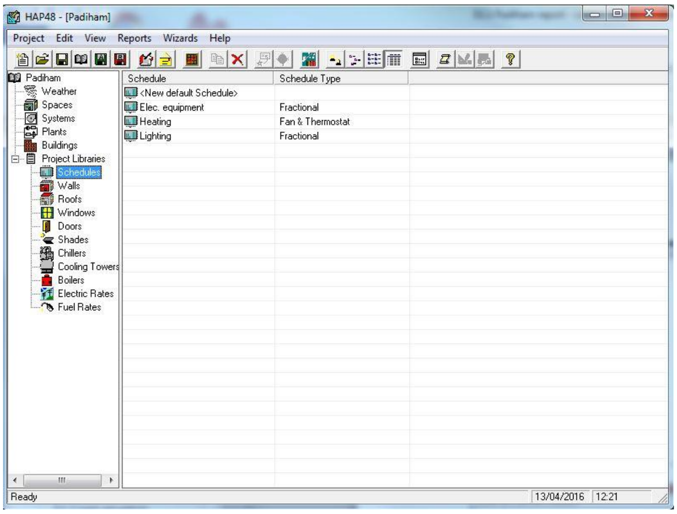


Figure 71 Wall and windows definition

While defining a space, information about the construction of walls, roofs, windows, doors and external shading devices is needed, as well as information about the hourly schedules for internal heat gains. This construction and schedule data can be specified directly from the space input form (via links to the construction and schedule forms), or alternately can be defined prior to entering space data. In this first approach we have define three different schedules: one for the electrical equipment, one for heating and one for lighting.



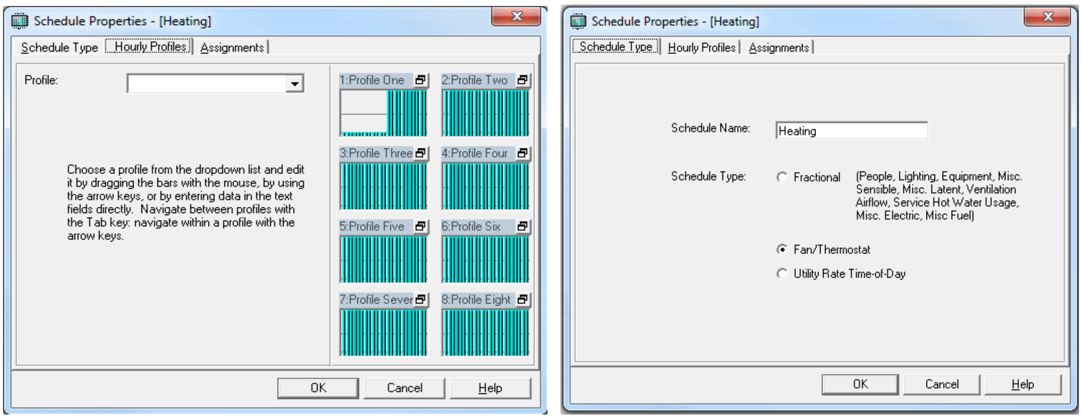
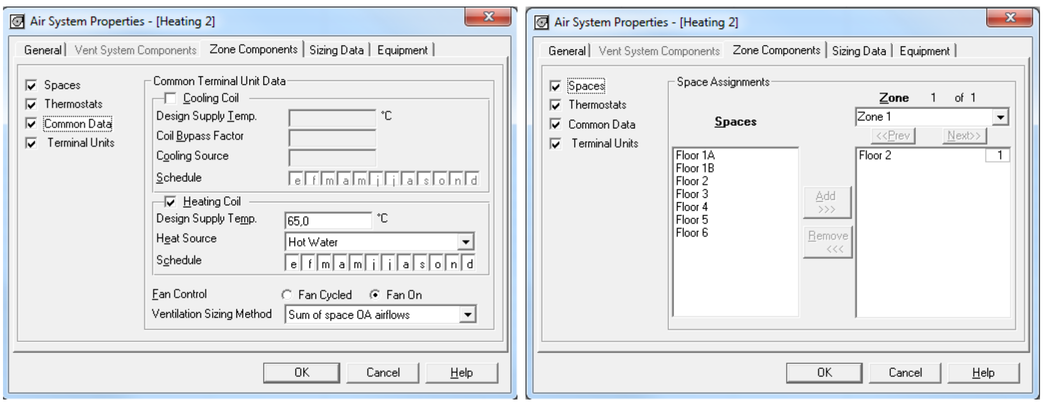


Figure 72 Schedule definition

In Treviso we have electric radiators as terminal units (heating system) so the design supply temperature must be quite close to 65 ºC. Heating T-stat Set points is 22ºC.



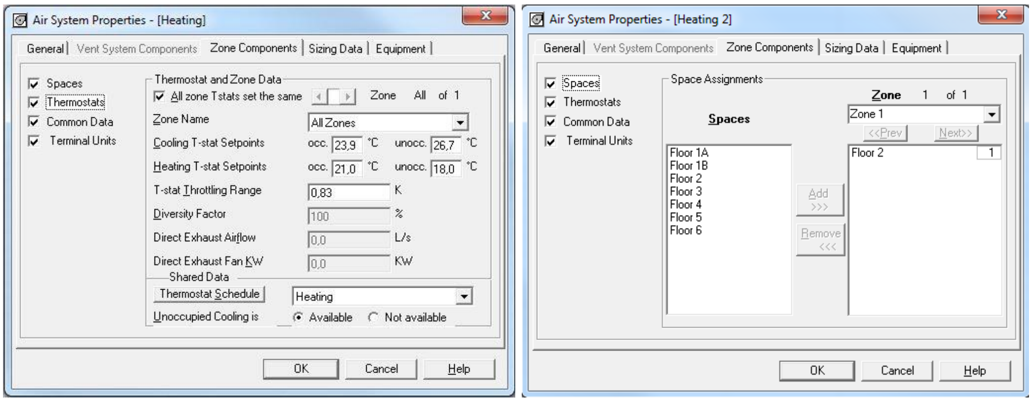
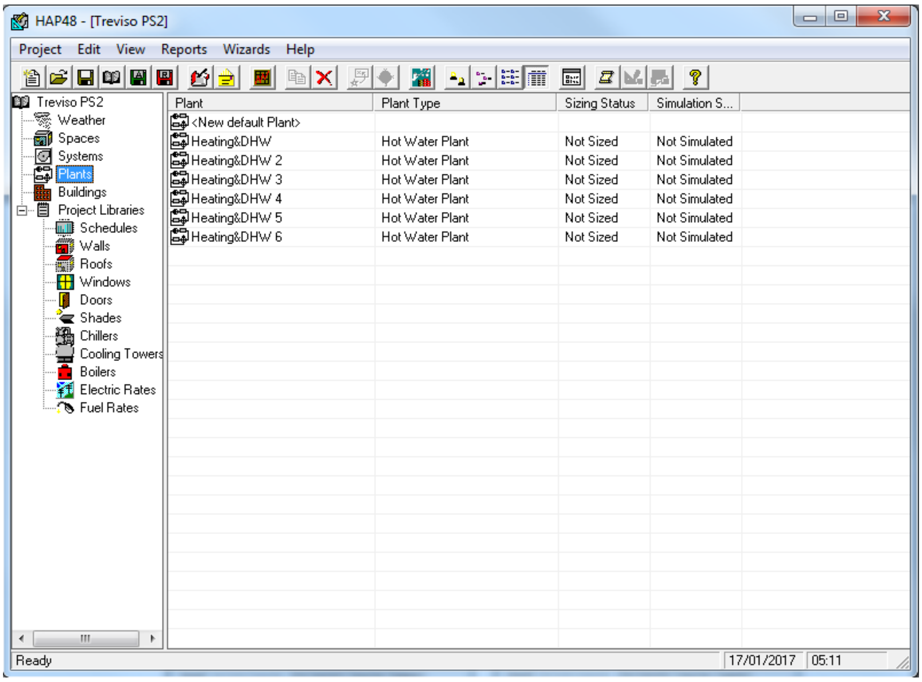


Figure 73 System definition



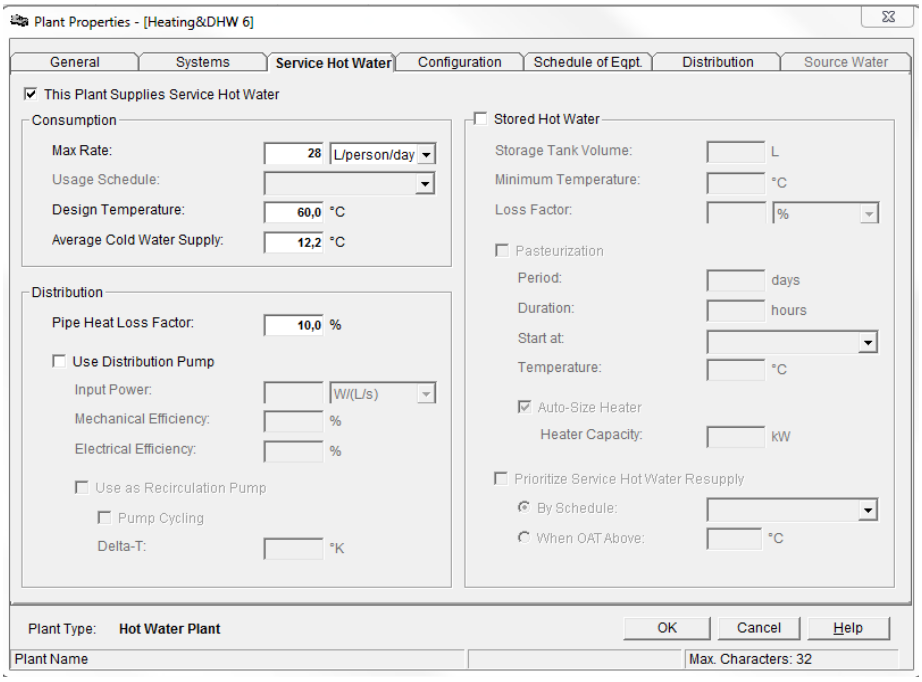
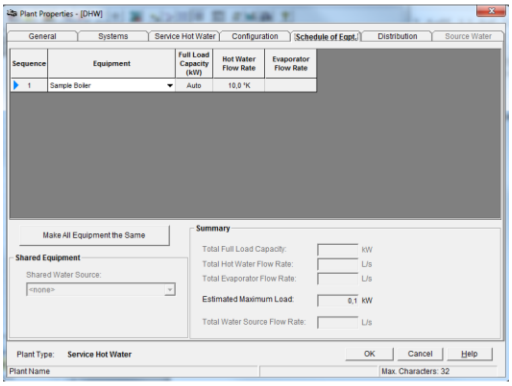
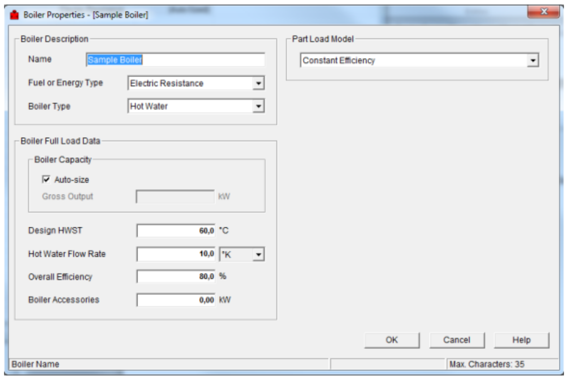


Figure 74 Plant definition

The Domestic Hot Water plant has been simulated taking into account 28 l/person/day, distribution losses of 10% and a design temperature of 60ºC.





dreeam

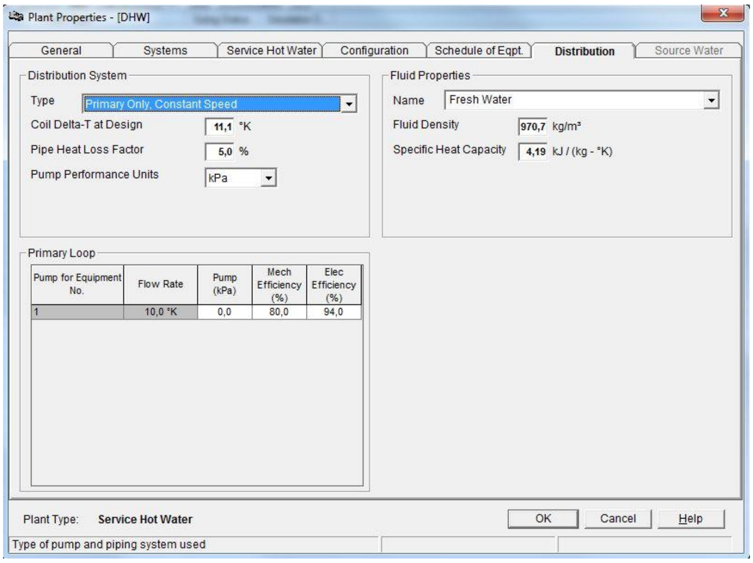


Figure 75 Plant definition

In our simulation the boilers that provide DHW and hot water for heating systems has been defined with the same features that they have in the real situation.

In the following figures we have the results that comes from the simulation tool. It is shown the consumption of DHW + heating between floors, due to the different demands:

- First floor

Monthly Simulation Results for Heating&DHW 1

Treviso PS2 — 01/19/2017
Exeleria — 04:42

Plant Simulation Results (Table 1):

Month	Service HW Load (kWh)	Heating Coil Load (kWh)	SHW Piping Losses (kWh)	Plant Heating Load (kWh)	Boiler Output (kWh)	Boiler Input - Gas (kWh)	Boiler Misc. Electric (kWh)
January	243	4863	22	5106	5106	6382	0
February	219	3344	20	3563	3563	4454	0
March	243	1788	22	2031	2031	2538	0
April	235	205	21	440	440	550	0
May	243	0	22	243	243	304	0
June	235	0	21	235	235	294	0
July	243	0	22	243	243	304	0
August	243	0	22	243	243	304	0
September	235	0	21	235	235	294	0
October	243	52	22	295	295	368	0
November	235	2502	21	2737	2737	3421	0
December	243	4289	22	4532	4532	5665	0
Total	**2861**	**17042**	**260**	**19903**	**19903**	**24878**	**0**

Monthly Simulation Results for Heating&DHW 1

Treviso PS2 — 01/19/2017
Exeleria — 04:43

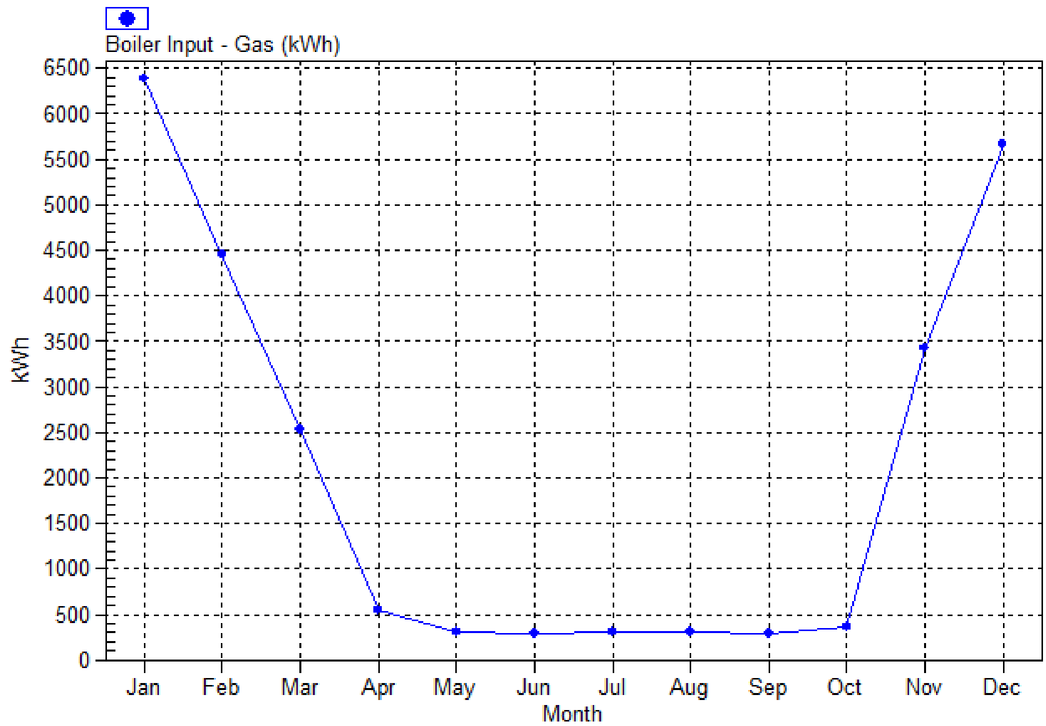


Figure 76 Heating and DHW in floor 1

- Type floor (floor 2 to floor 5)

Monthly Simulation Results for Heating&DHW 2

Treviso PS2 01/19/2017
Exeleria 04:47

Plant Simulation Results (Table 1):

Month	Service HW Load (kWh)	Heating Coil Load (kWh)	SHW Piping Losses (kWh)	Plant Heating Load (kWh)	Boiler Output (kWh)	Boiler Input - Gas (kWh)	Boiler Misc. Electric (kWh)
January	243	4716	22	4959	4959	6199	0
February	219	3261	20	3480	3480	4350	0
March	243	1723	22	1966	1966	2458	0
April	235	209	21	444	444	555	0
May	243	0	22	243	243	304	0
June	235	0	21	235	235	294	0
July	243	0	22	243	243	304	0
August	243	0	22	243	243	304	0
September	235	0	21	235	235	294	0
October	243	56	22	299	299	373	0
November	235	2494	21	2729	2729	3412	0
December	243	4203	22	4446	4446	5557	0
Total	**2861**	**16662**	**260**	**19523**	**19523**	**24403**	**0**

Monthly Simulation Results for Heating&DHW 2

Treviso PS2 01/19/2017
Exeleria 04:47

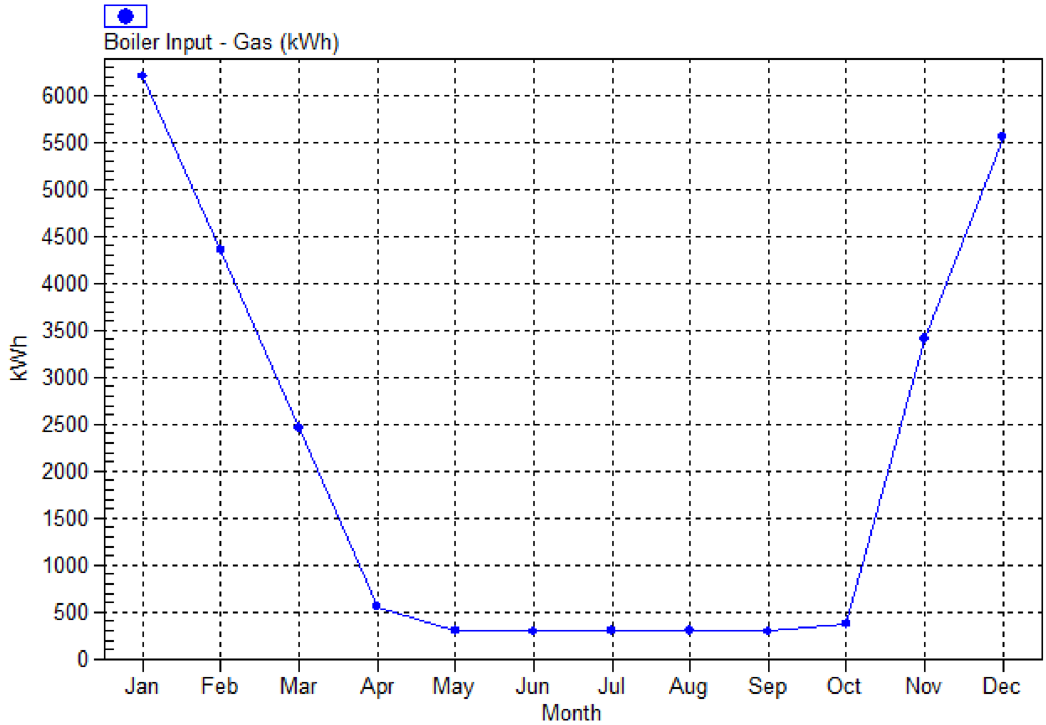


Figure 77 Heating and DHW in type floor

- Upper floor

Monthly Simulation Results for Heating&DHW 6

Treviso PS2 01/19/2017
Exeleria 04:54

Plant Simulation Results (Table 1):

Month	Service HW Load (kWh)	Heating Coil Load (kWh)	SHW Piping Losses (kWh)	Plant Heating Load (kWh)	Boiler Output (kWh)	Boiler Input - Gas (kWh)	Boiler Misc. Electric (kWh)
January	243	5584	22	5827	5827	7284	0
February	219	4007	20	4226	4226	5283	0
March	243	2425	22	2668	2668	3335	0
April	235	378	21	613	613	766	0
May	243	0	22	243	243	304	0
June	235	0	21	235	235	294	0
July	243	0	22	243	243	304	0
August	243	0	22	243	243	304	0
September	235	0	21	235	235	294	0
October	243	146	22	389	389	486	0
November	235	3134	21	3369	3369	4211	0
December	243	4985	22	5228	5228	6535	0
Total	**2861**	**20659**	**260**	**23519**	**23519**	**29399**	**0**

Monthly Simulation Results for Heating&DHW 6

Treviso PS2 01/19/2017
Exeleria 04:54

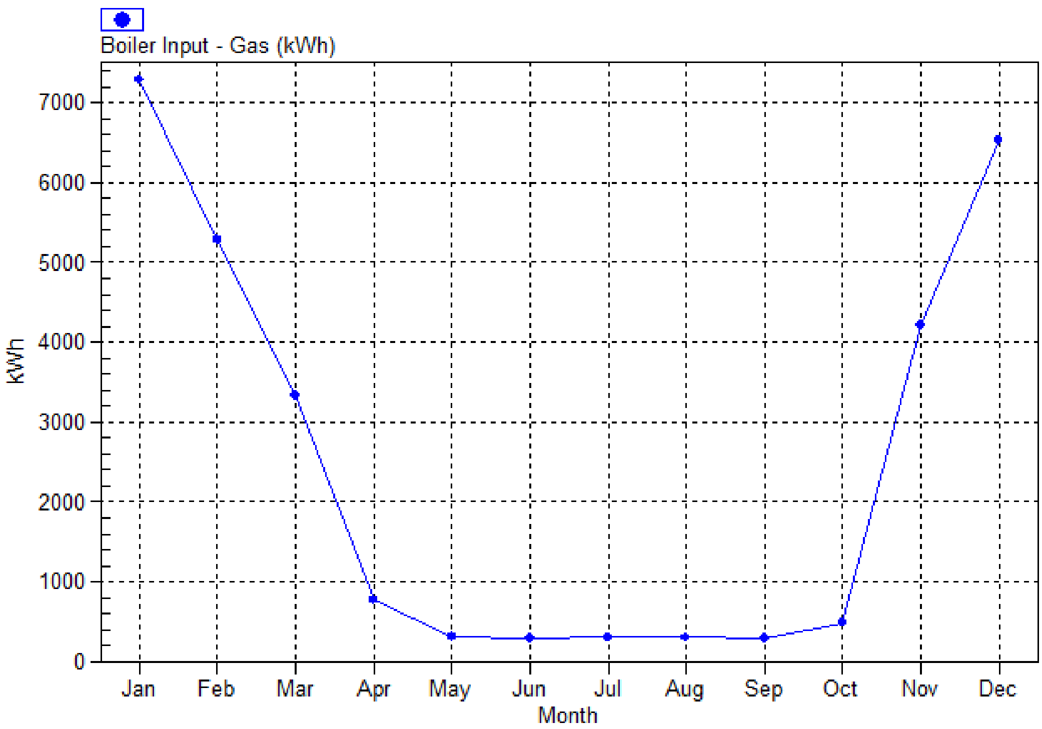


Figure 78 Heating and DHW in upper floor

The heating demand in the first floor and in the upper floor is higher than in the others due to the heating losses produced to heat against the storage room and outside air in the case of first floor and the ceiling in the case of the upper floor.

Organizing the data provided by the software, we can summarize the energy consumption of the building in:

- Viale Francia 1:

Energy system	[kWh/year]	[kWh/m2year]
Heating	130.435	80,0
DHW	21.456	13,2
Lighting	16.208	9,9
Electric equipment	12.968	8,0
TOTAL	**181.067**	**111,1**

- Via Borgo Furo 35/A:

Energy system	[kWh/year]	[kWh/m2year]
Heating	127.621	78,3
DHW	21.456	13,2
Lighting	16.208	9,9
Electric equipment	12.968	8,0
TOTAL	**178.253**	**109,4**

7.2 Analysis of sensitivity

After the simulation analysis with the HAP tool, the following parameters have been modified to see how they affect to the result of the consumption:

7.2.1 Room temperature

For the current analysis calculated before, it has been considered a room temperature of 21 ºC while heated. An increment and a decrease of 1 ºC on this temperature has been modified and checked the variation on the heating energy demand.

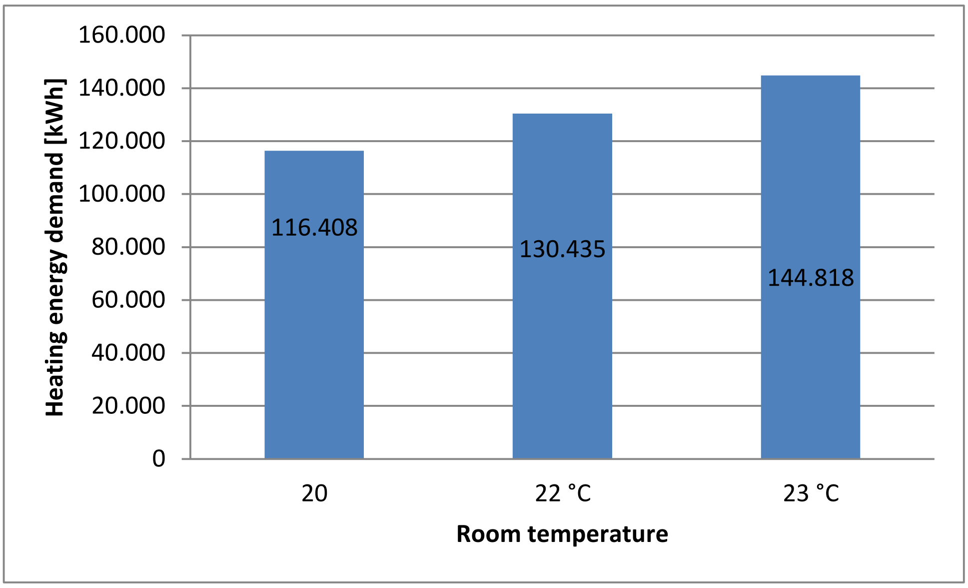


Figure 79 Heat energy demand in relation to room temperature

The variation in percentage produced is:

Temperature	Heating energy demand [kWh]
-1 ºC	-10,8 %
21 ºC	130.435
+1 ºC	+11,0 %

7.2.2 U-Value

In the following analysis the U-Values used in the simulation are compared with the with the current values (source:BPIE[4]) that a new construction in Italy can have:

- Wall= 0,5 W/m²K
- Floor= 0,4 W/m²K
- Roof= 0,4 W/m²K
- Windows= 2 W/m²K

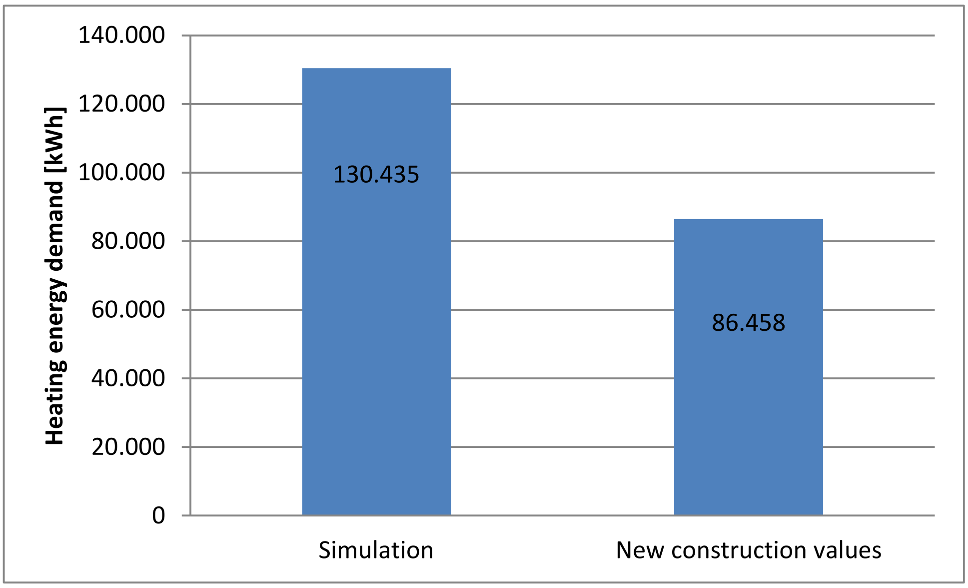


Figure 80 Heat energy demand in relation to the U-Value

There is a 33,7 % lower demand for the new construction values.

7.2.3 Infiltration

For the current analysis calculated before, it has been considered an infiltration of 0,5 air change per hour. An increment or decrease of it modify the heating energy demand:

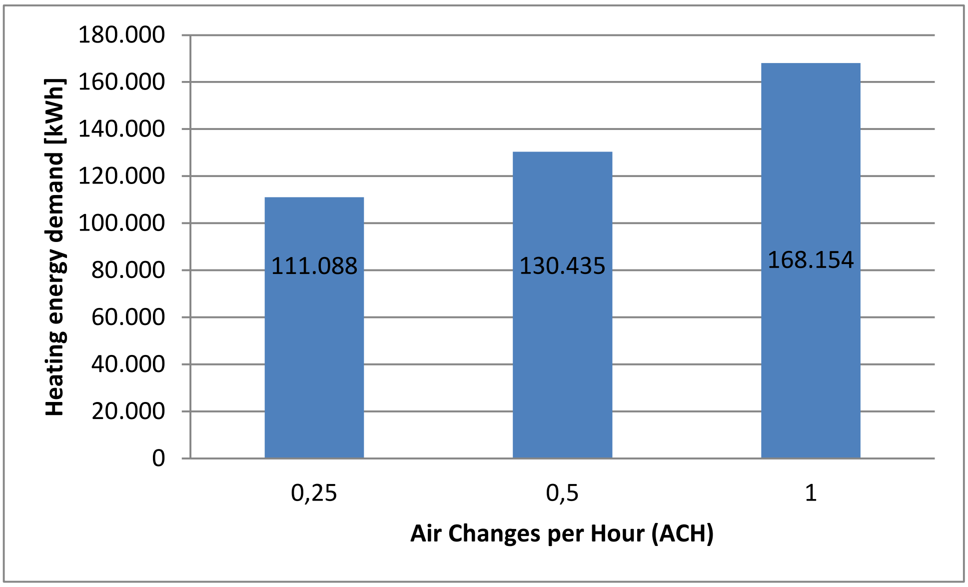


Figure 81 Heating energy demand in relation to the infiltration

Air Changes per Hour (ACH)	Heating energy demand [kWh]
0,25	-14,8 %
0,5	130.435
1	+28,9 %

A discussion on how to use for this simulation analysis is done in the conclusions section.

7.2.4 Overview

Parameter	Heating energy demand [kWh]	Percentage
Temperature -1 ºC	116.408	-10,8 %
Temperature +1 ºC	144.818	+11,0 %
Better U-Values	130.435	-33,7 %
ACH from 0,5 to 0,25	111.088	-14,8 %
ACH from 0,5 to 1	168.154	+28,9 %

8 Summary and conclusions

8.1 Passive Components

8.1.1 Thermographic analysis

From the thermographic analysis we can get the conclusion that generally, there is no presence of leaks of energy systems or significant differences in the envelope components. However, there is presence of humidity in some dwellings

The distribution of hot water through the radiators is working properly. The windows show to be perfectly sealed. Despite of this, there are areas where exist thermal bridges as for example in the joint between wall and ceiling (Figure 51)

8.1.2 U-Value analysis

The values obtained in the measure for the walls are very similar to the calculated theoretically with the real composition of it:

Figure 82 Composition of the wall

	U-Value [W/m²K]	
Wall (mm)	Measured	Calculated
Brick (250)	0,990	0,98
Polyestiren (15)	1,096	
Brick (250)		

For the values of the roof and floor, where we do not have information about the composition, the values used for the simulation come from a database (BPIE[4]) in relation to the envelope performance in the country along the last years. The following photo shows how it can be taken for the case of the roof:

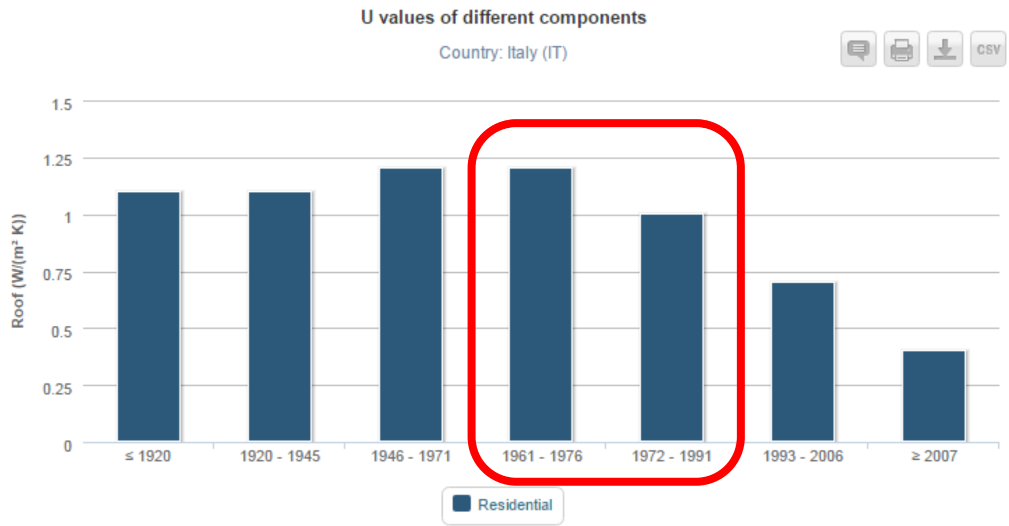


Figure 83 U-Values database

To sum up, the values used in the simulation are:

Component	U-Value [W/m²K]
Wall	0,99
Roof	1,00
Floor	1,09
Windows	2,34

8.2 Active Components

8.2.1 Heating & DHW production

The boilers are 20 years old. That means that they are very close to the end of it useful life and a replacement of it will be necessary in the short term.

The efficiency of a conventional boiler is less than a 80%. The installation of a boiler with a newer technology will reduce this losses.

8.2.2 Terminal units

In the case of the radiators, the control of the heating depends on the user which can switch on or switch off it depending on their thermal comfort (not on the room temperature or the outside temperature). This system is not very efficient from an efficiency point of view.

8.2.3 Lighting

There are installed a significant number of lamps that suppose a waste of energy comparing with the newest kind of lamps as LED or low consumption lamps. The use of lamps with a high nominal power in a dwelling increase significantly the power consumption considering the total amount and the number of hours they are working.

8.3 Simulation analysis

8.3.1 Results obtained

A comparison between the consumption obtained in the simulation and the real consumption cannot be made due to the lack of information enough to compare the results of every month of the year and study the shape of the curve described in a diagram.

In spite of it, a ratio of consumption per surface has been made:

- Viale Francia 1:

Energy system	[kWh/year]	[kWh/m2year]
Heating	130.435	80,2
DHW	21.456	13,2
Lighting	16.208	10,0
Electric equipment	12.968	8,0
TOTAL	**181.067**	**113,3**

- Via Borgo Furo 35/A:

Energy system	[kWh/year]	[kWh/m2year]
Heating	127.621	78,5
DHW	21.456	13,2
Lighting	16.208	10,0
Electric equipment	12.968	8,0
TOTAL	**178.253**	**109,6**

The ratios obtained are very similar to the ones obtained for the first pilot site in Treviso, which have similar construction properties, period of construction and source of energy (see annex 2).

The different heating demand between the two buildings is produced by it orientation. For the case of Via Borgo Furo 35/A is less than in the other building because it has more surface of façade oriented to the south, which has the advantage of higher solar gains.

8.3.2 Analysis of sensitivity

A sensitivity analysis has been done showing the influence of changes in the most relevant parameters.

- Room temperature

An increment or a decrease of 1 ºC on the room temperature produces a variation around 11 % in the heating energy demand. A temperature of 21 - 22 ºC during the day ensures a minimum of habitability conditions.

It can be considered that the temperature vary from one room to another. For example, in the bathroom can exceed this temperature to 23 °C and the rooms that are not usually used up to 18 °C.

To heat the building with a room temperature above 22 ºC implies a significant waste of energy.

- U-Value

The variation produced in the energy consumption having better U-Values shows the importance of having a good insulation system.

In this case, the new consumption is one third less than before.

- Infiltration

Through the analysis of the infiltrations in the building, it can be shown that they have an important impact not only in the comfort of its users but also in the level of energy efficiency of the building. It is obvious that when the outside temperature is low, have an income of cold air inside the building increases the heating energy demand.

A small increment in the value of air changes per hour produces a significant higher heating energy demand. For example the heating energy demand from 0,5 to 1 air changes per hour is increased a 28,9%.

Landskrona (SWE)

Pilot site

9 Pilot Site overview

9.1 General Description

The purpose of the visit is to evaluate the baseline situation of the building providing the starting point for the renovation DREEAM approach.

This technical baseline will be focus on the gathering of information about:

- **Passive technologies:** The thermal properties of the walls, roof, etc. analysing in which conditions are they currently and the features of the windows.
- **Active technologies:** Identifying every component of the installation of the buildings including electrical parts, heating systems, storage and lighting among other things.

9.2 Buildings Description

The visit took place in the city of Landskrona (Sweden) in social housing buildings located in Koppargården.

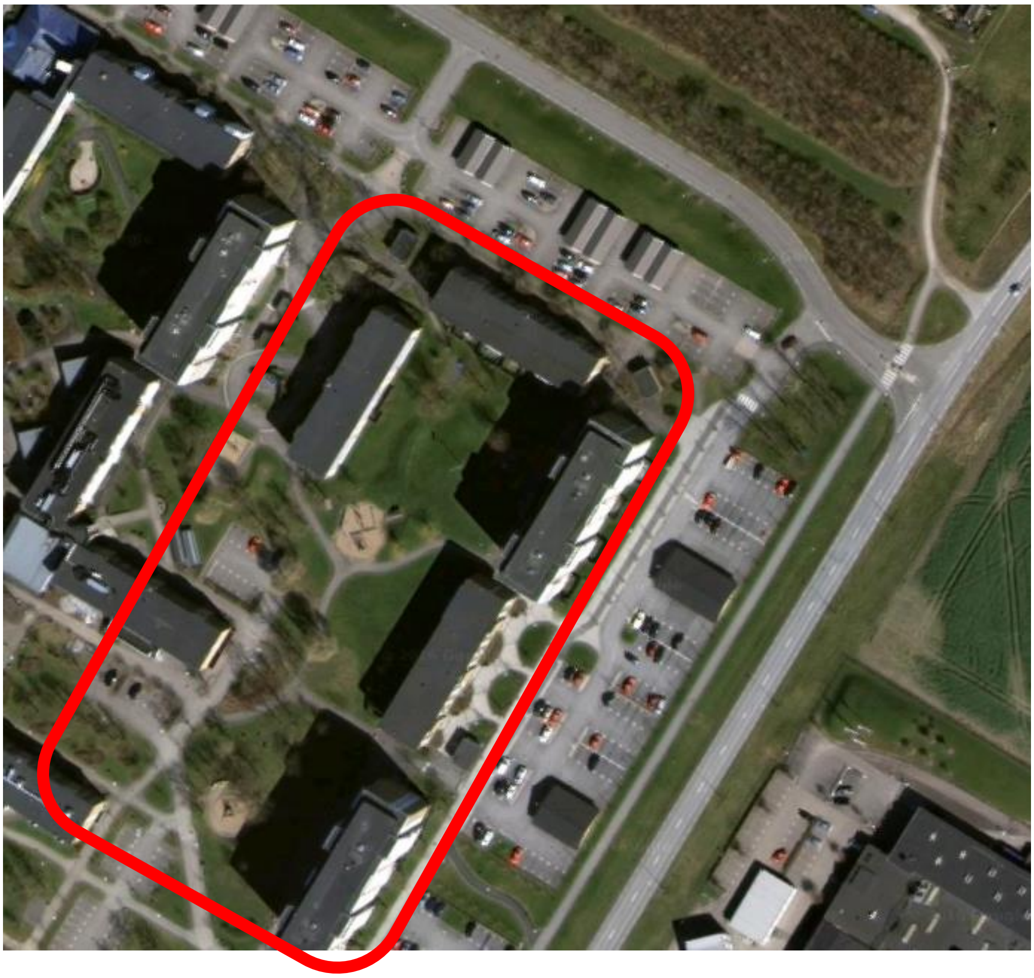


Figure 84 Koppargården

The energy production is located only in one of the buildings and supply the others. From the entire construction, two buildings were examined: the one with the heating production and another one.

Figure 85 Façade of the building visited

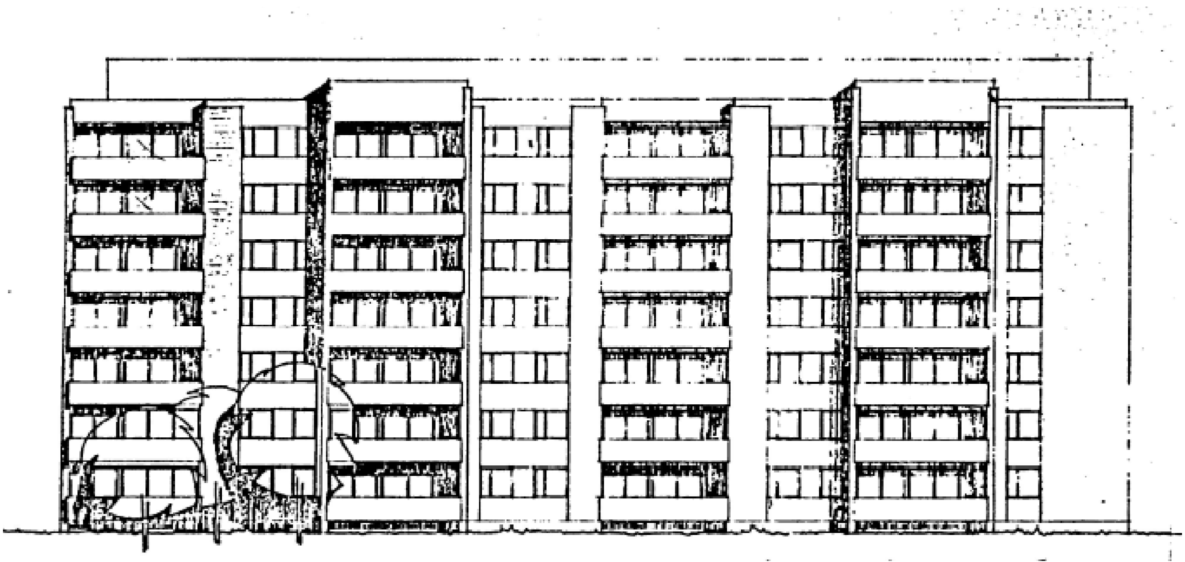


Figure 86 Elevation plan

9.3 BO requirements and objectives

To carry out the pilot visit, the collaboration of the building owners is required to allow the other collaborating parts in the visit to gather as much information as possible that can be used after the visit to make a deep analysis about the current situation of the building. For it, Landskronahem AB has made available the entry to different flats and technical rooms allowing to make a thermography analysis, to measure the thermal transmission of the passive components and to analyse the active components.

The main objective of the building owner about this visit is to have an understanding of the current situation of their properties. This information must cover the components of the building and the energy consumption of the social housing. It will be the first step of the renovation process.

9.4 Information needed

To perform the analysis of the building and compare the data obtained from the measurements it is necessary to have the construction plans which include every information about the typology, orientation, dimensions, components and details of the building.

Landskronahem AB has provided some information that allow Exeleria to get a deep study of the building.

This information includes:

- Building spaces Lay-out
- Elevation drawings
- Envelope components detailed description
- Heating & DHW technical drawings (central production systems schemes)
- Energy consumptions of the central heating & DHW systems

10 On site data gathering

10.1 Pasive components

10.1.1 Thermographic analysis

The detailed information related to the thermographic analysis could be found in the methodology document included in the annexes.

To carry out the thermographic analysis, a minimum thermal conditions for the difference of temperature between indoor-outdoor were necessary.

The temperature inside the building during the thermographic work ranged between 17 and 19 °C. The temperature outside was around 1 ºC. Which means a difference between 16-18 ºC.

After de thermographic analysis in the different parts of the building we can obtain the following conclusions:

There are small thermal bridges in the corners of the façade against the outside air. We can appreciate a difference of temperature around 3 ºC.

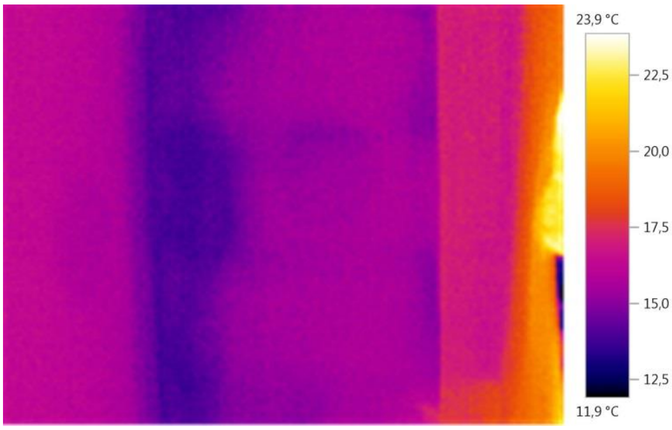


Figure 87 Thermal bridge in a corner

In the following photo important points with very low temperature between de window and the wall can be seen. There is a very high difference of temperature between de top of the window (5 ºC) and the wall (17 ºC):

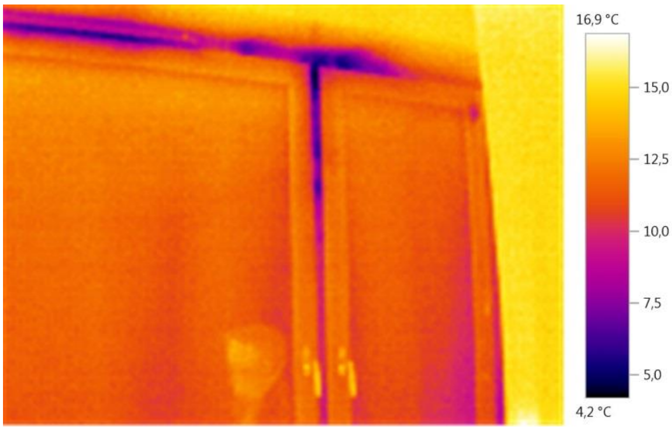


Figure 88 Window 1

Another example of window, but this time the minimal temperature is lower (3 ºC):

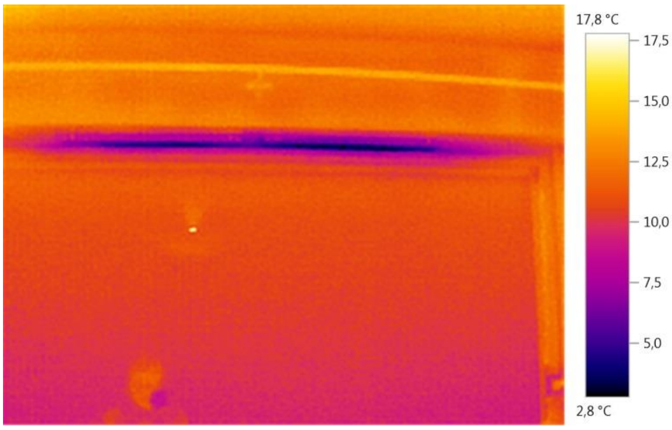


Figure 89 Window 2

In the following photo we can see that the water heated is not well distributed along the radiator.

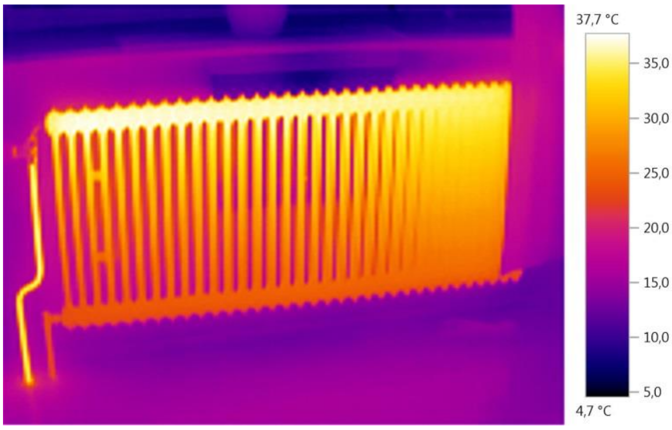


Figure 90 Radiator

There are some parts of the Heating and DHW heat transfer substation (where the exchange with the district heating network occurs) installation without a insulation system, therefore there are a high loss of energy.

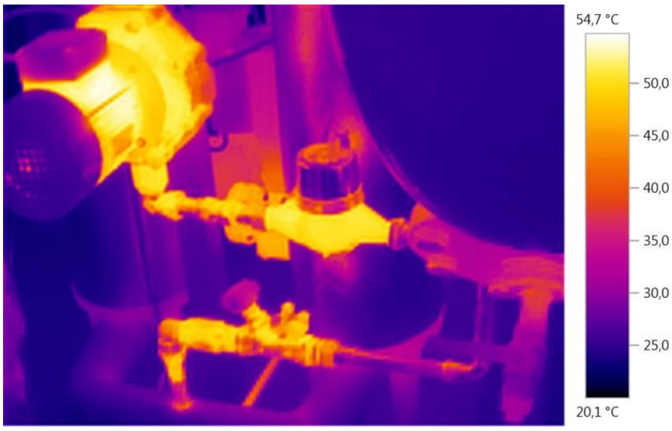


Figure 91 Lack of insulation

The façade analysis from the outside shows the point with highest temperature are in the windows and a homogeneous temperature around -3 ºC along the wall.

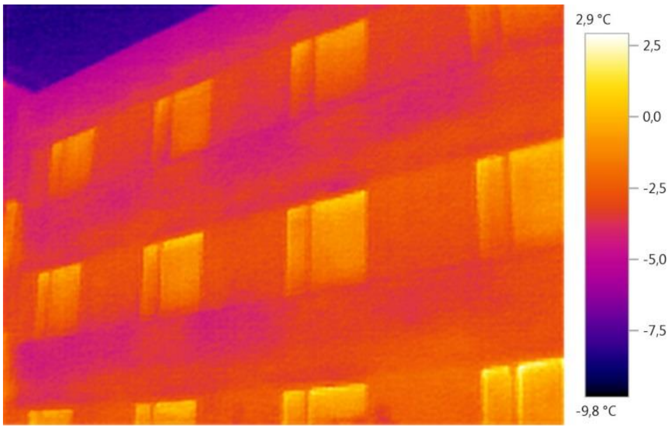


Figure 92 Façade

Generally, there is no presence of humidity, leaks of energy in the heating system or significant differences in the envelope components.

10.1.2 U-Value analysis

To ensure the accuracy of the measurements the ideal conditions required are:

- Temperature difference (outdoor - indoor) of at least 15 ºC
- External surfaces un exposed to solar radiation

A representative batch within each pilot case based on construction features (num. of bedroom, orientation, m2…) is selected. The equipment for measuring U-values include heat flux meters, thermistor temperature probes and data-loggers.

For the analysis of the building envelope five components of it have been analysed and obtained the currently U-value of them.

Two information sources has been compared, measured U-values (coming from the field measurements) and calculates U-values (based on the composition information provided by the BO and some assumptions about the thickness of some components).

The results obtained are:

Number	Component	U-Value obtained [W/m²K]	U-Value calculated [W/m²K]
1	Wall against exterior air	0,609	0,49
2	Wall against exterior air	0,509	0,59
3	Wall against exterior air	0,928	0,49
4	Wall against exterior air	1,234	0,59
5	Roof against exterior air	0,736	0,40

Following this a detailed description of the measurements:

1. Wall against exterior air. This is the wall located on a balcony oriented to SE. The results obtained are:

- Temperature difference: 17,3 ºC
- Solar radiation: Not influenced

Date	Time	U-Value [W/m²K]	Tw [ºC]	Ti [ºC]	Hr [%]	To [ºC]
17.02.2016	9:27:55	0,609	16,82	18,20	72,00	0,9

Comparing with the data obtained theoretically:

[mm] Composition	[mm] Thickness	U-Value [W/m²K]
Concrete light (150) Brick (120)	270	0,49

Figure 93 U-Value analysis of the roof

2. Wall against exterior air. This is a wall with windows situated in the kitchen oriented to NE. The results obtained are:

- Temperature difference: 16,2 ºC
- Solar radiation: Not influenced

Date	Time	U-Value [W/m²K]	Tw [ºC]	Ti [ºC]	Hr [%]	To [ºC]
17.02.2016	9:56:13	0,509	16,40	17,47	71,00	1,3

Comparing with the data obtained theoretically:

[mm] Composition	[mm] Thickness	U-Value [W/m²K]
Concrete (150) Mineral wool (50) Brick (120)	320	0,59

Figure 94 U-Value analysis of the wall

3. Wall against exterior air. This is the wall situated in a room oriented to NW. The results obtained are:

- Temperature difference: 16,1 ºC
- Solar radiation: Not influenced

Date	Time	U-Value [W/m²K]	Tw [ºC]	Ti [ºC]	Hr [%]	To [ºC]
17.02.2016	11:28:45	0,928	15,83	17,77	69,70	1,7

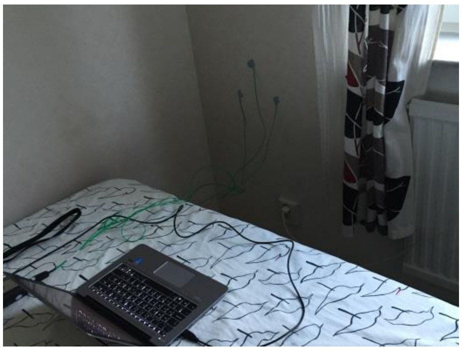


Figure 95 U-Value analysis of the wall

4. <u>Wall against exterior air</u>. This is the wall of the stair case oriented to NE. The results obtained are:

- Temperature difference: 14 ºC
- Solar radiation: Barely influenced

Date	Time	U-Value [W/m²K]	Tw [ºC]	Ti [ºC]	Hr [%]	To [ºC]
17.02.2016	10:22:28	1,234	13,60	15,85	66,80	1,9

Figure 96 U-Value analysis of the wall

5. <u>Roof against exterior air</u>. This is the roof situated in the third floor against exterior air. The results obtained are:

- Temperature difference: 13,3 ºC
- Solar radiation: Not influenced

Date	Time	U-Value [W/m²K]	Tw [ºC]	Ti [ºC]	Hr [%]	To [ºC]
17.02.2016	17:55:13	0,736	15,71	17,0	60,3	3,7

Comparing with the data obtained theoretically:

[mm] Composition	[mm] Thickness	U-Value [W/m²K]
Concrete (200) Glass wool (50)	250	0,4

Figure 97 U-Value analysis of the wall

10.1.3 Windows

The basic features of the windows can be obtained using the application PRISM@VER 2012 which gives the user the number of layers of glass, their thickness and the length of the cavity between glasses.

Landskronahem AB has provided the information about the windows. Those are 2-glazed with an air cavity and wood frame.

These features suit with the U-Value provided by Landskronahem of 2,0 W/m²K:

Figure 98 Window and the analysis of it

10.2 Active Components

10.2.1 Heating & DHW production

For the heating and DHW production in the building a district heating system is used. This is a system for distributing heat generated in a centralized location for residential and commercial heating requirements such as space heating and water heating. In Landskrona, the district heating is generated by a mix of energy sources as biomass and residual heat among others.

A heat exchanger is required to provide in the building the heat from the system. In the pilot site the exchange is located in the building of the following photo:

Figure 99 Building with heat exchange

In that building 3 heat exchangers are located:

- Two heat exchangers for the DHW
- One heat exchanger for the heating system

Figure 100 Heating installation

10.2.2 Terminal units

A terminal unit is the part of an installation which receives hot or cool air or water from a centralized system to provide heat or cool on a conditioned area.

The terminal units found in the building are:

- Radiators: Are the elements used in the building to transfer the heat generated by the district heating system. There are located one radiator per room and the dimensions of it depends on the area to be heated: For example we can find a 1,5 x 0,7 m (34 modules) in the living room and 0,5 x 0,7 m(12 modules) in the bathroom.

Figure 101 Examples of radiators in living room and in bathroom

In most of the rooms they are located under the windows or near it when possible.

dreeam

All radiators have a thermal valve consisted in an automatic device coupled to a thermostatic valve body that actuates the shaft opening thereof, which controls the flow of water flowing through the emitter and therefore its thermal power.

Figure 102 Regulation in a radiator

In some radiators there is a conduct for the ventilation air supply, the system forces the outdoor air to pass through the radiators with the purpose to heat the air which comes from the outside before it is introduced in the room and therefore improve the thermal comfort.

Figure 103 Ventilation System

10.2.3 Lighting

Room lighting can be general, punctual, ambient or decorative.

Depending on the lamp:

- Incandescent: a wire filament is heated to a high temperature, by passing an electric current through it. They have a very low efficiency (5%)
- Halogen: is an incandescent lamp that has a small amount of a halogen such as iodine or bromine added. They have a lifetime around 1.500 hours of use.
- Fluorescent: is a low pressure mercury-vapor gas-discharge lamp that uses fluorescence to produce visible light. They are more expensive than incandescent but they have more efficiency and life.
- Low consumption: are also fluorescent lamps adapted to the size, shape and stands of conventional bulbs. They are more expensive but easily to be depreciated with a lifetime between 6.000 and 9.000 hours.
- LED: it is a p–n junction diode, which emits light when activated. LED lamps have a very high efficiency (around 90%) Despite of its high price, they are the best option at long term.

The kind of lamps used in the building and it powers depends on the decision of the tenants. Generally the most used are:

- Incandescent: This kind of lamp is very common for the bedrooms and living-room with power range between 40 and 60 W.

Figure 104 Incandescent lamp

- Fluorescent: This kind of lamp is used for the kitchen and toilets.

- Low consumption lamp: This kind of lamp is used in many rooms in the building.

Figure 105 Low consumption lamps

The consumption of lighting and appliances will be taken into consideration for the baseline analysis but not for the next steps due to the difficulty to establish energy savings measurements because of the variety and number of devices, the behaviour of the user, etc.

11 Simulation analysis

11.1 Hourly analysis program software

The main goals of this simulation are:

- To help to verify that the measured U-values and gathered building information are able to explain the current energy consumption.
- Sensitivity analysis of the different parameters, seeking for those parameters that have influence on energy consumption.
- Feasibility check: This model will be the starting point for the feasibility check to be developed later on.

11.1.1 Introduction

HAP is designed for consulting engineers, design/build contractors, HVAC contractors, facility engineers and other professionals involved in the design and analysis of commercial building HVAC systems.

In addition, HAPs 8760 hour energy analysis capabilities are very useful for green building design. For instance, HAP energy analysis results are accepted by the US Green Building Council for its LEED®1 (Leadership in Energy and Environmental Design) Rating System. Visit the USGBC's website, www.usgbc.org, for more LEED info.

11.1.2 Load calculation

HAP software uses:

- ASHRAE Transfer Function cooling load calculation procedures,
- ASHRAE design heating load calculation procedures, ASHRAE design weather data.
- ASHRAE design solar calculation procedures.

Features:

- Calculates space and zone loads 24-hours a day for design days in each of the 12 months. In doing so it calculates heat flow for all room elements such as walls, windows, roofs, skylights, doors, lights, people, electrical equipment, non-electrical equipment, infiltration, floors and partitions considering time of day and time-of-year factors.
- Performs detailed simulation of air system operation to determine cooling coil loads and heating coil loads and other aspects of system performance 24-hours a day for design days in each of the 12 months.
- Analyses plenum loads.
- Considers any operating schedule for HVAC equipment from 1 hour to 24 hours in duration.
- Permits hourly and seasonal scheduling of occupancy, internal heat gains, and fan and thermostat operation.

On the following figures are displayed some examples of the type of data required in HAP simulation related to design weather inputs but also the outcomes provided by the HAP tool.

Design Parameters:

City Name	**Malmo**	
Location	**Sweden**	
Latitude	**55,6**	Deg.
Longitude	**-13,4**	Deg.
Elevation	**105,8**	m
Summer Design Dry-Bulb	**25,0**	°C
Summer Coincident Wet-Bulb	**16,7**	°C
Summer Daily Range	**7,9**	°K
Winter Design Dry-Bulb	**-13,9**	°C
Winter Design Wet-Bulb	**-15,1**	°C
Atmospheric Clearness Number	**1,00**	
Average Ground Reflectance	**0,20**	
Soil Conductivity	**1,385**	W/(m-°K)
Local Time Zone (GMT +/- N hours)	**-1,0**	hours
Consider Daylight Savings Time	**No**	
Simulation Weather Data	**Stockholm (Bromma) (IWC)**	
Current Data is	**2001 ASHRAE Handbook**	
Design Cooling Months	**January to December**	

Design Day Maximum Solar Heat Gains

(The MSHG values are expressed in W/m²)

Month	N	NNE	NE	ENE	E	ESE	SE	SSE	S
January	32,0	32,0	32,0	78,6	225,0	412,0	532,5	628,9	654,4
February	50,3	50,3	66,1	232,8	443,3	595,7	707,9	756,3	770,5
March	69,8	69,8	229,4	420,5	598,0	700,3	750,1	755,7	755,7
April	89,8	196,2	369,0	555,5	655,5	716,4	708,7	675,1	653,1
May	125,6	295,1	484,6	606,1	686,5	690,7	647,1	593,3	561,9
June	167,0	334,3	514,3	619,0	682,6	670,5	615,0	552,3	520,1
July	127,8	302,8	473,9	602,0	669,0	677,2	634,2	578,5	552,2
August	95,4	192,4	364,4	534,8	632,9	689,0	684,2	651,9	633,5
September	72,9	72,9	211,2	377,7	558,6	654,4	717,9	727,7	719,0
October	52,5	52,5	52,5	237,5	406,9	573,2	662,9	723,3	736,7
November	32,6	32,6	32,6	65,1	237,6	392,3	533,4	612,0	635,1
December	23,5	23,5	23,5	29,2	148,8	307,7	432,4	526,2	545,8
Month	**SSW**	**SW**	**WSW**	**W**	**WNW**	**NW**	**NNW**	**HOR**	**Mult**
January	619,3	546,7	394,2	245,2	55,0	32,0	32,0	130,4	1,00
February	757,9	704,3	593,9	443,0	240,2	64,2	50,3	295,1	1,00
March	762,4	756,6	706,8	587,0	429,9	219,4	69,8	475,1	1,00
April	675,9	707,0	716,4	663,9	552,0	381,3	191,2	617,0	1,00
May	593,4	645,4	689,0	687,2	603,7	484,9	292,5	701,0	1,00
June	552,0	610,1	665,0	682,0	627,2	510,6	347,8	728,6	1,00
July	578,7	627,6	670,6	672,8	600,0	476,1	301,1	698,5	1,00
August	653,5	682,1	690,3	639,6	531,0	369,5	186,4	611,0	1,00
September	726,8	716,9	653,9	559,1	379,6	211,5	72,9	455,3	1,00
October	721,5	674,6	572,2	414,9	232,8	58,4	52,5	290,3	1,00
November	615,5	525,9	400,8	223,6	75,1	32,6	32,6	129,9	1,00
December	526,8	426,0	310,9	136,6	31,1	23,5	23,5	76,3	1,00

Mult. = User-defined solar multiplier factor.

Figure 106 Design weather data

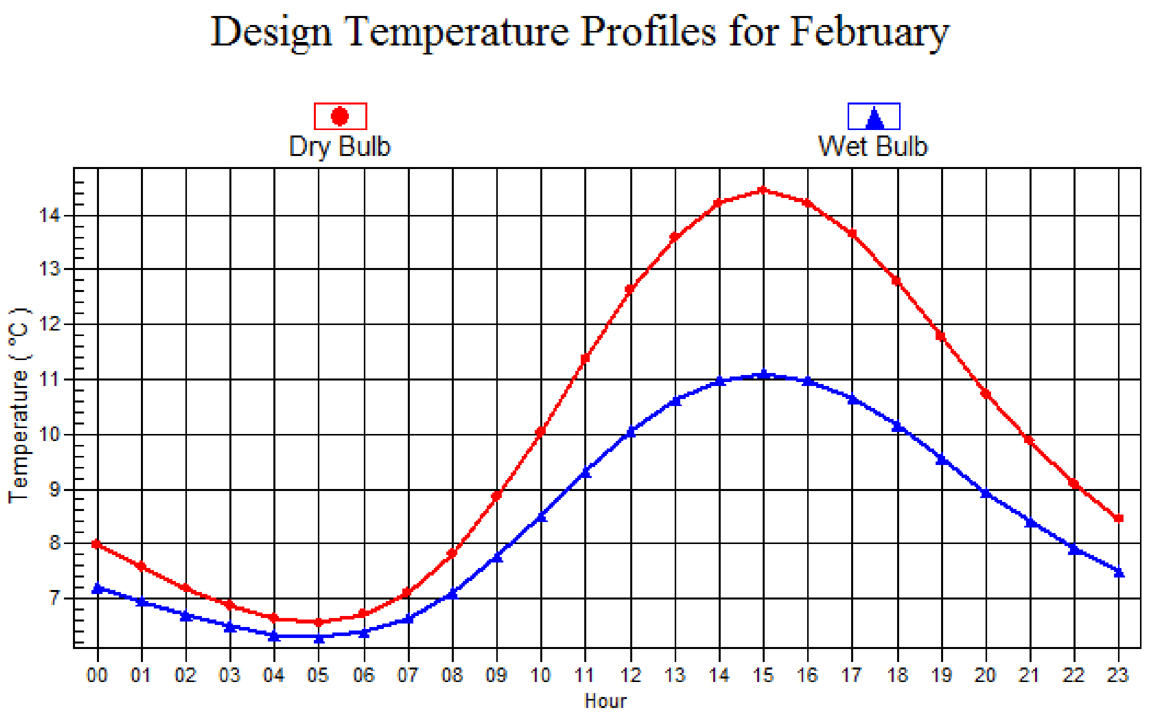


Figure 107 Example of February temperature

11.1.3 Simulation approach in Landskrona

In Landskrona each floor has been defined as a different space. According to the data provided by the Building owner, in our simulation we took into account all the building, that are number 11, 13, 15, 17 and 19, because we have real energy consumption data related to all the building.

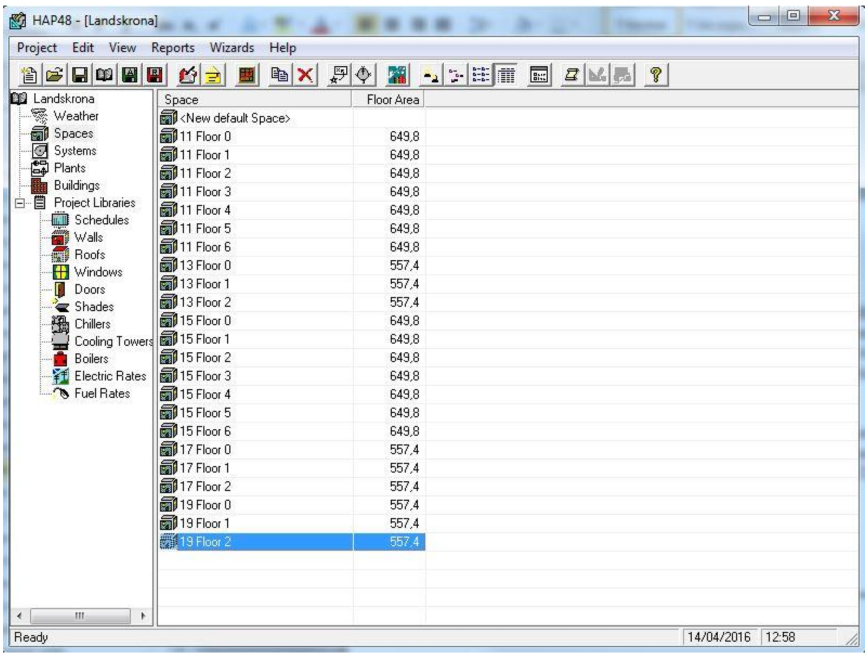


Figure 108 Spaces definition

We have defined three different walls composition with different U-values, separating between walls faces to NE, NW and SE and also four different windows. In this first approach we have estimated the occupancy in each space, defining 24 people in each floor. According to construction and energy codes we also assume 5 W/m^2 for lighting and 6 W/m^2 for electrical equipment.

Ventilation parameters are really significant in residential sector to assess the energy demand (Heating and Cooling) at the buildings. In Landskrona according to construction and energy codes we have estimated an infiltration of 0,50 ACH (Air Changes per Hour) which means a low level of infiltration.

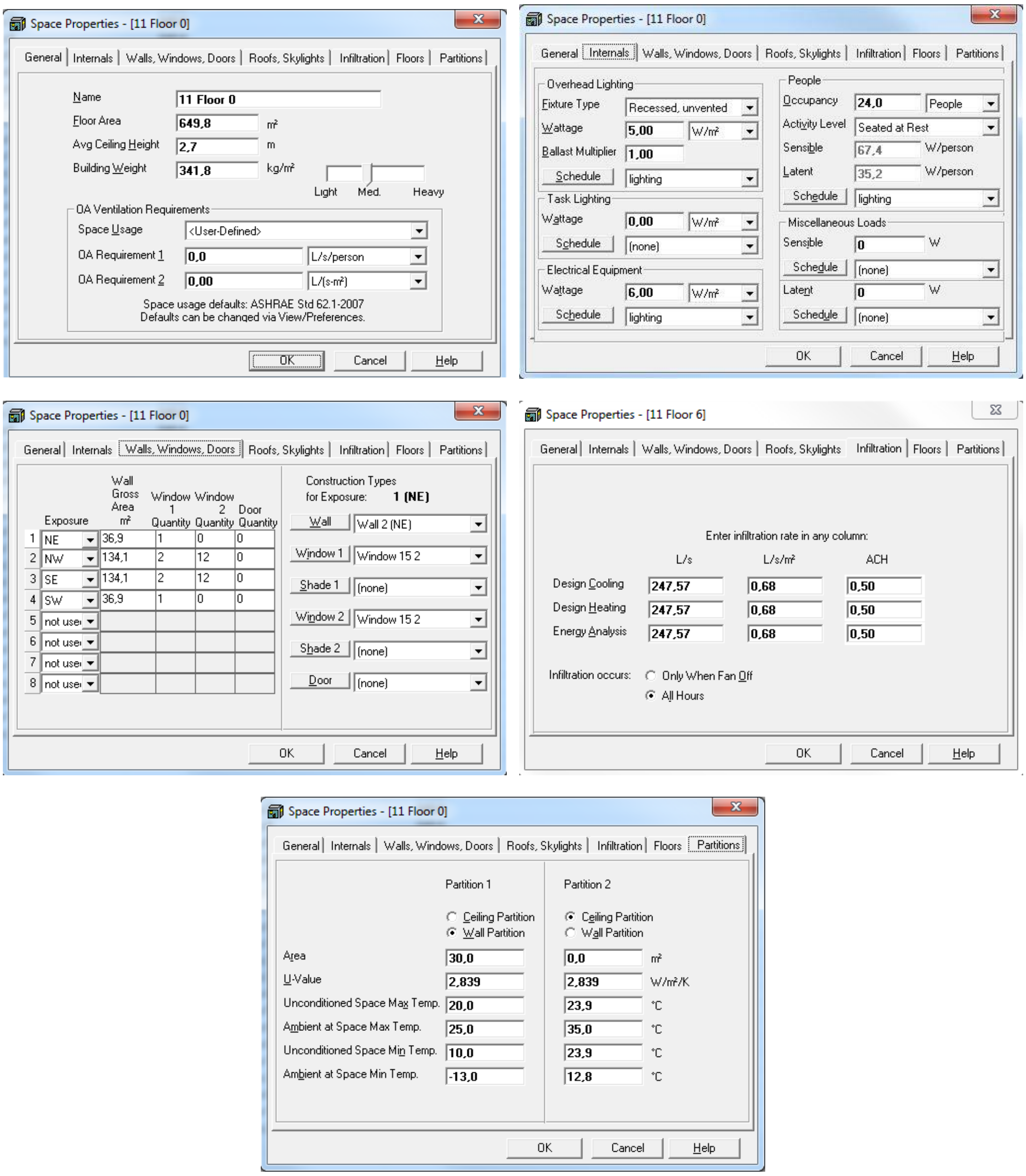


Figure 109 Spaces definition

In the next figures we have the different walls and windows defined as well as an example of the type of input required by the tool.

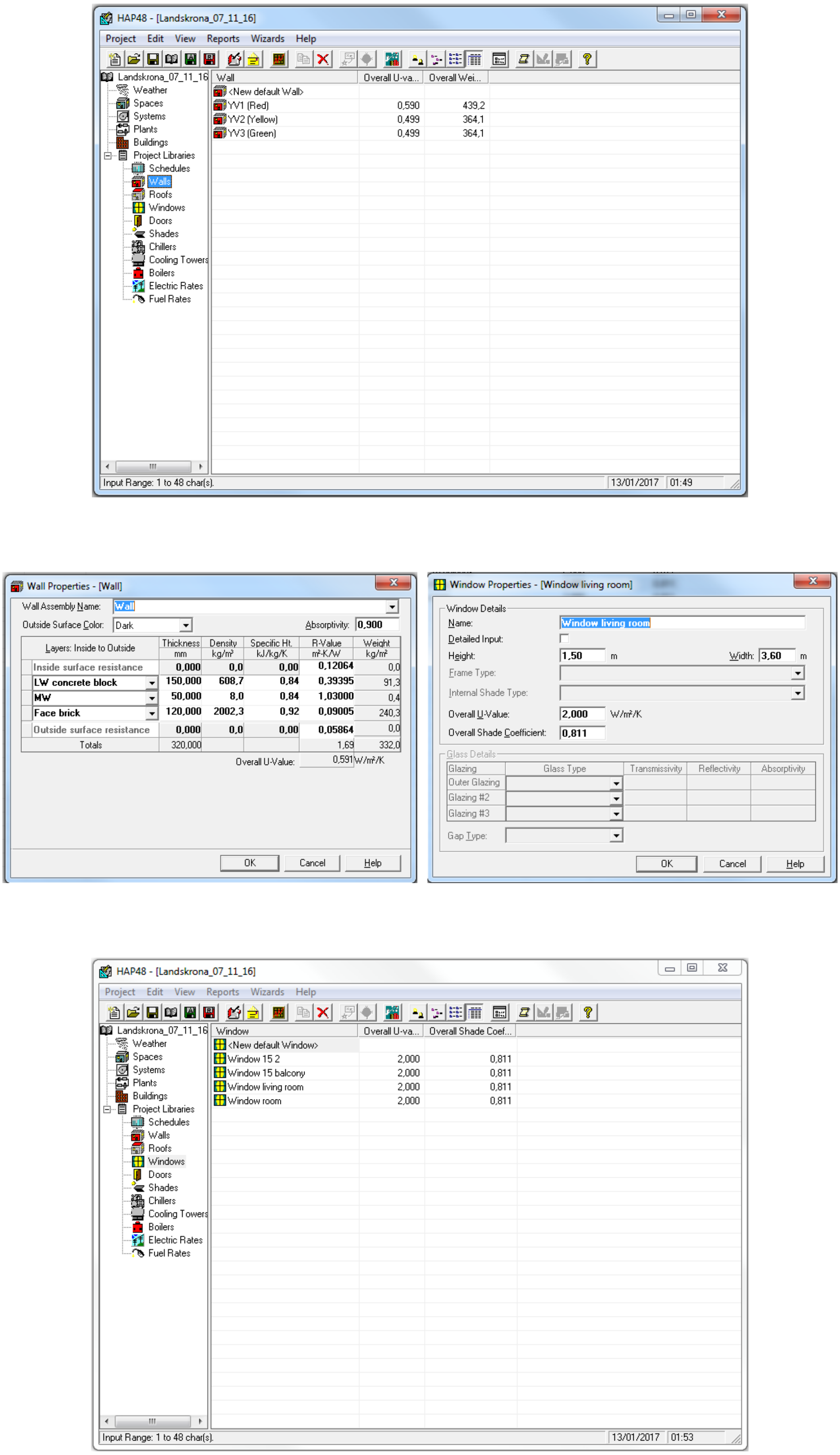


Figure 110 Walls and windows definition

While defining a space, information about the construction of walls, roofs, windows, doors and external shading devices is needed, as well as information about the hourly schedules for internal heat gains. This construction and schedule data can be specified directly from the space input form (via links to the construction and schedule forms), or alternately can be defined prior to entering space data. In this first approach we have define three different schedules, once we get data related to real occupancy and people behaviour from WP4 we will introduce these information in our simulation.

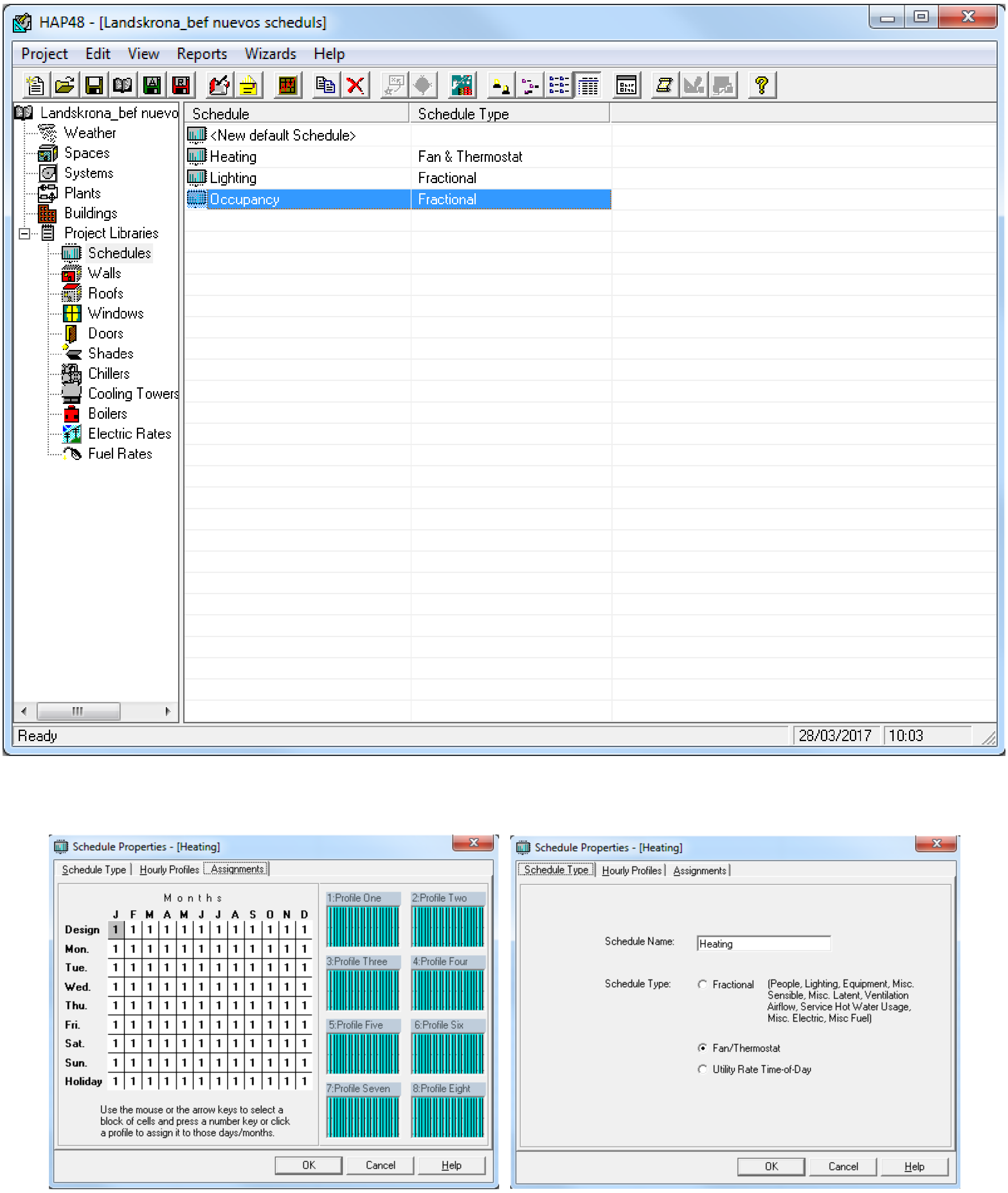


Figure 111 Schedule definition

In Landskrona we have radiators as terminal units (Heating system) so the design supply temperature must be quite close to 55 ºC. Heating T-stat Set points is 22ºC.

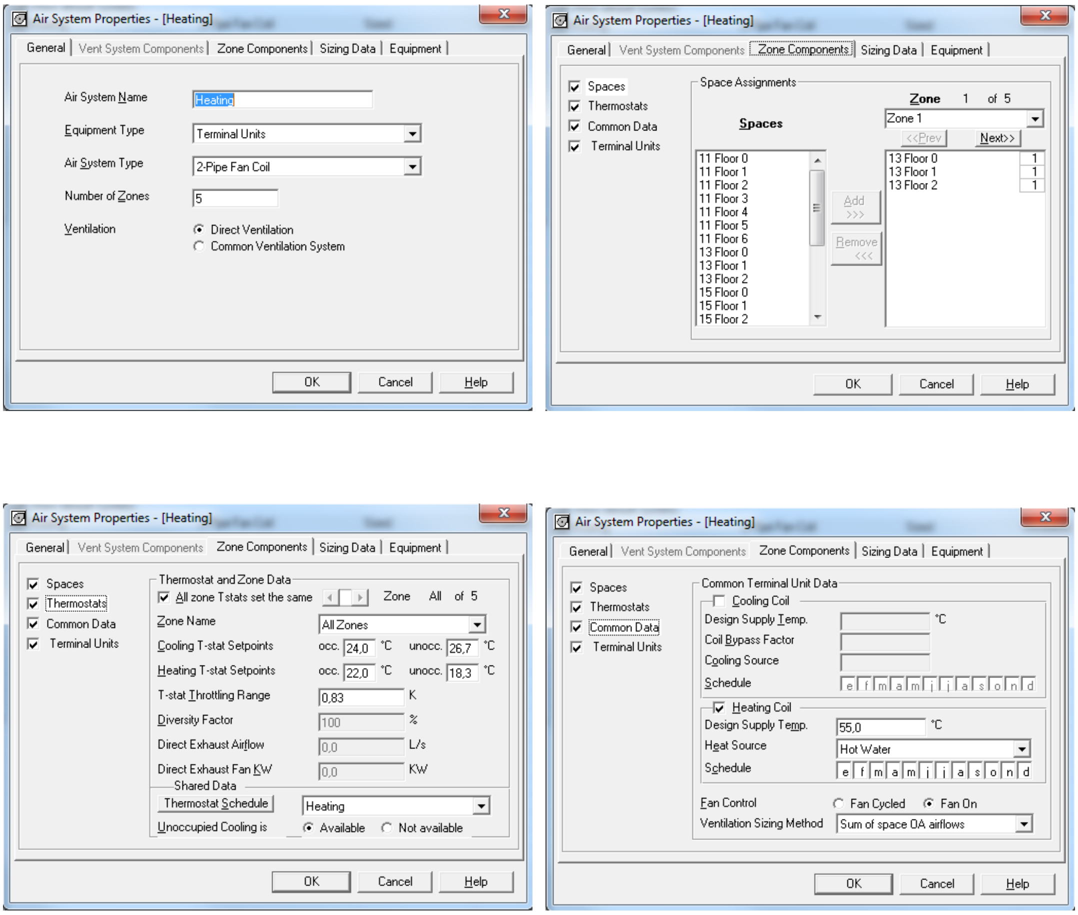
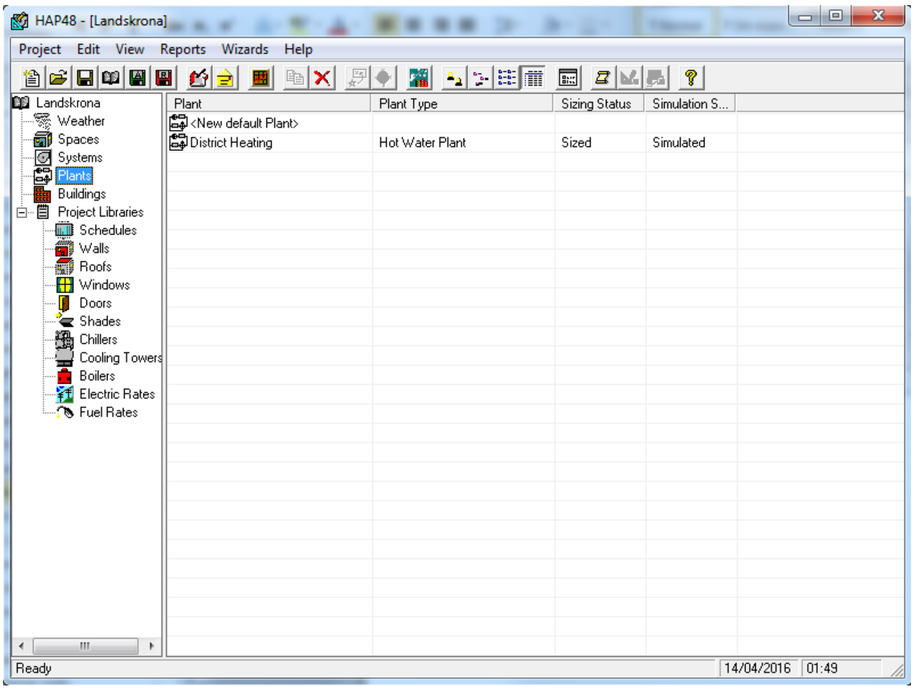


Figure 112 System definition



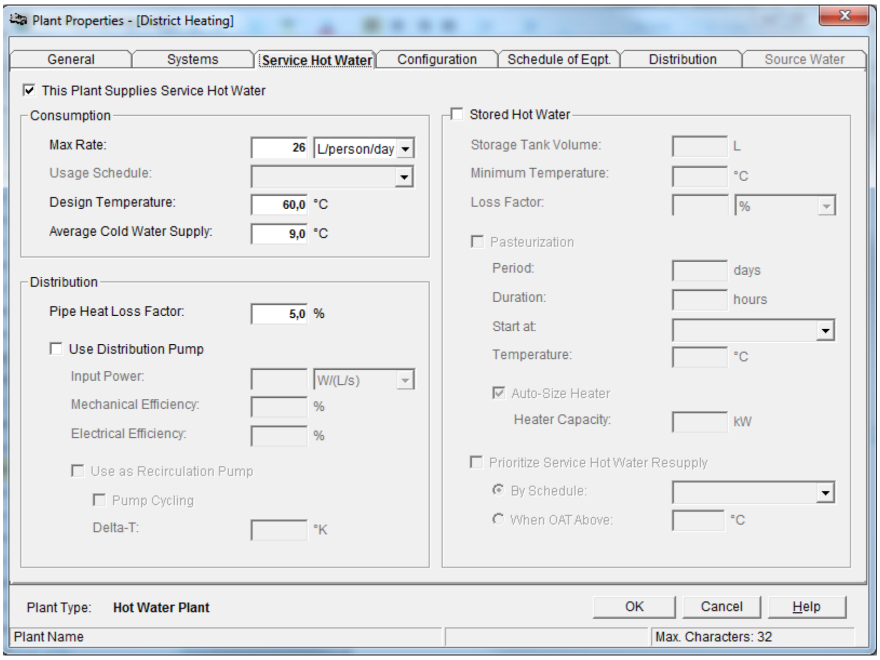
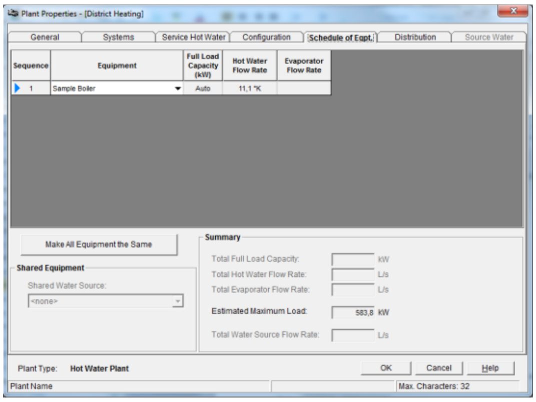
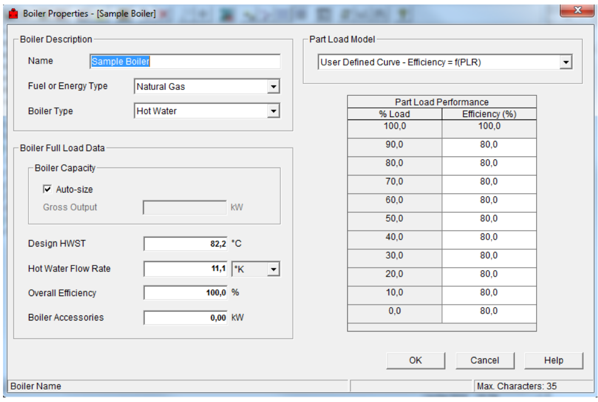


Figure 113 Plant definition

The Domestic Hot Water plant has been simulated taking into account 26 l/person/day, distribution losses of 5% and a design temperature of 60ºC.





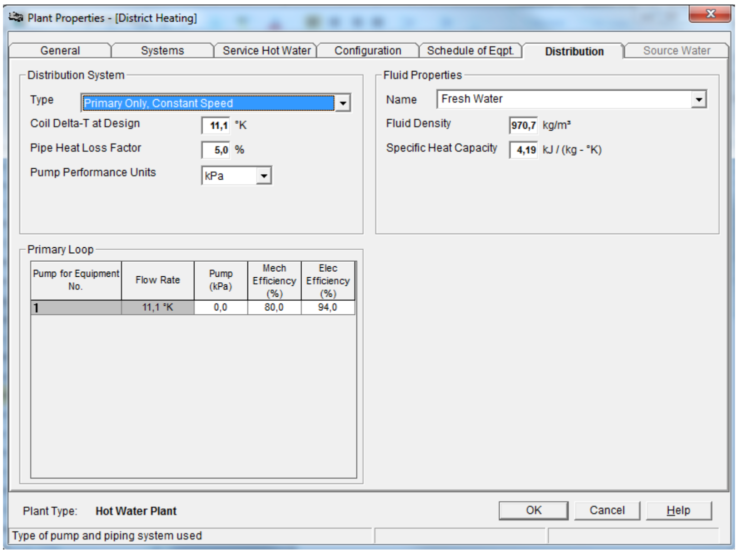


Figure 114 Plant definition

In the simulation one system of district heating provides DHW and water for heating in the five buildings.

In the following figure we have the results that comes from the simulation tool. It shows the sum of heating and DHW consumption.

Monthly Simulation Results for District Heating

Landskrona_
Exeleria

03/28/2017
10:06

Plant Simulation Results (Table 1):

Month	Service HW Load (kWh)	Heating Coil Load (kWh)	SHW Piping Losses (kWh)	Plant Heating Load (kWh)	Boiler Output (kWh)	Boiler Input - Gas (kWh)	Boiler Misc. Electric (kWh)
January	17765	214902	846	244300	244300	305375	0
February	16046	152470	764	176942	176942	221177	0
March	17765	133751	846	159091	159091	198864	0
April	17192	54841	819	75634	75634	94543	0
May	17765	115	846	18774	18774	23468	0
June	17192	6	819	18058	18058	22573	0
July	17765	0	846	18653	18653	23317	0
August	17765	0	846	18653	18653	23317	0
September	17192	6608	819	24989	24989	31237	0
October	17765	76294	846	98762	98762	123452	0
November	17192	144410	819	169682	169682	212102	0
December	17765	196795	846	225289	225289	281611	0
Total	**209168**	**980191**	**9960**	**1248827**	**1248827**	**1561034**	**0**

dreeam

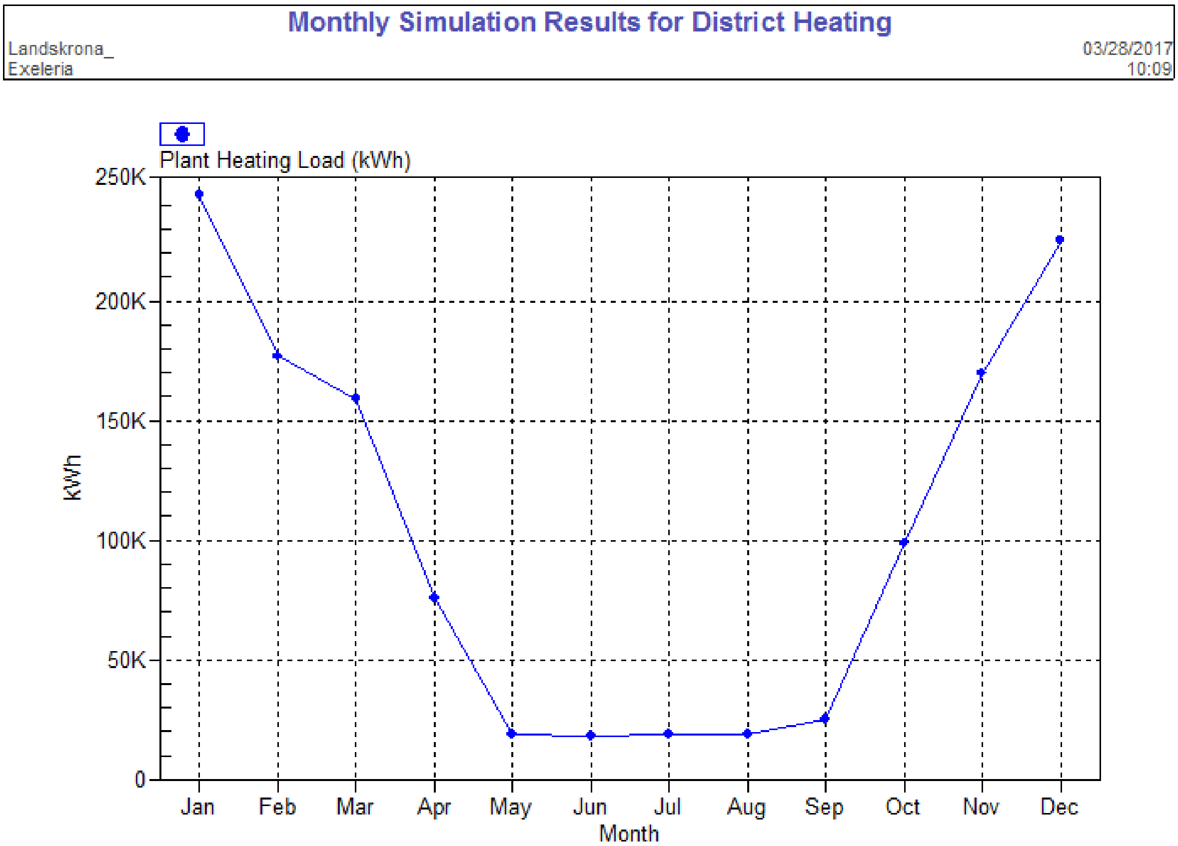


Figure 115 DHW simulation results

The following photo shows the electric consumption in the building for the lighting and the electric equipment:

Lighting (kWh)	Electric Equipment (kWh)
20454	24545
18475	22170
20454	24545
19795	23754
20454	24545
19795	23754
20454	24545
20454	24545
19795	23754
20454	24545
19795	23754
20454	24545
240835	**289002**

11.1.4 Overview

Energy system	[MWh/year]	[kWh/m2year]
Heating	1.029,2	72,9

DHW	219,6	15,6
Lighting	240,8	17,1
Electric equipment	289,0	20,5
TOTAL	**1.778,6**	**126,0**

11.2 Analysis of sensitivity

After the simulation analysis with the HAP tool, the following parameters have been modified to see how they affect to the result of the consumption:

11.2.1 Room temperature

For the current analysis calculated before, it has been considered a room temperature of 22 ºC while heated. An increment and a decrease of 1 ºC on this temperature has been modified and checked the variation on the energy demand.

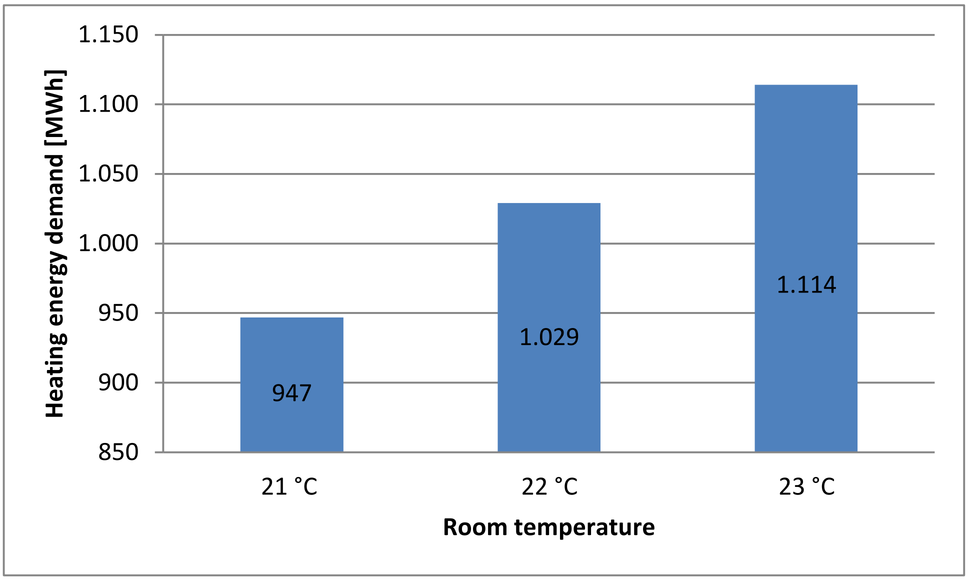


Figure 116 Energy demand in relation to room temperature

The variation in percentage produced is:

Temperature	Heating energy demand [MWh]
-1 ºC	-8,0 %
22 ºC	1.029
+1 ºC	+8,3 %

11.2.2 U-Value

In the following analysis the U-Values measured are compared with the current values (source:BPIE[4]) that a new construction in Sweden can have:

- Wall= 0,18 W/m²K
- Floor= 0,18 W/m²K
- Roof= 0,19 W/m²K
- Windows= 1,2 W/m²K

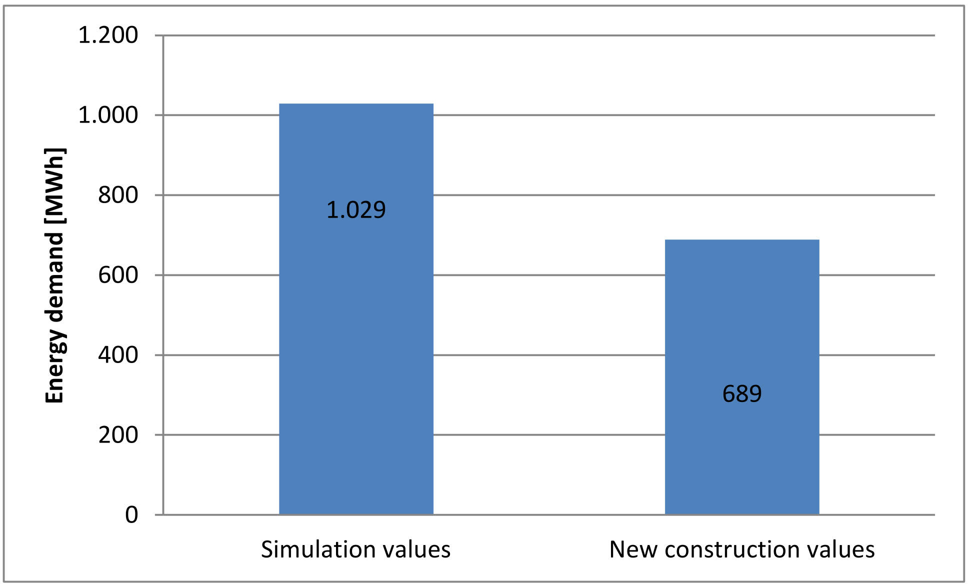


Figure 117 Energy demand in relation to the U-Value

U-Value	Heating energy demand [MWh]
Measured	1.430
New constuction	957
Difference	-33 %

11.2.3 Infiltration

For the current analysis calculated before, it has been considered an infiltration of 0,55 air changes per hour. An increment or decrease of it modify the heating energy demand:

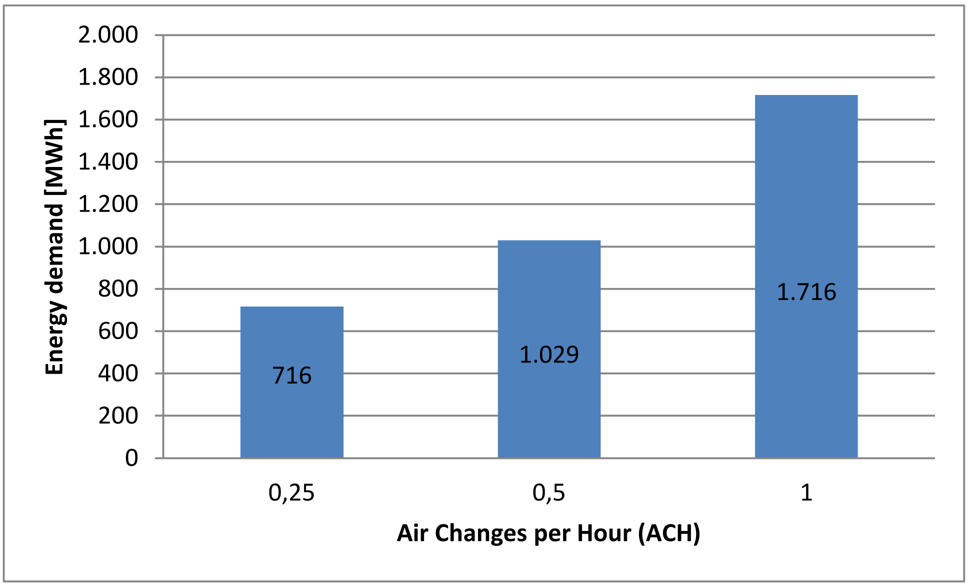


Figure 118 Energy demand in relation to the infiltration

Air Changes per Hour (ACH)	Heating energy demand [MWh]
0,25	-30,4 %
0,50	1.029
1	+66,8 %

A discussion on how to use for this simulation analysis is done in the conclusions section.

11.2.4 Overview

Energy system	[MWh/year]
Heating	1.029,2
DHW	219,6
Lighting	240,8
Electric equipment	289,0
TOTAL	**1.248,8**

12 Summary and conclusions

12.1 Passive Components

12.1.1 Thermographic analysis

From the thermographic analysis we can get the conclusion that generally, there is no presence of humidity, leaks of energy systems or significant differences in the envelope components. Despite of this, there are important areas to take into consideration where exist thermal bridges as for example the upper side of the windows (Figures 88 and 89) maybe due to a problem in the rubber seals.

Concerning to the distribution of hot water in the radiators (Figure 90) that must be located along them in the same proportion in every radiator.

The thermographic analysis done in the technical room (Figure 91) shows that there are heat loses in the part of the installation where there are no insulation system.

12.1.2 U-Value analysis

Generally, the values obtained are not high (under 1,0 W/m^2K) except for the wall oriented to the NW which have a higher U-Value compared with the other walls of the building.

The values obtained during the measure are very similar in some cases to the values calculated with the composition provided by Landskronahem AB (considering the insulation thickness taken in the cases where they have not been provided).

12.1.3 Windows

The windows demonstrate a very good isolation. The calculated U-Value provided of 2,0 W/m^2K matches with the features of the windows .

Regarding to the thermal bridges analysed before, the joint between windows and wall must be supervised.

12.2 Active Components

12.2.1 Heating & DHW production

In spite of the district heating is a modern system, as seen in the thermographic analysis, there are many points of the installation without insulation that it must be applied.

12.2.2 Terminal units

In the case of the radiators, the control of the heating depends on the user which can do that regulating the thermostatic valve depending on their thermal comfort (not on the room temperature or the outside temperature). This system can be only efficient when the user is taught from an efficiency point of view, but in practice they are normally used in an ON/OFF position.

It must be also checked if the water heated is well distributed along all the radiators according to the thermographic analysis.

12.2.3 Lighting

There are installed a significant number of lamps that suppose a waste of energy comparing with the newest kind of lamps as LED or low consumption lamps. The use of lamps with a high nominal power in a dwelling increase significantly the power consumption considering the total amount and the number of hours they are working.

12.3 Simulation analysis

12.3.1 Results obtained

In the following figure are compared the simulation result with the real consumption obtained during the last three years from the district heating supplier. The consumption in MWh describes a curve descending from winter to summer, having linear shape in summer (DHW consumption) and ascending again in winter (heating period):

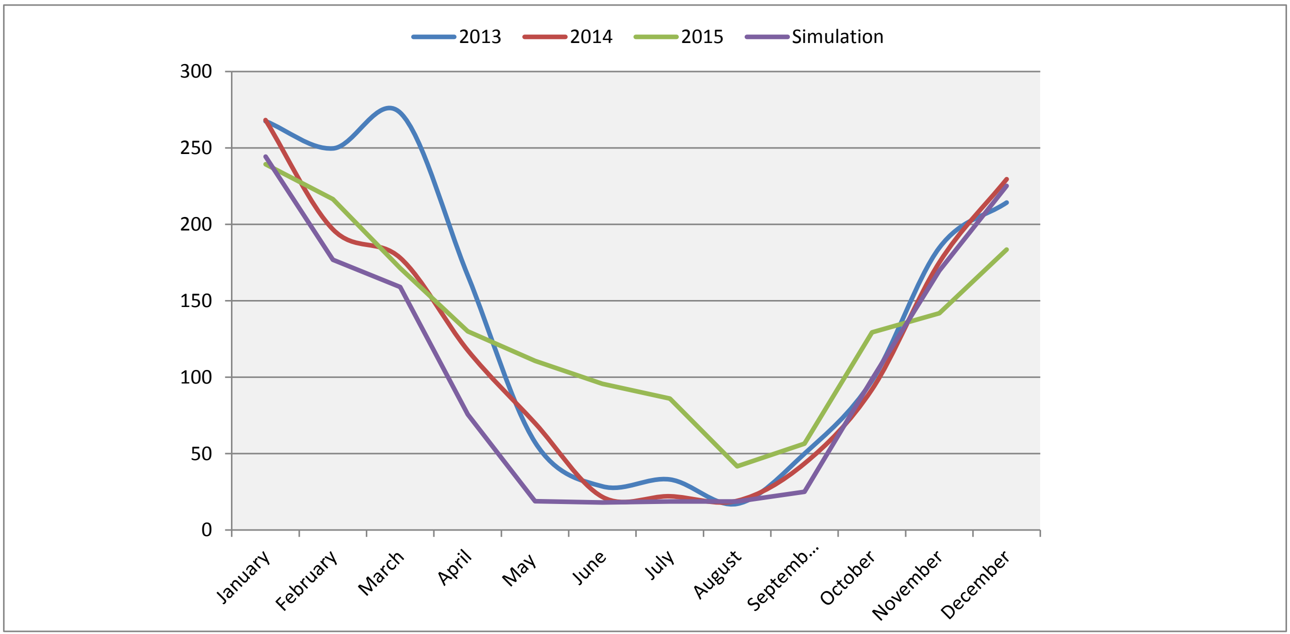


Figure 119 Real consumption and simulation

Month	2013	2014	2015	Simulation
January	267,57	268,30	239,38	244,30
February	249,73	196,76	216,59	176,94
March	273,05	178,07	171,40	159,09
April	166,77	117,67	130,04	75,63
May	57,41	69,95	110,64	18,77
June	28,57	21,65	95,65	18,06
July	33,09	22,09	85,95	18,65
August	17,14	19,11	41,63	18,65
September	50,00	43,55	56,52	24,99
October	97,68	91,94	129,43	98,76
November	184,68	175,08	141,87	169,68
December	214,32	229,61	183,52	225,29
TOTAL	**1.640,01**	**1.433,78**	**1.602,62**	**1.248,83**

The tendency of the curve is the same every year, but it has some outliers, as for example in March 2013 we can appreciate a higher consumption that can mean, this month was colder than usually or it happened a problem in the installation. Landskronahem AB warned also about the consumption during 2015 is not reliable due to a problem in the installation, as we can see there is an extremely high consumption in summer. Therefore, a consumption average has been done avoiding those variations:

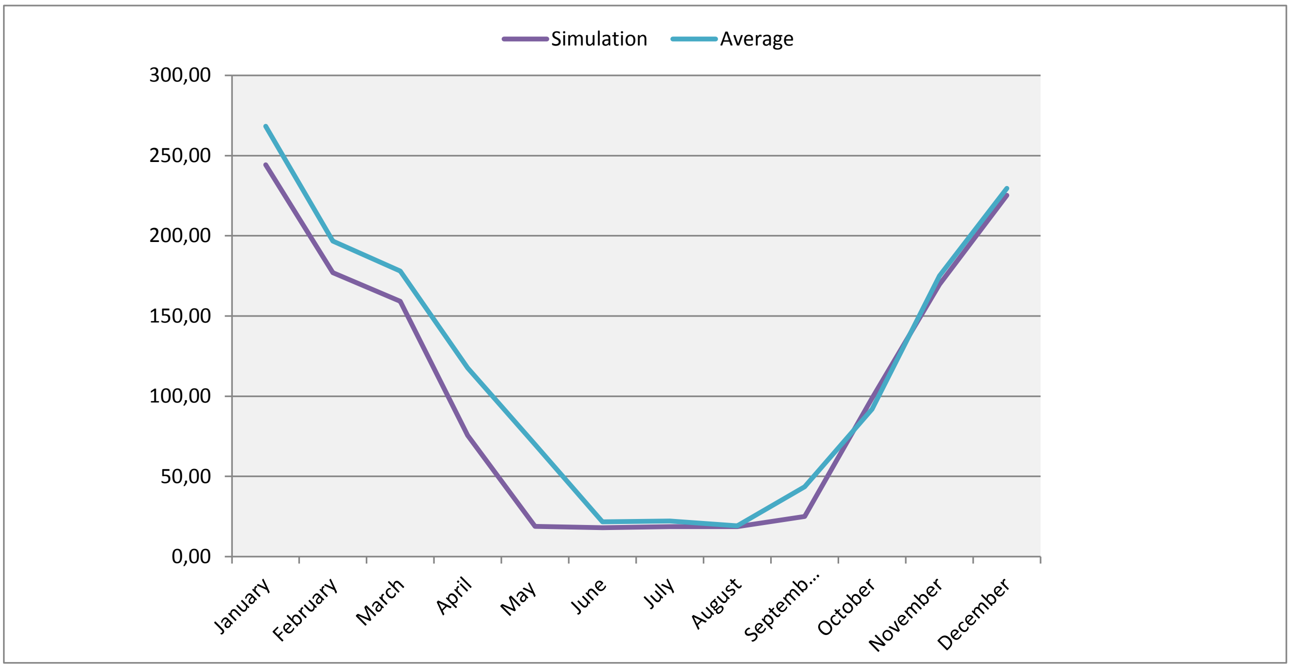


Figure 120 Simulated and average consumption

Month	Average	Simulation
January	258,42	244,30
February	206,68	176,94
March	174,74	159,09
April	117,67	75,63
May	63,68	18,77
June	25,11	18,06
July	27,59	18,65
August	18,13	18,65
September	46,77	24,99
October	106,35	98,76
November	167,21	169,68
December	209,15	225,29
TOTAL	**1.421,49**	**1.248,83**

The simulation result matches quite good with the average consumption. The total average consumption and the simulated are very similar, differing by around 10% and the shape of the curve matches pretty well stating that the assumptions taken in the monetization are reasonable:

Consumption	[MWh]
Simulation	1.249
Average	1.421
Difference	12 %

12.3.2 Analysis of sensitivity

A sensitivity analysis has been done showing the influence of changes in the most relevant parameters.

- Room temperature

  An increment or a decrease of 1 ºC on the room temperature produces a variation around 8 % in the heating energy demand. A temperature of 21 - 22 ºC during the day ensures a minimum of habitability conditions.

  It can be considered that the temperature vary from one room to another. For example, in the bathroom can exceed this temperature to 23 °C and the rooms that are not usually used up to 18 °C.

  To heat the building with a room temperature above 22 ºC implies a significant waste of energy.

- U-Value

  Instead of the good values obtained during the measure in Landskrona, those values are high if we compare them with the current values for new constructions. After the analysis of the building with a better values it is shown the importance of having a good insulation system.

  The energy demand obtained with those values is around 33 % less than the one calculated with the U-Values measured.

- Infiltration

  Through the analysis of the infiltrations in the building it can be shown that they have a very important impact not only in the comfort of its users but also in the level of energy efficiency of the building. It is obvious that when the outside temperature is low, have an income of cold air inside the building increases the heating energy demand.

  As we can see in the figure of infiltrations, a small increment in in the value of air changes per hour produces a significant higher heating energy demand. For example the heating energy demand from 0,50 to 1 air changes per hour is increased a 66%.

13 Annexes

1. Methodology used
2. Damp report (Padiham)
3. Electricity bills (Padiham)
4. ECP (Padiham)
5. Treviso 1st Pilot site Baseline description

13.1 Methodology used

Methodology used

D2.1 Baseline description

This project has received funding from the European Union's Horizon 2020 research and innovation programme under the Grant Agreement no 680511. This document does not represent the opinion of the European Union, and the European Union is not responsible for any use that might be made of its content.

1.

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1 Thermographic analysis

1.1 General description

Thermal imaging technology has become one of the tools most valuable diagnostics for predictive maintenance. It detects anomalies which are invisible with the naked eye and allows to make corrections before a costly system failures can happen.

Thermal imaging cameras are a unique tool to identify when and where maintenance is needed. It is a reliable instrument capable to analyse and visualize the distribution of the surface temperature in a system quickly and with accuracy.

Many industries worldwide have discovered the benefits of the use of thermal imaging technology in their predictive maintenance programs. Some of it applications are:

- **Electrical systems**
- **Mechanic systems**
- **Piping**
- **Envelope**
- Petrochemical plants
- Others

1.2 Thermal imaging in the building industry

Thermal imaging technology has become one of the most valuable diagnostic tools for building inspections. With a thermal imaging camera can be early identified problems that can be documented and corrected before they become serious and result more expensive to repair.

A thermal inspection in a building can help to:

- Visualize energy losses
- Detect a lack of insulation or a defect on it
- Locate air leaks
- Find humid in the construction
- Locate thermal bridges
- Detect water leaks in flat roof and brakes in hot water pipes
- Find faults in electrical wiring and central heating

1.3 How it works

A thermal imaging camera records the intensity of radiation in the infrared area of the electromagnetic spectrum and converts it into a visible image.

The infrared area is located between the visible light and microwaves in the electromagnetic spectrum. The main source of infrared radiation is heat or thermal radiation. Any object with a temperature above absolute zero (-273.15 ° C or 0 Kelvin) emits radiation in the infrared region. Even the coldest objects we can imagine, as ice cubes, emit infrared rays.

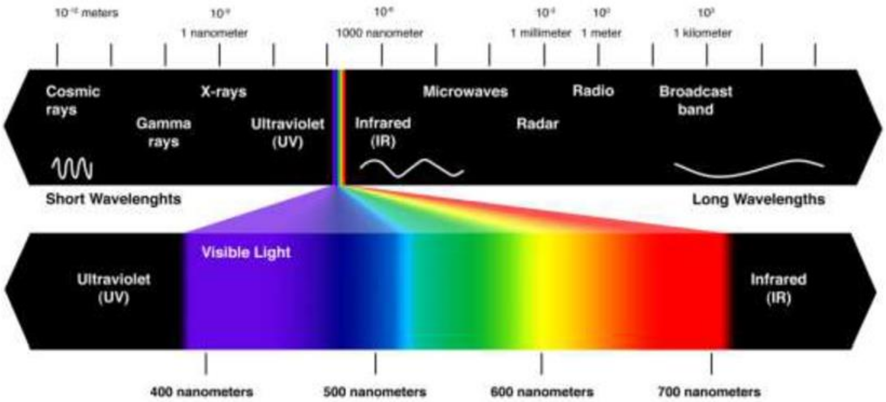


Figure 1 Infrared area

The infrared energy (A) which irradiates an object is focused by the optical system (B) onto an infrared detector (C). The detector sends the data to an electronic sensor (D) to process the image. This sensor converts the data into a image (E) compatible with the viewfinder and can be also seen in a screen.

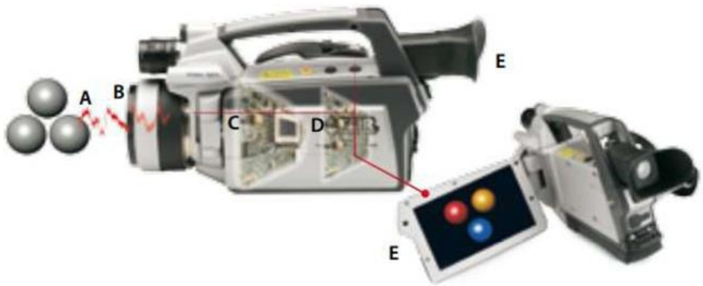


Figure 2 Infrared camera

1.4 Temperature conditions

The room temperature can have a big influence on the thermographic analysis. A high temperature can hide hot spots by heating the entire object, while a low temperatures could cool the hot spots to a temperature below a certain threshold determined previously.

Obviously, direct sunlight can also have a big influence, however, direct sunlight and shadows can influence the heat pattern even several hours after that finished exposure to sunlight. These patterns caused by sunlight should not be confused with patterns generated by heat transfer.

A weather factor that should be considered is the wind. Air flows cool the material surface, reducing the temperature differences between hot and cold areas.

Another factor that can render useless analysis by thermography is the rain, which cools the surface material. Even just after rain, water evaporation cools the material surface. Therefore, this can cause thermal patterns incorrectly.

1.5 Steps in a thermographic analysis

Following, the necessary steps to carry out a thermographic analysis:

- Selection and identification of the systems to be studied.
- Preparation and equipment connection, verifying a proper adjustment between camera connections, supply loading system and recording thermal imaging system.
- Identification of operational parameters: Very important to know the operational characteristics of the equipment to be inspected in values of temperature and operating pressure as well as internal equipment design features. This will result in a clear and accurate assessment of the results obtained during the inspection.
- Calibration of the equipment.
- Application of the test: Refers to the commencement of the inspection, it must be swept across the surface team to inspect emphasizing the lower areas or critical equipment.
- Analysis of the results.
- Issue the report: all the results obtained, identifying clearly what the damage and problems identified clearly to the location of the same and recommendations warranting the case, must also be demarcated in a colour photograph the extent of damage.

1.6 Equipment

The equipment used for the analysis is:

- Thermal camera from Testo: 870–1
- Thermometer

- Computer
- Software: Testo IRSoft

Figure 3 Thermal imaging camera Testo 720-1

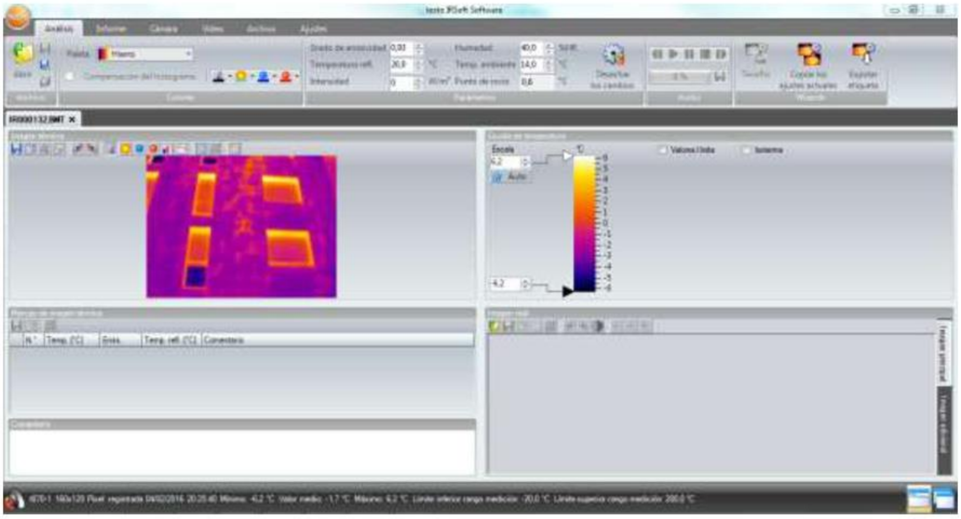


Figure 4 Software used for the analysis

2 U-Value analysis

2.1 General Description

The U-factor or U-value, is the overall heat transfer coefficient that describes how well a building element conducts. The elements are commonly assemblies of many layers of components such as those that make up walls, floors, roofs etc. It is expressed in watts per meter squared kelvin (W/m^2K). This means that the higher the U value the worse the thermal performance of the building envelope. A low U-value usually indicates high levels of insulation.

In order to obtain the U-value of a wall it is necessary to measure the heat flow, internal temperature and external temperature continuously over a sufficiently period of time. In heat flux meters were used to measure heat flow and thermistors were used to record internal and external temperatures. U-values were determined by comparing the heat flow through the element with the temperature difference across it.

$$U = f\,(T_i\,,\,T_e,\,T_{pi},\,r_{si}\,)$$

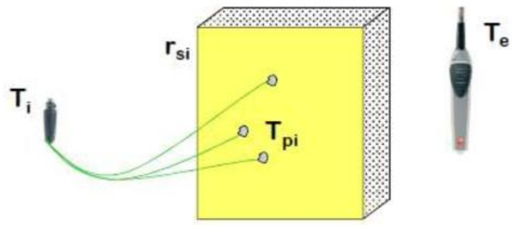


Figure 5 Factors involved in U-Value calculation

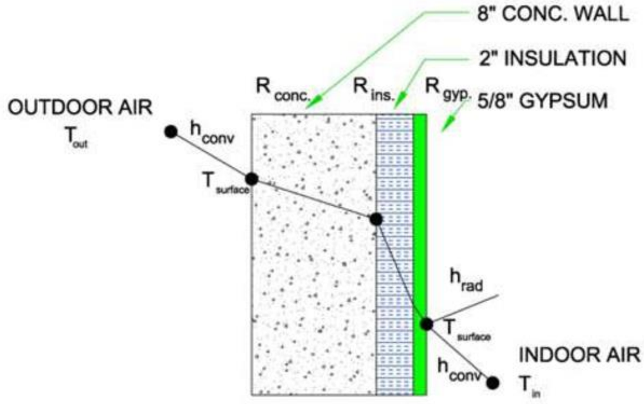


Figure 6 Heat transfer in a wall

The approach taken made use of **ISO 9869**, a standard which gives guidance on measuring U-values using small heat flux meters.

2.2 How to measure

To perform the measurement correctly it is necessary follow the following steps:

1. Connect the probe transmittance and launch the probe by radio, then start the measuring instrument.

   When the probe to calculate the U-value is connected, the measurement channels to the U-value (unit: W/m2K), Tw (surface temperature) and Ti (internal temperature) is automatically activated.

Figure 7 Device and outside probe

2. Paste three thermocouples temperature probe for calculation U-value with the help of modelling clay to the inner wall approximately 10 cm between them in a triangular shape.

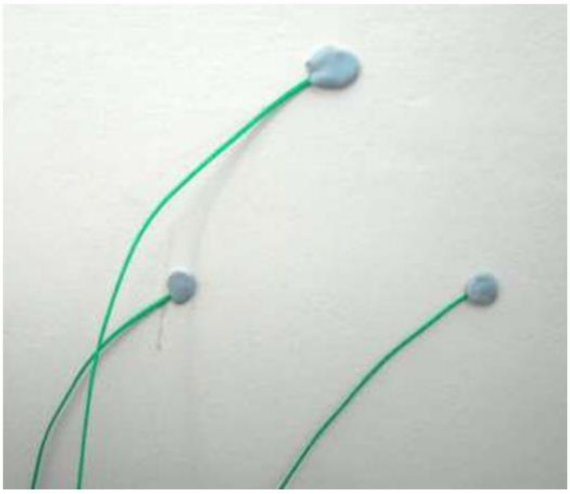


Figure 8 Thermocouples

3. During the measurement, place the instrument in a place away from sources cold or heat (not placed under the window and hold hand), at a distance from the wall at least 30 cm, and as far as possible to the same height as the three thermocouples temperature probe.

4. Put the probe on the outside.

Figure 9 Equipment

2.3 Equipment

The equipment for measuring U-values include heat flux meters, thermistor temperature probes and data-loggers.

The equipment used for the analysis is:

- Multifunction meter from Testo: 435 – 2
- Diverse accessories for the meter
- Computer
- Software: Testo Confort software

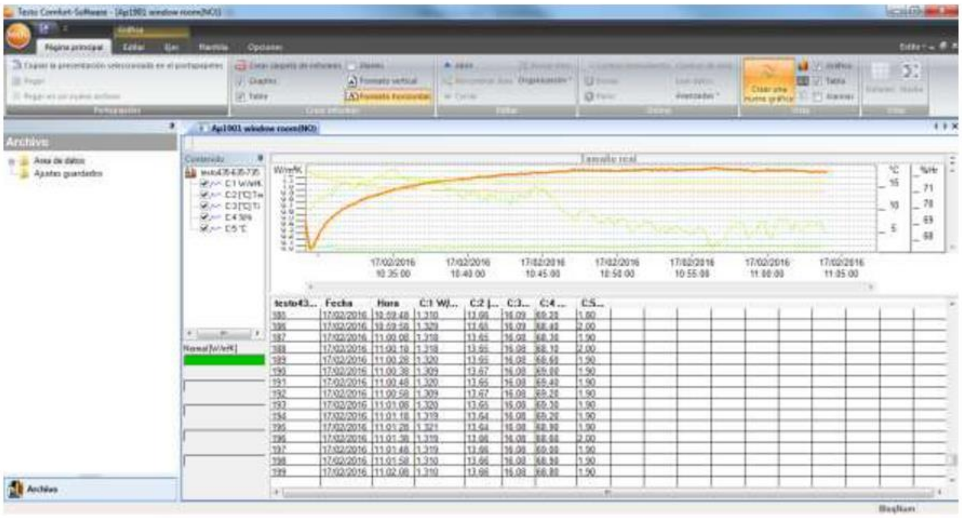


Figure 10 Software used for the analysis

Figure 11 U-Value stable (1,3 W/m2K)

3 Hourly Analysis Program software

3.1 Introduction

HAP (Hourly Analysis Program) is designed for consulting engineers, design/build contractors, HVAC contractors, facility engineers and other professionals involved in the design and analysis of commercial building HVAC systems.

In addition, HAPs 8760 hour energy analysis capabilities are very useful for green building design. For instance, HAP energy analysis results are accepted by the US Green Building Council for its LEED®1 (Leadership in Energy and Environmental Design) Rating System. Visit the USGBC's website, www.usgbc.org, for more LEED info.

HAP uses a graphical user interface to provide a quick and efficient access to project data. A modular approach is used to define components of the building and the HVAC systems. This provides maximum flexibility for configuring data to suit a wide range of applications.

It is necessary to introduce the following components to make more understandable how the tool develop the simulations.

1. **An Element** is a component of the building structure or building use associated with heat gain or loss. Elements include walls, windows, doors, roofs, skylights, floors, partitions, lighting, people, electric equipment, miscellaneous heat sources and infiltration. An element is described by its characteristics which affect the heat transfer. A wall, for example, is described by its area, orientation, and the materials from which it is constructed.

2. **A Space** is a region of the building comprised of one or more heat flow elements and served by one or more air distribution terminals. Usually a space represents a single room. However, the definition of a space is flexible. For some applications, it is more efficient for a space to represent a group of rooms or even an entire building.

3. **A Zone** is a group of one or more spaces having a single thermostatic control. In some systems, each room contains a thermostat. Thus, each zone would contain one space representing a single room. In other situations, one thermostat is allocated to a group of rooms. In this case, the zone would contain several spaces.

4. **An Air System** is the equipment and controls used to provide cooling and heating to a region of a building. An air system serves one or more zones. The presence of a thermostat in each zone permits a specific control of the air temperature in each zone. Examples of systems include central station air handlers, packaged rooftop units, packaged vertical units, split systems, packaged DX fan coils, hydronic fan coils and water source heat pumps. In all cases, the air system also includes associated a ductwork, supply terminals and controls. For energy analysis applications, the system also includes DX cooling, electric resistance heating and combustion heating apparatus.

5. **A Plant** is the equipment and controls used to provide cooling or heating to coil in one or more air systems. Examples include chiller plants, hot water plants and steam boiler plants.

6. **A Building** is the structure containing all the HVAC systems under consideration. When performing energy analysis studies, annual energy costs are computed for the building and all the energy consuming systems it contains. Taken literally, a building represents one individual structure. However, the definition of a building is flexible. It can also represent a group of structures. For example, a "building" could represent a campus in which all the structures are served by a common set of plant equipment.

3.2 Load calculation

HAP software uses ASHRAE Transfer Function cooling load calculation procedures, ASHRAE design heating load calculation procedures, ASHRAE design weather data and ASHRAE design solar calculation procedures.

- Calculates space and zone loads 24-hours a day for design days in each of the 12 months. In doing so it calculates heat flow for all room elements such as walls, windows, roofs, skylights, doors, lights, people, electrical equipment, non-electrical equipment, infiltration, floors and partitions considering time of day and time-of-year factors.
- Performs detailed simulation of air system operation to determine cooling coil loads and heating coil loads and other aspects of system performance 24-hours a day for design days in each of the 12 months.
- Analyses plenum loads.
- Considers any operating schedule for HVAC equipment from 1 hour to 24 hours in duration.
- Permits hourly and seasonal scheduling of occupancy, internal heat gains, and fan and thermostat operation.

3.3 Simulation approach

HAP uses a system-based approach to design calculations, which tailors sizing procedures and reports to the specific type of system being designed. This offers productivity advantages over simple "load calculation" programs which require the engineer to apply calculation results to size system components.

Features are suitable for sizing systems involving central station air handlers, packaged rooftop units, self-contained units, split systems, DX fan coils, hydronic fan coils and water source heat pumps.

The program provides features for quickly designing fan coil, WSHP, GSHP and VRF systems in batch runs.

Sizing data is provided for central cooling and heating coils, preheat and precool coils, fans, humidifiers, terminal reheat coils, CAV and VAV air terminals, fan powered mixing boxes, perimeter baseboard units, fan coils and terminal heat pumps plus chillers and boilers. HAP calculates required space, zone and system airflow rates. Calculations are tailored to the specific system type.

Airflow sizing calculations can be based on design values of supply temperature, CFM or CFM/sqft. Calculations also consider minimum flow specifications in CFM, CFM/sqft, CFM/person which are important for maintaining adequate ventilation and indoor air quality. Space minimum ventilation airflow requirements can be set based on ASHRAE®2 Standard 62-2001 and 62.1-2004/2007/2010, or user-defined values.

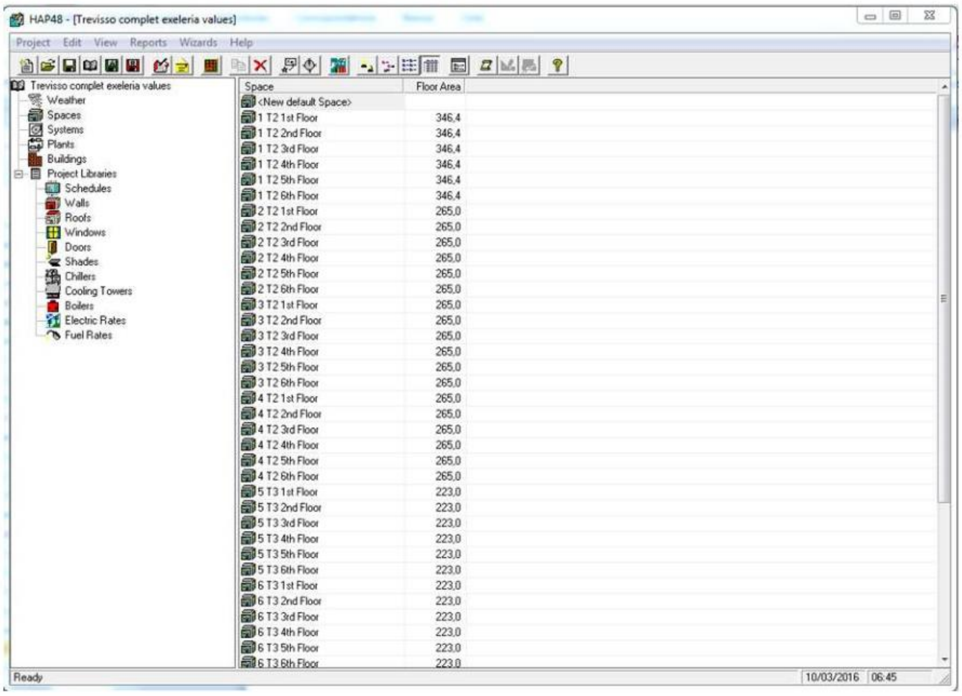


Figure 12 Spaces definition

System minimum ventilation airflow requirements can be calculated using the ASHRAE Standard 62-2001, 62.1-2004/2007/2010 calculation procedures, or can be calculated as a simple sum of space ventilation requirements.

The ASHRAE Transfer Function Method is used to calculate building heat flow. Key sizing reports summarize data needed for equipment selection in 2 simple pages. Additional reports provide component loads, hourly load profiles, detailed hourly performance data and psychometric charts.

The program is suitable for **new construction** and **retrofit applications**.

Air System Sizing Summary: Sizing data for central cooling and heating coils, supply and return fans.

Zone Sizing Summary: Peak loads and airflow rates for all spaces and zones served by the system. Also lists sizing data for zone reheat coils, mixing box fans and supplemental heaters. For DX fan coils, WSHPs and hydronic fan coils this report lists detailed airflow and coil sizing data for all fan coil or WSHP units.

Ventilation Sizing Summary: Documents how minimum ventilation airflow rates are calculated. Report has different content depending on whether ASHRAE Std 62-2001/2004/2007 or Sum of Outdoor Airflows was chosen as the calculation method.

Design Load Summaries: Three separate reports providing itemized lists of component loads for systems, zones and spaces respectively. Reports can be generated for any hour of any design day during the year.

Hourly Load Profiles: Two separate reports providing 24-hour profiles of loads and performance, available in both tabular and graphical formats. The system report lists system airflow rates and coil loads. The zone report lists zone loads, airflow rates, air temperatures and relative humidity. The reports can be generated for any design day during the year.

System Psychometrics: Tabular version of the report provides information about airflow rates, temperatures, humidities and heat flows for each point within the system. Useful for understanding and troubleshooting system operation. Graphical version of the report plots **state points on a psychometric chart. Can be generated for any hour of any design day.**

Plant Sizing Summaries: Separate reports provide sizing information for chilled water, hot water and steam plants serving one or more air systems.

Chiller Load Profiles: Lists 24-hour profiles of loads for a chiller plant serving one or more air systems. Can be generated for any design day and can be graphed.

This topic briefly describes how to use the HAP to estimate annual energy use and energy cost for HVAC designs in the detailed design phase of a project. First of all it is necessary to define the scope and objectives of the energy analysis. For example, what type of building is involved? What type of systems and equipment are required? What alternate designs or energy conservation measures are being compared in the analysis?

1. **Enter Weather Data**. Weather data defines the temperature, humidity and solar radiation conditions the building encounters during the course of a year. These conditions play an important role in influencing loads and system operation throughout the year. Both design and simulation weather data are needed. To define design weather data, a city can be chosen from the program's weather database, or weather parameters can be directly entered.

   Simulation weather is selected by loading a simulation weather file from the library provided with the program or by importing data from an external source. This step is also used to define the calendar for your simulation year. All three types of data are entered using the weather data.

Design Parameters:

City Name	Venice	
Location	Italy	
Latitude	45,5	Deg.
Longitude	-12,3	Deg.
Elevation	5,8	m
Summer Design Dry-Bulb	30,6	°C
Summer Coincident Wet-Bulb	23,3	°C
Summer Daily Range	9,1	°K
Winter Design Dry-Bulb	-5,0	°C
Winter Design Wet-Bulb	-7,1	°C
Atmospheric Clearness Number	1,00	
Average Ground Reflectance	0,20	
Soil Conductivity	1,385	W/(m-°K)
Local Time Zone (GMT +/- N hours)	-1,0	hours
Consider Daylight Savings Time	No	
Simulation Weather Data	Venice (IWC)	
Current Data is	2001 ASHRAE Handbook	
Design Cooling Months	January to December	

Design Day Maximum Solar Heat Gains

(The MSHG values are expressed in W/m²)

Month	N	NNE	NE	ENE	E	ESE	SE	SSE	S
January	52,1	52,1	52,1	179,0	417,1	575,5	716,3	772,6	788,1
February	67,4	67,4	123,0	357,7	545,1	704,9	769,4	782,9	784,5
March	84,2	84,2	285,5	492,4	663,2	734,4	757,9	721,5	700,2
April	101,1	205,9	422,3	593,1	683,8	716,9	669,1	595,9	554,6
May	113,0	318,5	491,5	638,4	689,8	671,6	585,8	487,8	435,0
June	151,2	355,1	517,5	646,7	679,7	645,3	547,0	437,9	383,4
July	116,6	312,1	493,7	627,3	668,8	657,4	574,5	475,1	425,7
August	106,6	194,2	412,6	568,0	664,7	689,9	647,0	575,9	537,7
September	87,3	87,3	270,5	447,7	623,9	704,4	727,3	698,1	671,7
October	69,6	69,6	122,6	334,5	535,0	663,0	746,2	762,9	753,8
November	52,6	52,6	52,6	196,5	395,7	583,2	694,3	753,6	767,6
December	45,2	45,2	45,2	119,7	350,2	514,9	669,9	739,7	759,8
Month	**SSW**	**SW**	**WSW**	**W**	**WNW**	**NW**	**NNW**	**HOR**	**Mult**
January	774,2	711,3	589,3	406,7	198,6	52,1	52,1	316,2	1,00
February	787,3	774,5	702,3	555,0	345,4	132,0	67,4	478,0	1,00
March	720,9	751,6	748,3	647,4	503,8	273,1	84,2	628,3	1,00
April	593,5	661,6	714,1	692,0	592,9	405,0	215,1	737,1	1,00
May	485,1	582,0	666,5	695,5	631,7	500,6	316,0	795,5	1,00
June	433,0	545,9	635,6	685,5	633,1	530,0	347,8	811,3	1,00
July	469,1	572,0	646,8	681,4	614,0	497,9	309,5	789,6	1,00
August	573,2	638,0	688,4	667,5	572,0	394,2	211,6	726,5	1,00
September	698,2	726,9	708,2	621,1	456,7	269,9	87,3	602,8	1,00
October	760,5	741,2	671,1	527,7	342,6	105,4	69,6	466,0	1,00
November	750,4	697,5	581,7	400,7	191,7	52,6	52,6	310,6	1,00
December	735,1	663,6	532,4	342,0	135,8	45,2	45,2	248,0	1,00

Mult. = User-defined solar multiplier factor.

Figure 13 Design weather data

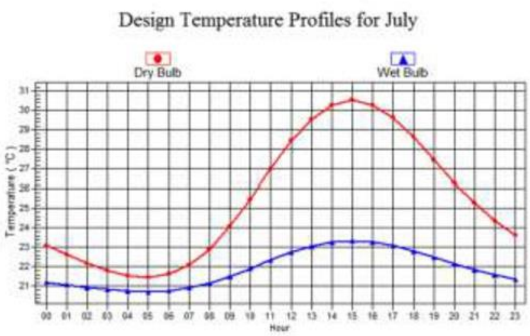


Figure 14 Example of daily temperature in July

2. **Enter Space Data**. A space is a region of the building comprised of one or more heat flow elements and served by one or more air distribution terminals. Usually a space represents a single room. However, the definition of a space is flexible. For some applications, it is more efficient for a space to represent a group of rooms or even an entire building. In Treviso each floor has been defined as a different space made up of two apartments.

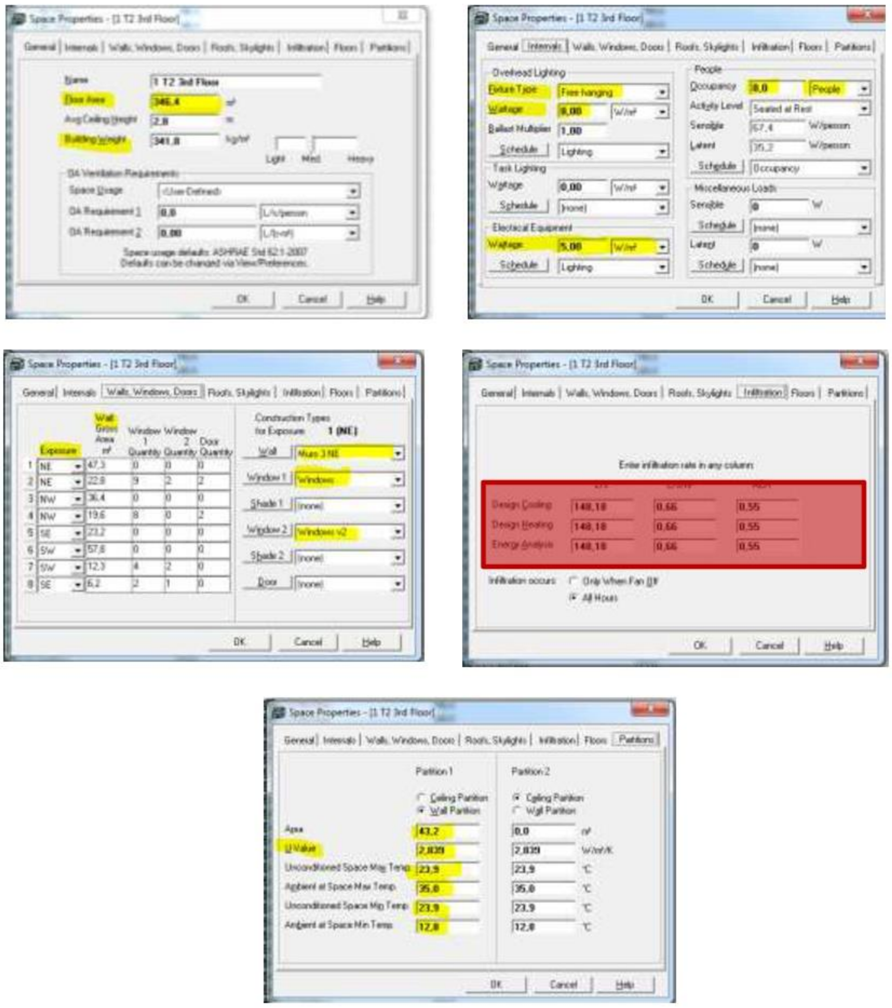


Figure 15 Spaces definition

To define a space, all elements which affect heat flow in the space must be described. Elements include walls, windows, doors, roofs, skylights, floors, occupants, lighting, electrical equipment, miscellaneous heat sources, infiltration, and partitions. Space data is entered using the space input form. In Treviso we have define 3 different walls composition for the simulation; separating between wall faces to NE, SW and walls below windows and also three different windows.

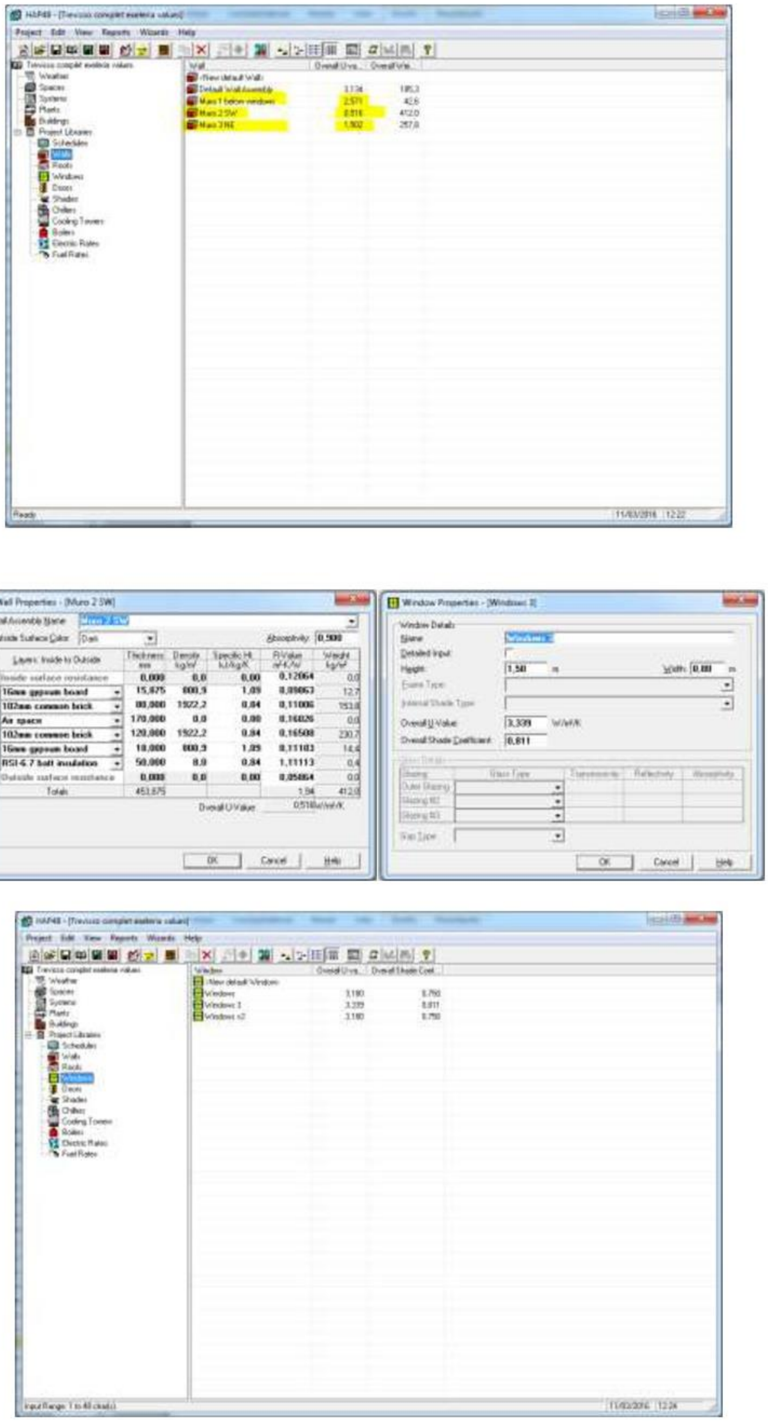


Figure 16 Walls and windows definition

While defining a space, information about the construction of walls, roofs, windows, doors and external shading devices is needed, as well as information about the hourly schedules for internal heat gains. This construction and schedule data can be specified directly from the space input form (via links to the construction and schedule forms), or alternately can be defined prior to entering space data.

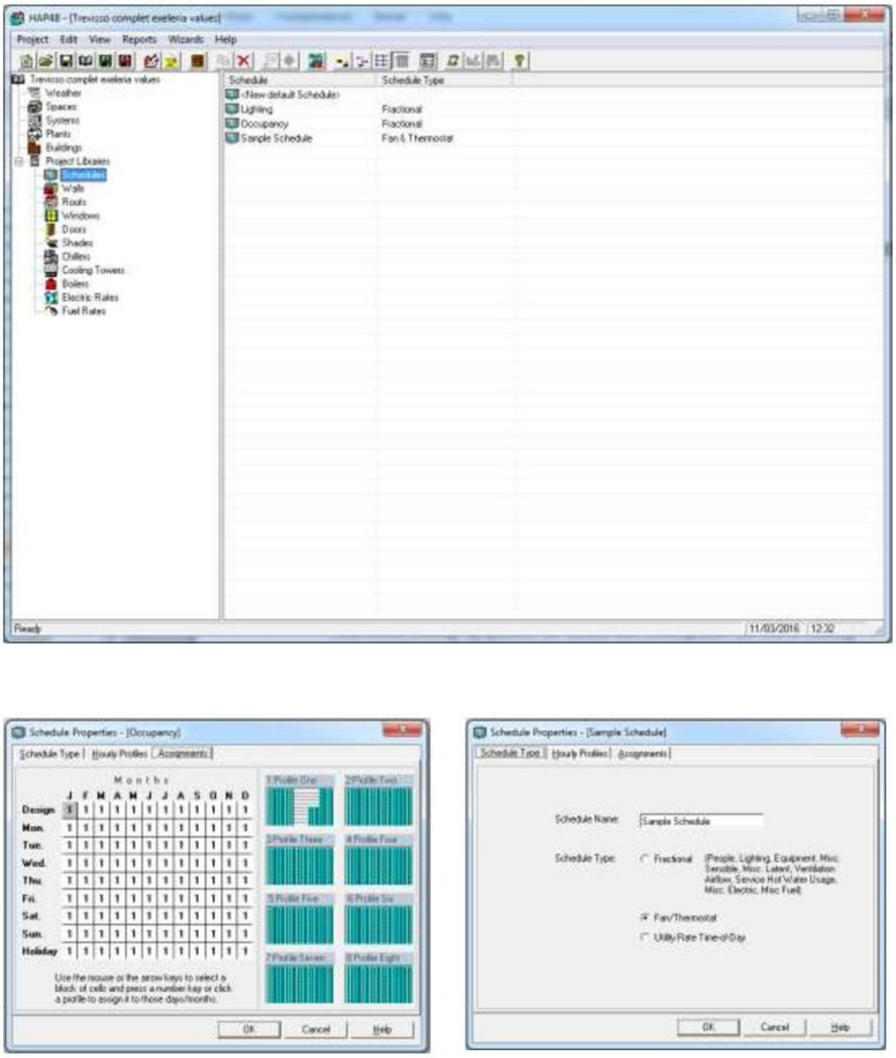


Figure 17 Schedule definition

Space information is stored in the project database and is later linked to zones in an air system.

3. **Enter Air System Data**. An air system is the equipment and controls used to provide cooling and heating to a region of a building. An air system serves one or more zones. Zones are groups of spaces having a single thermostatic control. Examples of systems include central station air handlers,

packaged rooftop units, packaged vertical units, split systems, packaged DX fan coils, hydronic fan coils and water source heat pumps. In all cases, the air system also includes associated ductwork, supply terminals and controls. In the case of packaged DX, split DX, electric resistance heating and combustion heating equipment, the system also encompasses this DX or heating equipment. For example, when dealing with a gas/electric packaged rooftop unit, the "air system" includes the DX cooling equipment and the gas heating equipment.

To define an air system, the components, controls and zones associated with the system must be defined as well as the system sizing criteria. For energy analyses, performance information about DX cooling equipment and electric and combustion heating equipment must also be defined. All of this data is entered on the air system input form.

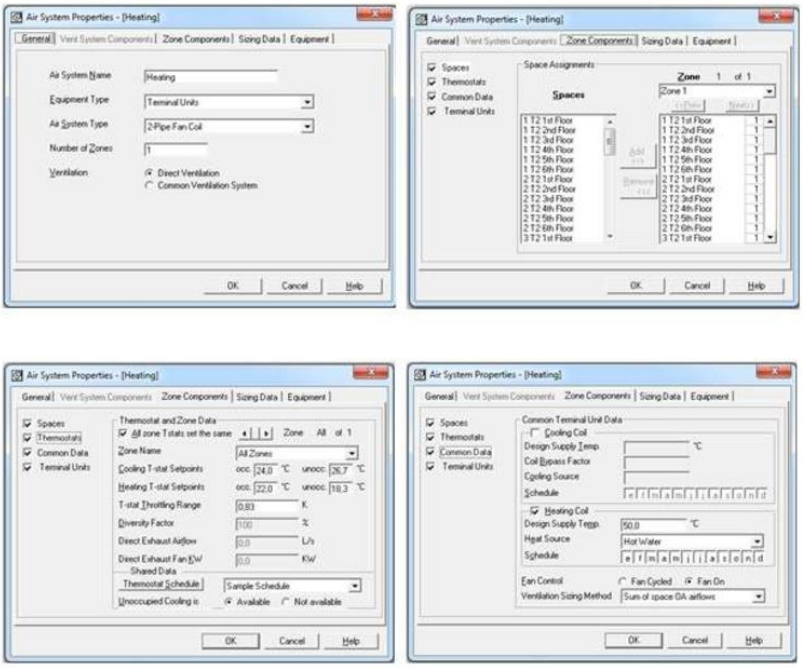


Figure 18 System definition

4. **Enter Plant Data.** A plant is the equipment and controls used to provide cooling via chilled water or heating via hot water or steam to coils in one or more air systems. Examples include chiller plants, hot water plants, steam boiler plants and remote source cooling and heating plants. In Treviso we have develop two plants, on one hand for the heating system and on the other hand the Domestic Hot Water.

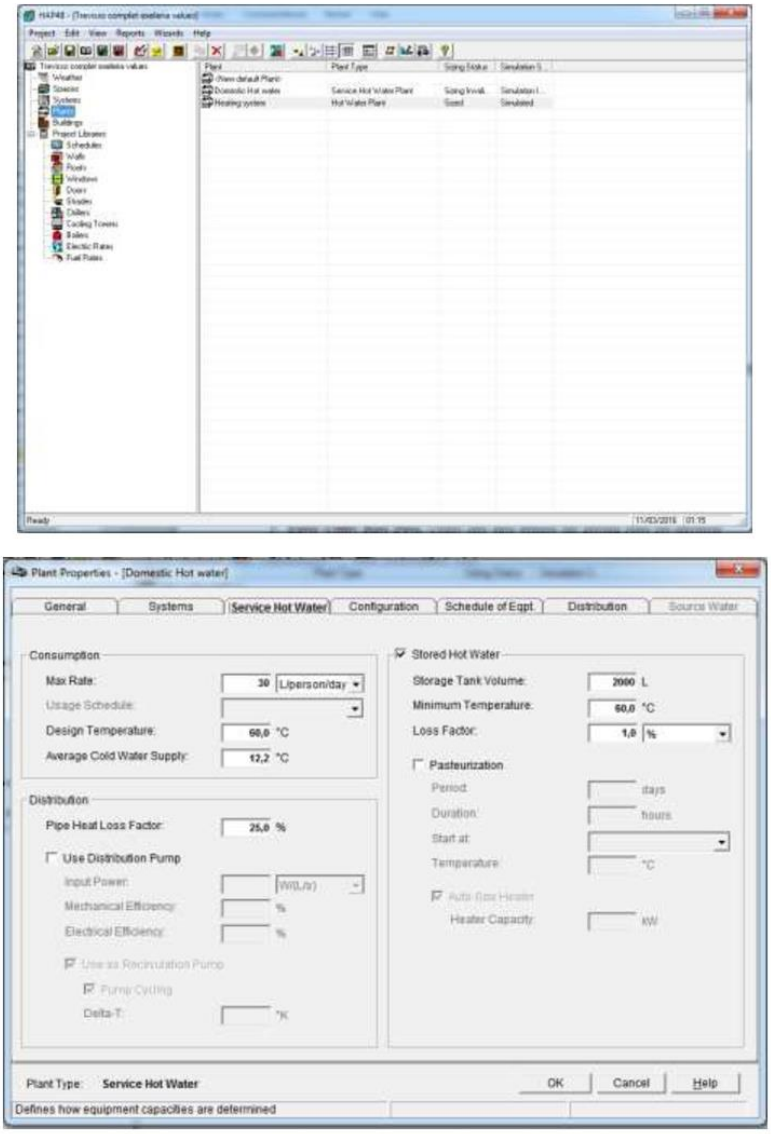


Figure 19 Plant definition

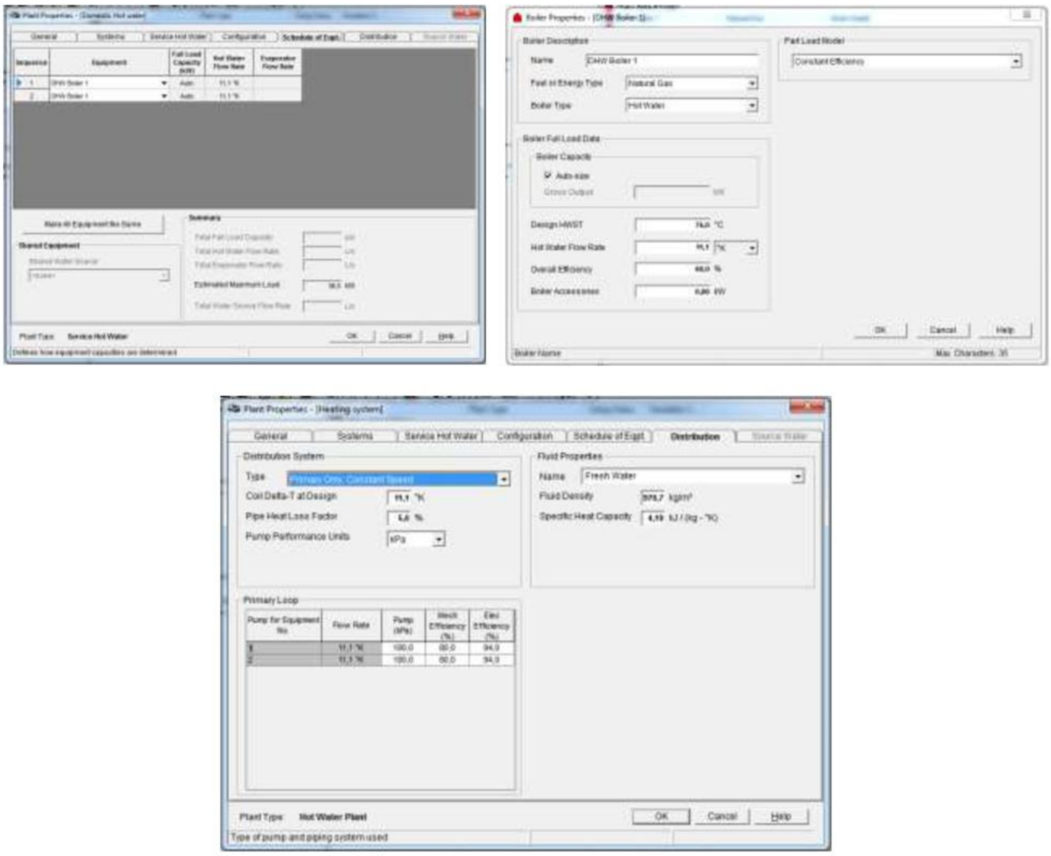


Figure 20 Plant definition

This step is optional; it is only required if chilled water, hot water or steam plants are used in your building. To define a plant for energy analysis purposes, the type of plant and the air systems it serves must be defined along with its configuration, controls and distribution system information. This data is entered on the plant input form.

5. **Enter Utility Rate Data.** Utility rate data defines the pricing rules for electrical energy use and fuel use. An electric rate structure must be defined for all energy studies. One fuel rate for each non-electric fuel source must also be defined.

   Electric rate data is entered using the electric rate form. Fuel rate data is entered using the fuel rate form.

6. Enter **Building Data**. A building is simply the container for all energy-consuming equipment included in a single energy analysis case. One Building is created for each design alternative being considered in the study. Building data consists of lists of plants and systems included in the building, utility rates used to determine energy costs and data for non-HVAC energy or fuel use. Data is entered using the building form.

Simulation Results:

Building Simulation Reports contain energy consumption and energy cost data produced by the building energy simulation. These reports can be used to compare energy use and energy costs for alternate designs (each represented by a separate "building" case) or to investigate energy use patterns for an individual building case. HAP offers fourteen different building simulation reports Note that simulation reports are only available in the full edition of HAP and not in HAP System Design Loads.

Using various menu options and toolbar buttons in HAP, there are four different ways of generating building simulation reports. These methods are described in the Generating Building Simulation Reports topic. All four procedures require selection of report option on the Building Simulation Reports dialog shown below.

The Building Simulation Reports Dialog is used to specify which reports should be generated and how they should be generated. The form is divided into two tabs and also provides a panel with command buttons. These features are described below:

The **Standard Reports** tab contains 13 of the 14 building simulation reports offered. The tab consists of a series of check box items used to select individual report items. To select a report place a check in the box next to the report title. This tab is subdivided into four sections:

a. **Comparative Reports** contains options for two reports which allow cost and energy results for groups of buildings to be compared side-by-side on the same report.
b. **Summary Reports** contain annual cost and energy use data for individual building cases.
c. **Detailed Reports** contain tables of monthly energy and cost data for a single building case. This section also contains a "Billing Details" report which documents the calculation of the utility bill for each energy type or fuel source. These reports are useful when investigating energy use patterns for a building or validating utility bill results.
d. **Use Profiles** contain the hour-by-hour energy use profile for a building for one energy source or fuel type. Separate reports can be generated for each energy source or fuel type. Further, separate tabular, graphical and TXT file versions of this report are offered. The latter report is used to export use profiles to a disk file that can be loaded into spreadsheet programs.

The contents of each building simulation report are summarized later in this help topic.

The **LEED Report** tab is used to select and configure this report. This report is used when performing analysis for LEED Energy and Atmosphere Credit 1 or LEED Energy and Atmosphere Prequisite 2 (Whole Building Energy Simulation option). Based on the project preference you specified, the tab will either indicate that the LEED NC-2.2 or the LEED 2009 version of the report will be generated.

These LEED analyses require comparing energy use and energy costs for a Proposed building design and four variants of a Baseline building design that complies with ASHRAE 90.1 prescriptive requirements. Typically those five buildings were selected on the HAP main window before requesting reports. To select this report, place a check in the box opposite the report title. Then assign the buildings selected for reporting to the Proposed and Baseline designations. Assignments are made by selecting items from the drop-down lists. These lists only contain the buildings you selected for reporting. If the buildings use common naming with prefixes like [B000], [B090], etc.., then HAP will automatically make the proper building designations. If custom naming is used, then you will need to make the assignments yourself.

Note that the software allows you to generate this report with fewer than 5 buildings assigned. For example when experimenting with energy conservation measures, it may be useful to compare Proposed and Baseline 0 deg cases on the report to determine potential for LEED EA Credit 1 points. Later, when the Proposed design is finished, the complete report with Proposed and all four Baselines might be generated in preparation for submittal. When buildings are omitted from the report, HAP adjusts the content of the report to provide useful information for the buildings that are included.

HAP offers different building simulation reports. Each report is summarized below.

1. **The Annual Cost Summary report** compares annual energy cost results for buildings. Costs are listed by system component categories (e.g. fans, cooling, heating, etc..). Length: 1 page.
2. **The Annual Energy and Emissions Summary report** compares annual energy cost results for buildings with costs listed by energy or fuel type. It also tabulates estimates of atmospheric emissions such as CO_2, SO_2 and NO_x, if the emissions calculation option was selected in utility rate inputs. The emissions calculation is sometimes required for green building studies. Length: 3 pages.
3. **The Annual Component Costs report** contains annual energy costs for a single building tabulated by system component categories such as fans, cooling, heating, etc.. The report displays the data both in pie chart and table format. Length: 1 page.
4. **The Annual Energy Costs report** contains annual energy costs for a single building tabulated by energy or fuel type (e.g., electric, gas). The report displays the data both in pie chart and table format. Length: 1 page.
5. **The HVAC & Non-HVAC Cost Totals report** contains annual energy cost totals for HVAC and non-HVAC uses. The report displays the data both in pie chart and table format. Length: 1 page.
6. **The Energy Budget by System Component report** lists annual energy consumption itemized by system components such as fans, cooling, heating etc... Energy data is provided in neutral units (kBTU for English, kWh for Metric) so that all categories can be compared on an equal basis. The report tabulates both site and source energy use. This report is sometimes required for demonstrating compliance with energy efficiency codes. Length: 1 page.
7. **The Energy Budget by Energy Type report** lists annual energy consumption itemized by energy and fuel type categories such as electric, gas, fuel oil, etc... Energy data is provided in neutral units (kBTU for English, kWh for Metric) so that all categories can be compared on an equal basis. The report tabulates both site and source energy use. This report is sometimes required for demonstrating compliance with energy efficiency codes. Length: 1 page.

8. **The Monthly Component Costs report** contains month-by-month energy costs for system component categories such as fans, cooling, heating, etc... The data is provided both in bar chart and table format. Length: 1 page.
9. **The Monthly Energy Costs report** lists month-by-month energy costs for separate energy and fuel types. The data is provided both in bar chart and table format. Length: 1 page.
10. **The Monthly Energy Use by System Component report** provides month-by-month energy use for each system component category such as fans, cooling, heating, etc.. Data is also itemized by energy or fuel source within each system component category. This output is useful when investigating monthly variations in energy use for various system components. Length: 1 page.
11. **The Monthly Energy Use by Energy Type report** lists monthly-by-month energy use for each energy or fuel type. Length: 1 page.
12. **The Billing Details report** documents how the utility bill is calculated. It tabulates the month-by-month component charges for energy and demand, monthly energy use, monthly peak demand and the time of peak demands. A separate copy of the report can be generated for each energy or fuel source used in the building. Length: 2 pages.
13. **The Use Profiles report** contains hour-by-hour profiles of energy use for the building for one energy or fuel type. Separate reports can be generated for each energy or fuel type. This report is available in tabular, graphical and text file versions. The text file option generates a TXT disk file containing use profile data in a format suitable for import into spreadsheet programs. Lengths: Tabular – 1 page for each 18 days; Graph – 1 page for all cases.
14. **The LEED NC 2.2 EA Credit 1 Summary report** is generated when the project preference is set to LEED NC-2.2. It provides energy consumption, demand and cost data in a format matching that found on the LEED NC-2.2 Energy and Atmosphere Credit 1 online submittal template. This report is useful for evaluating LEED EAc1 points potential as you develop your design. When you are ready to submit to USGBC, the fact that data matches the online submittal template format makes transfer of data into the template efficient. Length: Typically 2 to 3 pages, but can be longer for complex projects.
15. **The LEED 2009 EA Credit 1 Summary report** is generated when the project preference is set to LEED 2009. The report provides energy consumption, demand and cost data in a format matching that found on the LEED 2009 EA Prerequisite 2 online submittal template. This is where energy simulation results are collected in LEED 2009 for both the EA Prerequisite 2 and EA Credit 1 analyses. This report is useful for evaluating LEED EAp2 and EAc1 points potential as you develop your design. When you are ready to submit to USGBC, the fact that data matches the online submittal template format makes transfer of data into the template efficient. Length: Typically 2 to 3 pages, but can be longer for complex projects.

3.4 Analysis of sensitivity

3.4.1 Introduction

The purpose of the analysis of the sensitivity of the energy consumption is to know how it is affected depending on the modification of different parameters used on its calculation. The reason to do this analysis is to show the variation of the consumption produced by every parameter and how important is to have better values. every parameter in the final result.

3.4.2 Parameters analysed

The energy consumption in a building is calculated based in many different parameters. This analysis will only focus in some parameters used in the calculation with the software HAP that they have not been determined precisely.

The parameters analysed are:

- U-Values. Those values have been calculated based on the composition provided by the building owner (theoretical) and calculated using the method described in this document (practical)
- Infiltration. This is the amount of energy entering in the building directly from the outside. It depends on many factors as for example weather conditions, wind speed or the geometry of the building among others. Infiltration typically occurs because of leakage around windows and doors, and leakage from the opening and closing of doors in the space.
- Room temperature. The temperature of a room in the building depends on the requirements of the tenants. The range between different temperatures can be high.

13.2 Damp report (Padiham)

REPORT ON DISREPAIR AND ASSOCIATED MATTERS

70 Whitegate Close, Padiham
Lancashire BB12 8TS

Surveyor: Mark Green
Company: Places for people

Date: 31/05/2016

2.

Contents

Preliminaries

Property address:		70 Whitegate Close, Padiham BB12 8TS	
Landlord:		Place for People, Ltd	
Tenant:		Ms. Donna Clough	
Date of inspection:		24th May 2016	
Time:		14:00	
Weather:		Dry/sunny	
Attendees:	Mark Green	Building Surveyor	Places for people
	Ms. D. Clough	Customer	Tenant of PFP

Background information

In the Matrix Solicitors letter to Places for People dated 16/05/2016 which we received on 17/05/2016, the tenant's allegations of disrepair are said to be as follows.

1. Throughout the property, there is penetrating damp.
2. Externally, re-pointing is required to the gable wall.
3. Internally miscellaneous, heating should be upgraded. The electric wall heaters are worse for condensation.
4. Internally, there is bad plastering within the property which requires replacing and also anti-fungus paint should be applied to it.
5. Externally, the patch pointing to the gable where scaffolding will be required.
6. Externally, the external wall to the property is causing damp which requires rectifying.
7. Living room – there is mould and damp on all the walls in the living room. The walls are wet with high readings; there is also moss all over it and defective pointing externally.
8. Bedroom 1 – got mould and damp on all the walls.
9. Bedroom 2 - got mould and damp on all the walls.

Description

The subject property is a 2 bed end terraced property, thought to be built circa 1985. The property is of brick cavity construction beneath a pitched roof covered in clay tile. The property has PVCu double glazed windows fitted, timber front and PVCu rear doors.

Accommodation is briefly

Ground floor: Front door entrance opens up to a hallway that leads to the lounge and kitchen to the rear of the ground floor. The staircase leads to a landing from which are accessed a large front bedroom, a smaller second bedroom and a bathroom.

Caveats

Limitations of inspection: This is not a full building survey

Roof and floor voids were not fully inspected. Services were not visually examined. The premises were furnished and had partly fitted floor coverings throughout, and no assessment could be made of any elements which were covered, unexposed or inaccessible.

Opinions as to dampness and other defects complained of are based on a combination of a visual and physical inspection.

Observations

The inspection was carried out in relation to each item raised in the initial notification letter.

Item 1 - Throughout the property, there is penetrating damp:

From inspection of the property, there was no evidence of water ingress to the general wall areas at time of inspection. However, it was apparent that the mortar pointing to the gable end brick work was defective to several areas, which would be advised for re-pointing as soon as practicable – see Item 2 & 5.

Item 2 - Externally, re-pointing is required to the gable wall:

During inspection of the external mortar pointing, it was noted that several areas of the gable brick work has defective mortar finishes that requires remedial action at the earliest opportunity. Tower access will be required to affect these works. The front and rear elevations appeared to be generally in reasonable condition at time of inspection with adequate mortar pointing.

Item 3 - Internally miscellaneous, heating should be upgraded. The electric wall heaters are worse for condensation:

The heating system presently installed at this property is an electric storage heating system. The storage heaters are of an approximate age and condition that would normally advise a replacement date of 2017/18, although the individual units are advised as currently working by the customer and appeared serviceable at time of inspection. These systems are not the most economical or effective systems to control, although this would not be adequate reason to replace outside of a planned maintenance programme
The heating system would preferably be considered for replacement on a forthcoming planned works programme, say 2016/17, with consideration given to installation of a more effective heating system at this time. The lounge radiator has recently been replaced with a new electric storage.

Item 4 - Internally, there is bad plastering within the property which requires replacing and also anti-fungus paint should be applied to it:

At time of inspection, there were no significant areas of mould growth affecting the property, although it was noted that significant re-plastering works have been carried out to the lounge and bedrooms in response to this reported defect. This includes removal of affected plaster finishes and reinstatement with damp proof membranes beneath dry lined wall finishes. Several areas of wall finishes have also been treated with anti-fungicidal wash and paint to affected areas throughout the property.

Item 5 - Externally, the patch pointing to the gable where scaffolding will be required:

This reported defect has been previously addressed in Item 2.

Item 6 - Externally, the external wall to the property is causing damp which requires rectifying:

This reported defect has been previously addressed in Item 2. There were no other areas of external wall with significantly defective pointing other than the gable.

Item 7 - Living room – there is mould and damp on all the walls in the living room. The walls are wet with high readings; there is also moss all over it and defective pointing externally:

On inspection, the full external gable wall to the lounge area had been dry lined, including removal of affected plaster finishes and reinstatement with damp proof membranes beneath dry lined plasterboard and skim finish. Other areas of wall finishes affected by fungus have also been treated with anti-fungicidal wash and paint as part of the works package. There were no significant areas of mould growth affecting the lounge at time of inspection.

Item 8 - Bedroom 1 – got mould and damp on all the walls:

On inspection, an approximate $5m^2$ to Bedroom 1 had been stripped and re-plastered. Other areas of wall finishes affected by fungus have also been treated with anti-fungicidal wash and paint as part of the works package. There were no significant areas of mould growth affecting the bedroom at time of inspection.

Item 9 - Bedroom 2 – got mould and damp on all the walls:

On inspection, an approximate $5m^2$ to Bedroom 1 had been stripped and re-plastered. Other areas of wall finishes affected by fungus have also been treated with anti-fungicidal wash and paint as part of the works package. There were no significant areas of mould growth affecting the bedroom at time of inspection.

General
A positive air pressure unit has also been fitted to the first floor landing ceiling during recent maintenance works linked to the condensation issues affecting the property. The lounge radiator has been replaced with a new electric storage.

Additional Items –

There were no additional items observed or advised during the inspection.

Appendix i – Scott schedule

Scott schedule						
Address: 70 Whitegate Close, Padiham BB12 8TS				**Customer details**: Ms D. Clough		
Date of survey: 24/05/2016 – 14:00am						
Item no.	**Location**	**Breach Complained of**	**Remedial works required**	**Tenants comments**	**Surveyors comments**	**Estimated costs £**
1	Internal - general	Throughout the property, there is penetrating damp.	See Item 2 & 5 below.	No comment.	There was no evidence of penetrating damp to the general property at time of inspection.	N/A
2	External	Externally, re-pointing is required to the gable wall.	Re-point all defective mortar pointing to gable elevation – approx. $4m^2$.	No comment.	It was noted that several areas of the gable brick work has defective mortar finishes that requires remedial action at the earliest opportunity.	120.00
3	Internal - general	Internally miscellaneous, heating should be upgraded. The electric wall heaters are worse for condensation.	**No immediate works required.** Single lounge unit has been recently replaced.	Heating system is poor quality and expensive to run.	The heating system should be considered for replacement on 2017/18 programme.	N/A
4	Internal - general	Internally, there is bad plastering within the property which requires replacing and also anti-fungus paint should be applied to it	**No immediate works required, as previously completed.**	Works completed to customer satisfaction.	Several areas have been recently re-plastered and treated throughout the property.	N/A
5	External	Externally, the patch pointing to the gable where scaffolding will be required.	Works covered in Item 2.	No comment.	This item is as per Item 2.	See Item 2

6	External	Externally, the external wall to the property is causing damp which requires rectifying.	Works covered in Item 2.	No comment.	This is as per Item 2. There were no other areas of external wall with visible defects other than the gable.	See Item 2.
7	Living Room	Living room – there is mould and damp on all the walls in the living room. The walls are wet with high readings; there is also moss all over it and defective pointing externally	**No immediate works required, as previously completed.**	Works had been completed to customer's satisfaction at time of inspection.	Works have been completed to a good standard, including dry lining and mould eradication treatments.	N/A
8	Bedroom 1	Bedroom 1 – got mould and damp on all the walls	**No immediate works required, as previously completed.**	Works had been completed to customer's satisfaction.	There was no evidence of mould or damp at time of inspection. Works have been completed, including dry lining and mould eradication treatments	N/A
9	Bedroom 2	Bedroom 2 – got mould and damp on all the walls	**No immediate works required, as previously completed.**	Works had been completed to customer's satisfaction.	There was no evidence of mould or damp at time of inspection. Works have been completed, including dry lining and mould eradication treatments	N/A
					Sub-total	120.00
					Total	120.00

Appendix iii

<u>Photographs Schedule – Photos in relation to disrepair item no.</u>

Fig. 1 – Rear elevation to property showing no apparent defects.

Fig. 2 – Gable elevation with defective pointing to brick work.

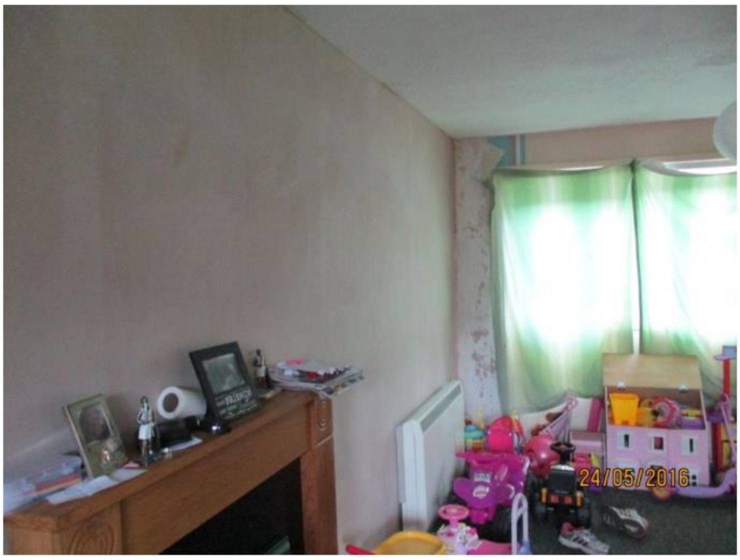


Fig. 3 – Lounge with completed dry lining to external gable wall.

Fig. 4 – Re-plastered wall finishes to Bedroom 1.

Fig. 5 – Re-plastered wall finishes to Bedroom 2.

Fig. 6 – Recently installed positive pressure ventilation unit to landing.

13.3 Electricity bills (Padiham)

British Gas
Looking after your world

11 WHITEGATE GARDENS
PADIHAM
BURNLEY
LANCASHIRE
BB12 8TL

Choose how often your meters take readings - every half hour, day or month - just call us on **0800 980 6121**. More readings give you a more personalised breakdown of energy usage. To download a record of up to 24 months of your usage go to **britishgas.co.uk/login**

Your customer number:

Your annual electricity summary

Date:
26 September 2015

Summary period:
01 Aug 2014 - 31 Jul 2015

Dear ,

This is not a bill, we've sent you this annual summary for your information so there's no need to call us, just top up your meter as usual. To help you budget, you can see how much electricity you've used in the past year, your estimated costs for the next year and how you might be able to save. Please keep this for your records.

We've also given you details of the tariff you're currently on, so you can compare with others and decide if it's the best value for you.

You can contact us online at britishgas.co.uk/contactus
Or call: 0800 107 7102⁺
If you're hard of hearing or speech impaired and use a Textphone, please call:
18001 0800 072 8633
Mon-Fri 8am-8pm / Sat 8am-6pm
Summaries for the visually impaired:
Call us: 0800 072 8625⁺

Remember – it might be worth thinking about switching your tariff or supplier†.

1 Your electricity usage summary

You're on our Standard tariff
You used

2595.89 kWh (kiloWatt hours)

Calculations include estimated meter readings.

If you use the same amount of energy over the next 12 months and stay on the same tariff, we estimate your cost will be **£448.83†**.

How does your electricity use compare to last year?

1847.45 kWh
1 Aug 2013 - 31 Jul 2014

2595.89 kWh
1 Aug 2014 - 31 Jul 2015

† Based on our current prices and includes some discounts and added charges, like VAT. If the price of your tariff changes or you change your tariff, or the amount you use, this forecast will change too.

2 Could you pay less?

Remember - it might be worth thinking about switching your tariff or supplier.
Personal Projection is our estimate of your energy costs (including VAT & other discounts) for the next 12 months and is based on previous actual consumption. This could be affected by future tariff, price or consumption changes.

Your 12 month Personal Projection for your current tariff is **£448.83**

Cheapest Similar Tariff
Great News! You are already on our cheapest similar tariff.

Cheapest Overall Tariff
You can save **£24.27** by switching to Standard DD☐△. Variable tariff

☐ You will need to pay by Direct Debit to get this tariff. △ You will need to switch to a credit meter to get this tariff. Tariffs may have eligibility criteria and limited availability.

You will not be charged an exit fee if you switch supplier before your tariff's end date. Please note that switching tariffs may involve changing to materially different terms and conditions.

You may be able switch supplier even with an outstanding balance on your account.

Visit britishgas.co.uk to know more about this or about tariffs.

More about my tariff **See step 4**

⁺ We record calls to help improve our service to you. If you are hard of hearing or speech impaired and use a textphone, please call 18001 0800 072 8626

3.

3 How could you save money?

1. Get free insulation in your home

If your home isn't properly insulated, you could be wasting money. As much as £140 through the loft and £160 through the walls, every year (that's what the Energy Saving Trust estimate, you can find out more at energysavingtrust.org.uk). The good news is, we're working with the government to roll out free insulation to millions of homes across Britain^.

It's easy to see if your home is suitable
Fill in our survey online at **britishgas.co.uk/insulation** or give us a ring on **0800 107 8499**† to check if your home is one of the millions that can get it for free.

2. Be energy aware

One of the best ways to reduce your bill is to use less energy. At British Gas, we want to help you get on top of your energy usage and are happy to provide advice about where to start and the tools you need to make a change. For top tips on saving energy in your home, visit: **britishgas.co.uk/energysaving**

You can get impartial advice on simple ways to save energy and money from the Energy Saving Advice Service. Just give them a call on **0300 123 1234**

^There are a few areas of the country we can't reach, to check if you live in one of them just give us a call. Modern houses are built with insulation - check the details on our website. We give free insulation under the Energy Companies Obligation and we'll need to do a survey to make sure your house qualifies. We'll cover the cost of the insulation itself but if your house needs more vents than usual, or we need to use scaffolding, you may need to help with the cost. But don't worry, we'll tell you in advance if this applies to your home. If you rent your house, you'll need your landlord's written permission.
†We're here Monday to Friday 8am to 8pm and Saturday 8am to 4pm. We record calls to help improve our service to you.

4 About your electricity tariff

Tariff details	
Tariff name	Standard
Tariff type	Variable
Payment method	Prepayment
Unit rate	13.910p per kWh
Standing charge	26.000p per day
Tariff ends on	No end date
Price guaranteed until	No end date
Exit fee (if you cancel this tariff before end date)	Not applicable
Discounts and additional charges	
Dual fuel discount	£15.00
Additional products or services included	Not applicable

Estimated electricity cost for you on this tariff for the next 12 months	
Your annual consumption (based on your actual usage in the last 12 months)	2595.89 kWh
Personal projection (based on current prices, including VAT)	£448.83
Tariff Comparison Rate (TCR) (all prices include VAT) If you're on a variable price tariff we'll give you 30 days notice before we increase your prices	16.73p per kWh

Key contractual terms

Exit fees
You may end your contract at any time without being charged an exit fee. We will need you to provide a meter reading and if you have any outstanding charges on your account, we can ask you to clear them before allowing you to move to another supplier.

Dual fuel discount
£15 annual discount when you have both gas and electricity with us.

Price Changes
Prices may increase or decrease at any time. We will give you 30 days advance notice before we increase your prices.

If you're thinking of switching – give us a call. To help you find a better deal, you'll need your energy data. Just scan this image to download it to your smart phone or tablet. For more information about QR codes, go to **britishgas.co.uk/bill**

Glossary

Tariff
This is our payment package for supplying you with electricity.

Estimate
If we do not have a meter reading for you we will estimate one based on your previous electricity usage.

kWh
A kWh (kiloWatt hour) is the unit used to measure energy.

Personal Projection
This is an estimate of your electricity charges for the year ahead, based on your actual electricity usage over the last 12 months. You can use the projection to compare the costs of other tariffs.

Switch
To change from the current supplier to a different supplier, or to change from the current tariff to a different tariff with the same supplier.

Tariff Comparison Rate (TCR)
The TCR is not based on your actual consumption but is based on the energy consumption of a typical customer using 3,100 kWh electricity and should be used as a guide only.

Unit rate
This is a form of measurement which explains how much you are paying for your energy. This figure is represented as pence per kWh.

Standing Charge
This is a fixed amount that's applied to your electricity meter daily.

5 Can you change supplier?

We won't charge you any exit fees if you decide to change to another supplier.

As a Pay As You Go Energy™ customer you may be eligible to switch energy supplier even if you are repaying a debt through your meter. Under **the Debt Assignment Protocol** (DAP), you are allowed to transfer a debt of up to £500 when changing supplier.

You must remain on a pay as you go meter until your debt is paid off. For more information please call us on **0800 107 7102**.

Need independent advice about switching your tariff or supplier?

For impartial advice on switching suppliers contact **Citizens Advice adviceguide.org.uk/energy** or call **03454 04 05 06**.

Ofgem has a **Confidence Code** for online switching sites to ensure consumers receive accurate, detailed and unbiased price comparisons: **ofgem.gov.uk/confidence-code**.

Know your rights

It's easy to get free, independent advice so that you 'Know your rights' as an energy consumer. You might want to get a better deal, find out how to make a complaint, get advice about the quality of your electricity or gas supply, or ask for help if you're struggling to pay your bills. To 'Know your rights' visit **citizensadvice.org.uk/energy** for up to date information or contact the Citizens Advice consumer service on **03454 04 05 06** for a paper copy.

6 Where can I get some help?

Your electricity supply number is:

Norweb Price Area
G4S read your meter

Online
britishgas.co.uk

Speak to one of our general enquiries team
0800 107 7102
Mon - Fri 8am - 8pm
Sat 8am - 6pm

Write to:
British Gas
PO Box 227
Rotherham
S98 1PD

We will reply as soon as we can.

If you have any questions about your Pay As You Go Energy™ account, visit our Help and Advice section at **britishgas.co.uk/paygehelp**

Our **Priority Service Register** is a free, confidential service that provides additional support to those most in need. To find out about eligibility and the services on offer, such as free gas safety checks and the password protection scheme, call us on **0800 294 8604** or go to **britishgas.co.uk/Priority-Service-Register**

Bills for the visually impaired
Call us: **0800 294 8604**
Textphone: **18001 0800 072 8626**

Emergency

Electrical emergency or power cut?
0800 195 4141
(24 hours a day)

The company responsible for the electricity supply delivery network is:
Electricity North West Limited
PO Box 4375
Manchester
M161 0ET

If you are unhappy with our service
We're really sorry you're not happy, we want to sort things out for you quickly, so please give us a ring on:
0800 072 8633

If you'd rather complain in writing go to **britishgas.co.uk/energycomplaints** or write to **Complaints Management Team, PO Box 226, Rotherham S98 1PB**

If you aren't happy with how we're handling your complaint, you can get in touch with Matt Idle, our Managing Director of Energy Customer Service. You can call his team on **0800 107 0184*** or email **customercomplaints@britishgas.co.uk** or you can write to him at the address above. When you get in touch to make a complaint we'll investigate fully and let you know what needs to happen next. We'll say sorry for anything we've got wrong and may make a goodwill gesture, or offer compensation.

If you need independent advice
The Citizens Advice consumer service gives free, confidential and impartial advice. You can get in touch with them for advice at anytime during the complaints process. Call them on **03454 04 05 06**, or visit **citizensadvice.org.uk/energy**

We aim to resolve complaints as quickly as possible
We'll make every effort to resolve your complaint within a day of receiving it. However, sometimes it can take a little longer, so if we haven't been able to sort things out within eight weeks, or if we can't agree a way forward with you, (we call this 'deadlock'), we'll write and let you know that you have the right to pass your complaint to the Ombudsman Services: Energy.

The Ombudsman is there to help sort out disputes between energy suppliers and their customers. It's free to use their services and they're totally independent – they don't take sides and their decisions are based only on the information they have. You can call them on **0330 440 1624**, Textphone **0330 440 1600**, email **enquiries@os-energy.org**, go online at **ombudsman-services.org/energy** or write to **Ombudsman Services: Energy, PO Box 966, Warrington, WA4 9DF**

You don't have to accept their decision, but if you do, we'll act on what they say. That might mean saying sorry, explaining what's gone wrong, fixing the problem or paying you compensation.

SCOTTISHPOWER

www.scottishpower.co.uk
0800 027 0072
8am - 10pm weekdays
8.30am - 6pm Saturday
Find us on

003193 008223 1107222011 SPTU940A 32000

38 WHITEGATE CLOSE
PADIHAM
BURNLEY
BB12 8TJ

Account Number:

Supply Address: 38 WHITEGATE CLOSE BURNLEY BB12 8TJ

Date: 4th July 2015

Dear

Statement period: **10 July 2014 to 9 July 2015**
You are on our **Key Prepayment - Pay As You Go** tariff

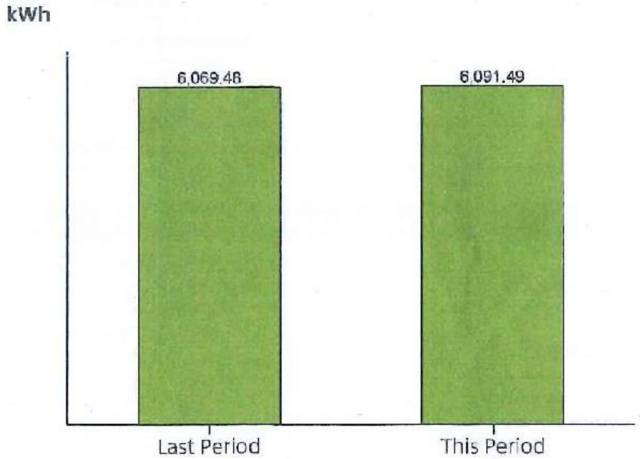
Your annual electricity summary

This statement is to help you stay informed and more in control of your energy. You can use this information to compare your current tariff with others that we offer. Please keep this summary for your records.
Remember - it might be worth thinking about switching your tariff or supplier.

Your electricity usage summary

- Your previous 12 months usage: **6091.49 kWh**
- Your previous 12 months total cost: **£892.09**
- The graph below shows your usage for the period 10 July 2014 to 9 July 2015 and compares it with the same period for the year before.

Your Electricity Summary



Your personal projection for the next 12 months is **£894.17** (based on your estimated consumption, tariff prices, discounts and VAT).

Could you pay less?

Our cheapest similar tariff
Good news: You are already on our cheapest similar tariff. If this changes we will let you know on your next bill or statement.
Our cheapest overall tariff
Online Fixed Price Energy July 2016
You could save: £215.56 per year

Please note that switching tariffs may involve changing terms and conditions. These tariffs are available for a limited period.

003193 SPTU940A 1 of 2

SCOTTISHPOWER

0800 027 0072
8am - 10pm weekdays
8.30am - 6pm Saturday

Useful advice

For useful and impartial advice, please visit the following websites:

- Reducing energy use could save you money, please visit www.energysavingtrust.org.uk
- For guidance on the energy industry, please visit www.scottishpower.co.uk/knowyourrights or contact us for a copy
- The Confidence Code is a Code of Practice that governs independent energy price comparison sites. For more information please visit www.ofgem.gov.uk
- For free, independent and confidential advice on consumer issues and switching your supplier, please visit www.citizensadvice.org.uk/energy

About your electricity tariff

Tariff details

Tariff Name	**Key Prepayment - Pay As You Go**
Tariff Type	**Variable Price**
Payment method	**Prepayment**
Unit rate - All/Day	**17.400p per kWh**
Unit rate - Night	**7.383p per kWh**
Standing charge	**27.39p per day**
Tariff ends on	**Not Applicable**
Price guaranteed until	**Not Applicable**
Exit fee (If you switch supplier more than 49 days before the tariff end date)	**Not Applicable**
Additional products or services included	

Estimated electricity cost for you on this tariff

Your annual consumption (based on your estimated consumption)	**6091.49 kWh**
Personal projection (based on current prices and including VAT)	**£894.17**
Tariff Comparison Rate (TCR)	**Not available for your account type**

Note - all charges displayed are inclusive of VAT at the applicable rate and this may be different to the way charges are displayed on your bill. Your personal projection is an estimate of your annual energy costs based on your previous 12 months consumption, existing tariff price, discounts and VAT.

Jargon buster

Exit fee - a fee that is applied if you switch supplier more than 49 days before the tariff end date.

kWh (kilowatt hour) - one kilowatt of power being used for one hour. Also known as a 'unit' of energy.

Personal projection - an estimate of your energy cost for the next 12 months based on your previous 12 months' consumption, tariff prices, applicable discounts and VAT. If there is less than 12 months left on your tariff, we've calculated your personal projection using our cheapest variable prices for the period after your tariff ends.

Tariff - the package of charges and conditions ScottishPower supply you.

Tariff Comparison Rate (TCR) - The TCR is a guide to compare the cost of energy tariffs. It is the average overall cost of each unit of energy and is based on a typical user of electricity or gas. It is not based on your personal consumption.

Standing charge - This fixed daily amount covers the fixed costs to service your account regardless of your energy use. May also be called Daily Service Charge.

Unit rate - The price you pay per unit of energy.

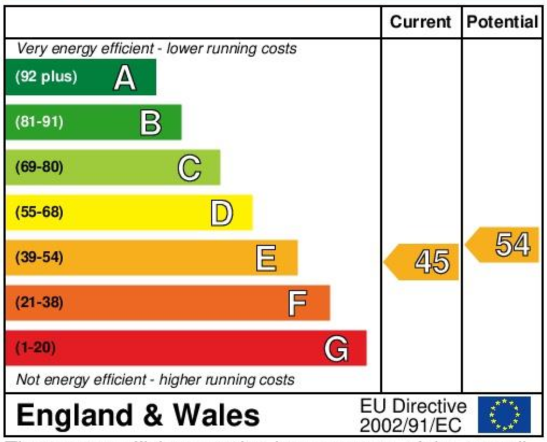
13.4 ECP (Padiham)

Energy Performance Certificate

50, Whitegate Close	Dwelling type:	Top-floor flat
Padiham	Date of assessment:	19 May 2010
BURNLEY	Date of certificate:	20 May 2010
BB12 8TJ	Reference number:	0272-2861-6251-9190-8361
	Type of assessment:	RdSAP, existing dwelling
	Total floor area:	48 m²

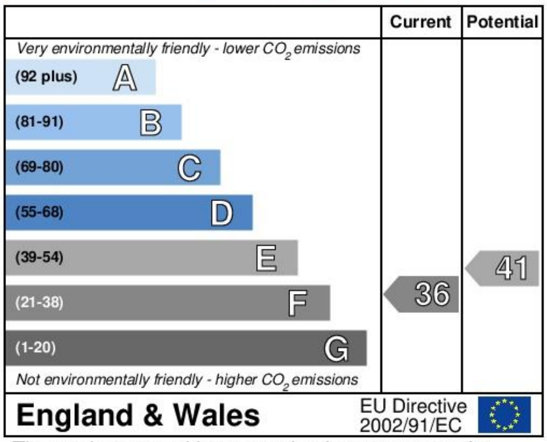
This home's performance is rated in terms of the energy use per square metre of floor area, energy efficiency based on fuel costs and environmental impact based on carbon dioxide (CO_2) emissions.

Energy Efficiency Rating



The energy efficiency rating is a measure of the overall efficiency of a home. The higher the rating the more energy efficient the home is and the lower the fuel bills are likely to be.

Environment Impact (CO_2) Rating



The environmental impact rating is a measure of a home's impact on the environment in terms of carbon dioxide (CO_2) emissions. The higher the rating the less impact it has on the environment.

Estimated energy use, carbon dioxide (CO_2) emissions and fuel costs of this home

	Current	Potential
Energy use	689 kWh/m² per year	609 kWh/m² per year
Carbon dioxide emissions	5.0 tonnes per year	4.4 tonnes per year
Lighting	£57 per year	£29 per year
Heating	£435 per year	£344 per year
Hot water	£226 per year	£226 per year

The figures in the table above have been provided to enable prospective buyers and tenants to compare the fuel costs and carbon emissions of one home with another. To enable this comparison the figures have been calculated using standardised running conditions (heating periods, room temperatures, etc.) that are the same for all homes, consequently they are unlikely to match an occupier's actual fuel bills and carbon emissions in practise. The figures do not include the impacts of the fuels used for cooking or running appliances, such as TV, fridge etc.; nor do they reflect the costs associated with service, maintenance or safety inspections. Always check the certificate date because fuel prices can change over time and energy saving recommendations will evolve.

To see how this home can achieve its potential rating please see the recommended measures.

energy saving recommended
Certification mark

Remember to look for the energy saving recommended logo when buying energy-efficient products. It's a quick and easy way to identify the most energy-efficient products on the market.

This EPC and recommendations report may be given to the Energy Saving Trust to provide you with information on improving your dwelling's energy performance.

13.5 Treviso 1st Pilot site Baseline description

4.

Treviso (IT) 1st pilot site

Baseline description

D2.1

This project has received funding from the European Union's Horizon 2020 research and innovation programme under the Grant Agreement no 680511. This document does not represent the opinion of the European Union, and the European Union is not responsible for any use that might be made of its content.

4.

Table of contents

Table of figures

1 Pilot Site overview

1.1 General Description

The purpose of the visit is to evaluate the baseline situation of the building providing the starting point for the renovation DREEAM approach.

This technical baseline will be focus on the gathering of information about:

- **Passive technologies:** The thermal properties of the walls, roof, etc analysing in which conditions are they currently and the features of the windows.
- **Active technologies:** Identifying every component of the installation of the buildings including electrical parts, heating systems, storage and lighting among other things.

1.2 Buildings Description

The visit took place in the city of Treviso (Italy) in social housing buildings located in the street Viale Francia.

Figure 1 Building in Viale Francia

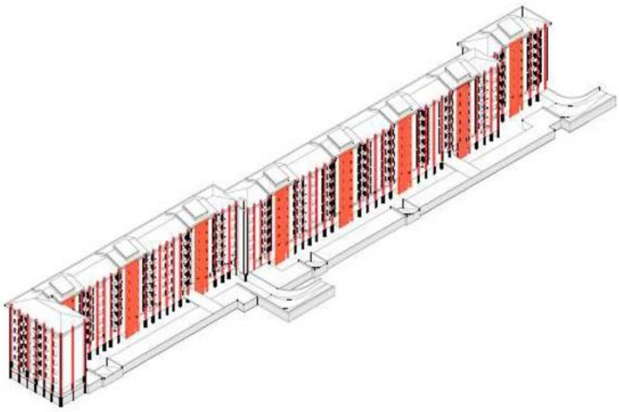


Figure 2 Axonometric sight

From the entire construction two types of buildings were included within the project: T2 and T4.

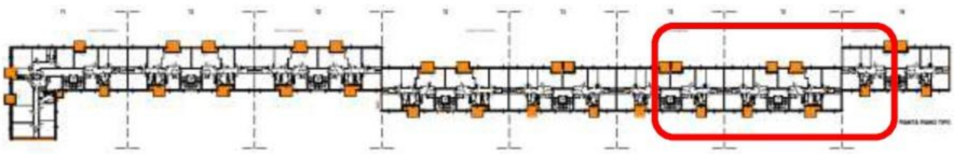


Figure 3 Dwelling plan

Figure 4 Typology 2 and 4

Typology 2: This is the building number 7. It has a basement, a ground floor and six floors with two flats per floor (a total of 12 flats).

The flat on the link has: 3 rooms, a living room, a kitchen, a toilet, and a bathroom. It has a net area of 80,92 m^2.

The flat on the right has: 3 rooms, a living room, a kitchen, a toilet, a bathroom and a storeroom. It has a net area of 95,5 m^2.

Typology 4: This is the building number 8. It has a basement, a ground floor and six floors with two flats per floor (a total of 12 flats).

The flat on the link has: 3 rooms, a living room, a kitchen, a toilet, and a bathroom. It has a net area of 79 m^2.

The flat on the right has: 3 rooms, a living room, a kitchen, a toilet, and a bathroom. It has a net area of 79 m^2.

1.3 BO requirements and objectives

To carry out the pilot visit, the collaboration of the building owners is required to allow the other collaborating parts in the visit to gather as much information as possible that can be used after the visit to make a deep analysis about the current situation of the building. For it, ATER Treviso has made available the entry to different flats and technical rooms allowing to make a thermography analysis, to measure the thermal transmission of the passive components and to analyze the active components.

The main objective of the building owner about this visit is to have an understanding of the current situation of their properties. This information must cover the components of the building and the energy consumption of the social housing. It will be the first step of the renovation process.

1.4 Information needed

To perform the analysis of the building and compare the data obtained from the measurements it is necessary to have the construction drawings which include every information about the typology, orientation, dimensions, components and details of the building.

ATER Treviso has provided all the construction drawings that allow Exeleria to get a deep study of the building.

This information includes:

- Building spaces Lay-out
- Elevation drawings
- Energy Performance Certificates of some dwellings
- Envelope components detailed description
- Heating & DHW technical drawings (central production systems schemes)

Energy consumptions of the central heating & DHW systems for the whole building

2 On site data gathering

2.1 Passive Components

2.1.1 Thermographic analysis

The detailed information related to the thermographic analysis could be found in the methodology document included in the annexes.

To carry out the thermographic analysis, a minimum thermal temperature difference between indoor-outdoor is necessary.

The temperature inside the building during the thermographic work ranged between 20 and 23 °C. The temperature outside was between 8 and 9. ºC. Which means a difference between 11-14 ºC.

After de thermographic analysis in the different parts of the building we can obtain the following conclusions:

There are small thermal bridges in the corners of the façade against the outside air. The temperature in the corner is 15 ºC, around 4 ºC less than in the rest of the wall and roof.

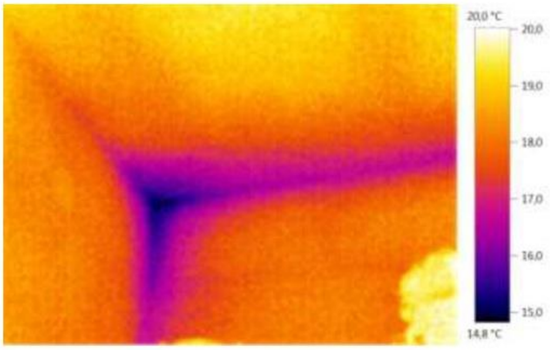


Figure 5 Thermal bridge in a corner

Another example of thermal bridge in a corner in another room with a lower temperature. The difference of temperature is the same as the last one.

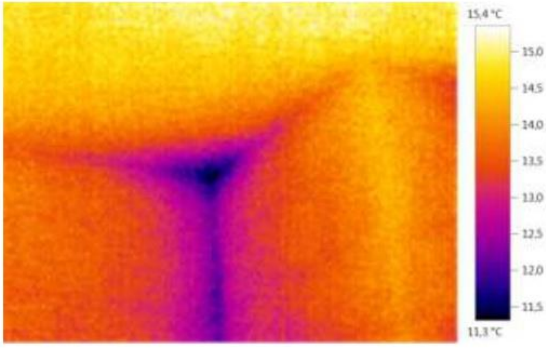


Figure 6 Thermal bridge in a corner

Nevertheless, in the highest floor we can appreciate very important thermal bridges as we can see in the photo, there are big areas with temperatures around 16 ºC when the rest of the room is around 20 ºC:

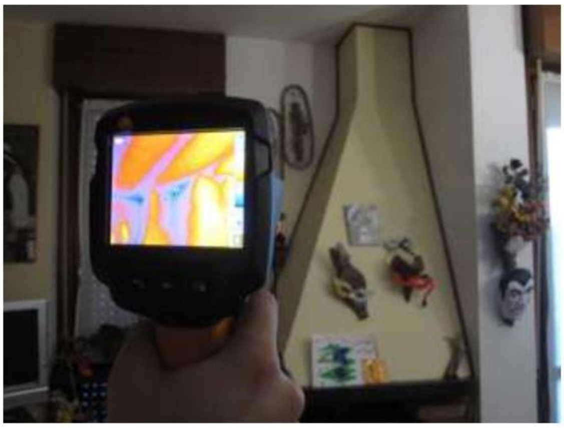


Figure 7 Photo of the thermal camera

In the next picture can be observed light irregularities in the joint between the wall and the ceiling in one room of the flat:

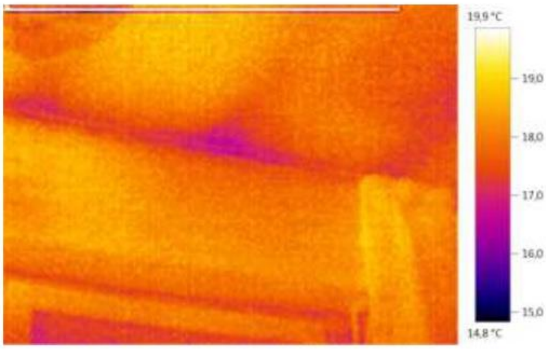


Figure 8 Joint between wall and ceiling

Small thermal bridges can be also observed between windows and walls with around 4 ºC of difference between them:

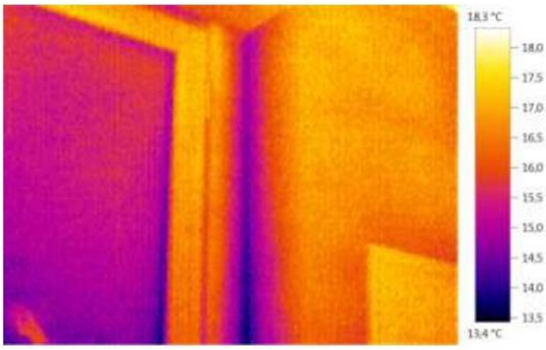


Figure 9 Thermal bridge in a window

Generally, there is no presence of humidity, leaks of energy in the heating systems or significant differences in the envelope components.

2.1.2 U-Value analysis

The detailed information related to the U-values analysis could be found in the methodology document included in the annexes.

To ensure the accuracy of the measurements the ideal conditions required are:

- Temperature difference (outdoor - indoor) of at least 15 ºC
- External surfaces un exposed to solar radiation

A representative batch within each pilot case based on construction features (num. of bedroom, orientation, m2…) is selected. The equipment for measuring U-values include heat flux meters, thermistor temperature probes and data-loggers.

For the analysis of the building envelope five components of it have been analysed based on the different envelope components make-up data given by the building owner.

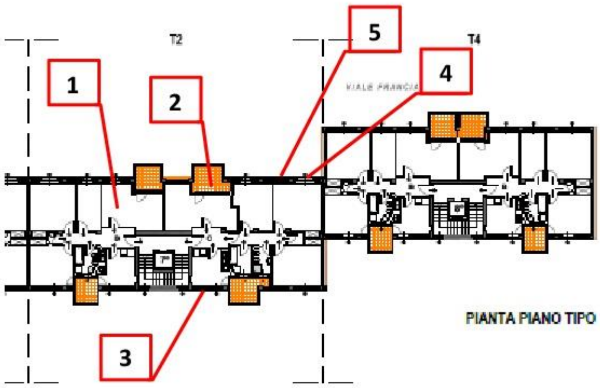


Figure 10 Components analysed

The results obtained are:

Number	Component	U-Value obtained [W/m²K]	U-Value calculated [W/m²K]
1	Roof against unheated room	2,526	1,335
2	Wall against exterior air	2,604	1,622
3	Wall against exterior air	0,53	0,439
4	Wall against exterior air	1,553	0,637
5	Wall against exterior air	0,721	no data

There are big differences between the measured and based on composition calculated data. A discussion on that is included in the conclusions.

Following this a detailed description of the measurements:

1. Roof against unheated room. This is the roof located on the sixth floor against an small unheated loft. The results obtained are:

- Temperature difference: 8,2 ºC
- Solar radiation: Not influenced

Date	Time	U-Value [W/m²K]	Tw [ºC]	Ti [ºC]	Hr [%]	To [ºC]
04.02.2016	17:19:19	2,526	20,18	22,88	30,9	14,7

Comparing with the data obtained theoretically based on the information given by ATER Treviso:

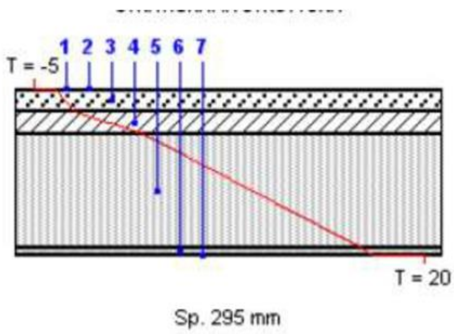


Figure 11 Construction detail of the roof

Composition [mm]	Thickness [mm]	U-Value obtained [W/m²K]
Mortar (15) Concret (200) Isolation (40) Cement (35) Flooring (5)	295	1,335

We can appreciate a worse statement of the roof than the calculated.

2. Wall against exterior air. This is a wall with windows situated in the balcony oriented to NE. The results obtained are:

- Temperature difference: 9,3 ºC
- Solar radiation: barely influenced

Date	Time	U-Value [W/m²K]	Tw [ºC]	Ti [ºC]	Hr [%]	To [ºC]
04.02.2016	17:27:18	2,604	19,76	22,94	33,6	13,6

Figure 12 U-Value analysis of the wall

Comparing with the data obtained theoretically based on the information given by Ater Treviso:

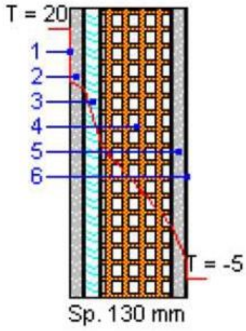


Figure 13 Construction detail of the wall

Composition [mm]	Thickness [mm]	U-Value obtained [W/m²K]
Mortar (15) wood fiber (20) perf. brick (80) mortar (15)	130	1,622

We can appreciate a worse statement of the wall than the calculated.

3. Wall against exterior air. This is the wall situated in the kitchen oriented to SW. The results obtained are:

- Temperature difference: 9,5 ºC
- Solar radiation: Influenced

Date	Time	U-Value [W/m²K]	Tw [ºC]	Ti [ºC]	Hr [%]	To [ºC]
04.02.2016	17:52:51	0,53	18,65	19,31	43,6	9,8

Figure 14 U-Value analysis of the wall

Comparing with the data obtained theoretically based on the information given by Ater Treviso:

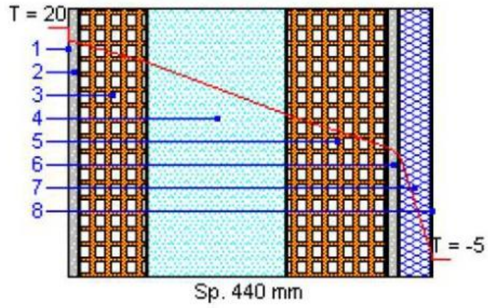


Figure 15 Construction detail of the wall

Composition [mm]	Thickness [mm]	U-Value obtained [W/m²K]
mortar (15) perf. brick (80) air cavity (170) perf. brick (120) mortar (15) isolation (40)	440	0,439

We can appreciate a similar statement of the wall with the calculated.

4. Wall against exterior air. This is the wall with windows situated in a room oriented to NE. The results obtained are:

- Temperature difference: 8,8 ºC
- Solar radiation: barely influenced

Date	Time	U-Value [W/m²K]	Tw [ºC]	Ti [ºC]	Hr [%]	To [ºC]
04.02.2016	18:01:14	1,553	17,68	19,47	42,4	10,7

Figure 16 U-Value analysis of the wall

Comparing with the data obtained theoretically based on the information given by Ater Treviso:

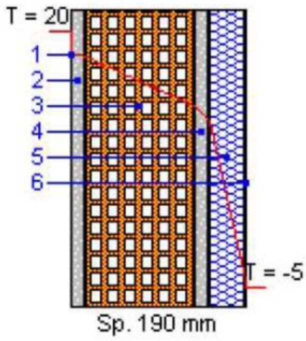


Figure 17 Construction detail of the wall

Composition [mm]	Thickness [mm]	U-Value obtained [W/m²K]
mortar (15) perf. brick (120) mortar (15) isolation (40)	190	0,637

We can appreciate a worse statement of the wall than the calculated.

5. Wall against exterior air. This is the wall situated in a room oriented to NE. The results obtained are:

- Temperature difference: 9,7 ºC
- Solar radiation: barely influenced

Date	Time	U-Value [W/m²K]	Tw [ºC]	Ti [ºC]	Hr [%]	To [ºC]
04.02.2016	18:17:09	0,721	17,57	18,03	49,5	8,3

Figure 18 U-Value analysis of the wall

There is not theoretical data of this component to compare.

6. Floor against unheated room. The evaluation of this component was not possible because the tenants of the first floor were not at home during the visit.

2.1.3 Windows

The basic features of the windows can be obtained using the application PRISM@VER 2012 which gives the user the number of layers of glass, their thickness and the length of the cavity between glasses.

Using the application for the windows in the building and in different orientations the conclusion obtained is that the features of the windows are the same for the whole building.

It consist in a double-glazed windows with a cavity between them apparently of gas. The measures of the windows are:

4 mm/ 14,5 mm/ 4 mm

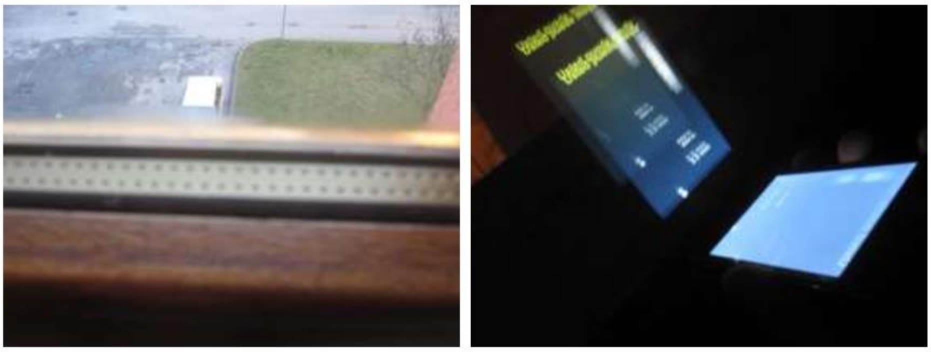


Figure 19 Window and the analysis of it

ATER Treviso has provided the following information about the windows. There are five different sizes and in spite of that they have the same U-Value for the glass and for the frame, they have different U-Value for the complete window.

Ag [m²]	Af [m²]	Lg [m²]	Ug [W/m²K]	Uf [W/m²K]	Uw [W/m²K]	Fg
1,699	0,551	7,960	3,302	1,900	3,171	0,75
1,285	0,430	6,790	3,302	1,900	3,188	0,75
0,449	0,191	2,680	3,302	1,900	3,134	0,75
3,712	0,845	12,480	3,302	1,900	3,206	0,75
1,285	0,430	6,790	3,302	1,900	3,188	0,75

2.2 Active Components

2.2.1 Heating & DHW production

The heat and the domestic hot water (DHW) is produced by the central heating system. It uses natural gas to heat water above its initial temperature. This hot water is used for many activities that include cooking, cleaning, bathing, and space heating.

For the heating and DHW production in the building a central system of gas boilers is used. It consist in two gas boilers for the heating and another two for the DHW. They are located in the boiler room, in the basement of the building number 4:

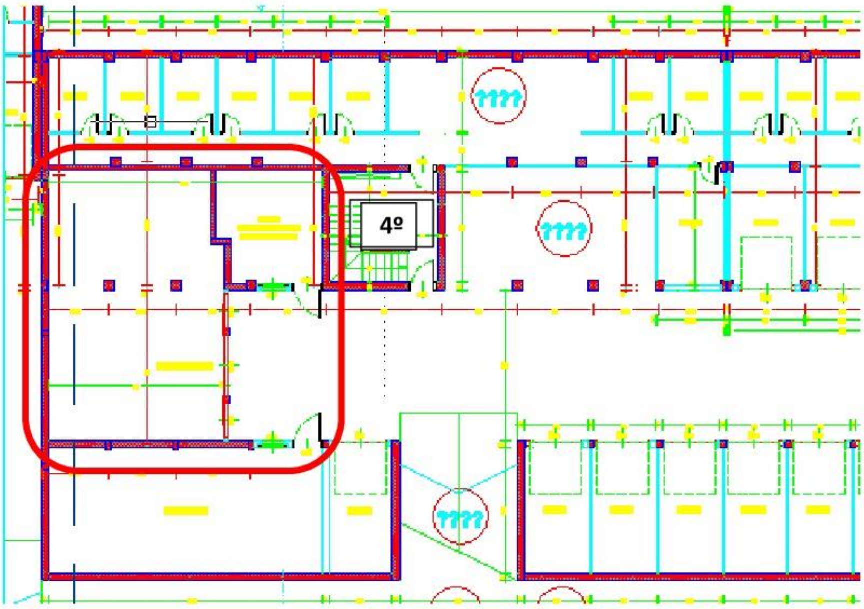


Figure 20 Boiler room

Figure 21 Boiler room

- Heating: There are two different boilers with burners for the heating production:
  - Ecoflam ECOMAX NC 630. It has a maximal nominal power of 630 kW.

Figure 22 Ecoflam ECOMAX NC 630

  - Ecoflam ECOMAX NC 420. It has a maximal nominal power of 420 kW

Figure 23 Ecoflam ECOMAX NC 420

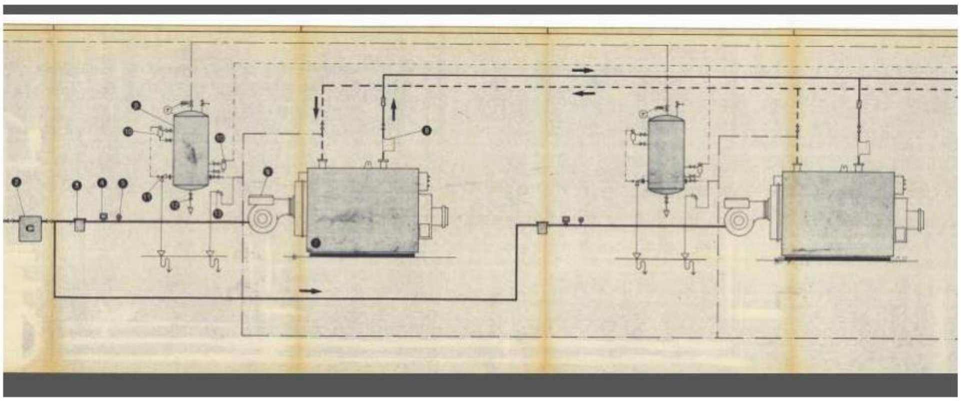


Figure 24Heating System Schematic diagram

- DHW: There are two identical boilers with burners for the domestic hot water production. It is a RIELLO 3500 180 3S which has a maximal nominal power of 133 kW.

Figure 25 RIELLO 3500 180 3S

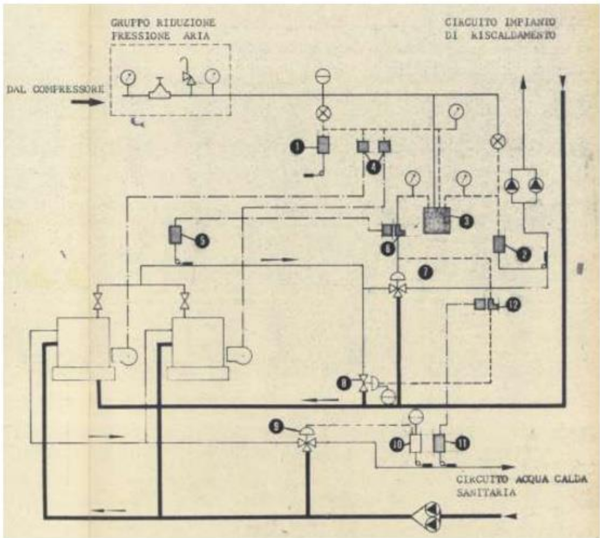


Figure 26 DHW Schematic diagram

The DHW is stored in two tanks of 800 l each one:

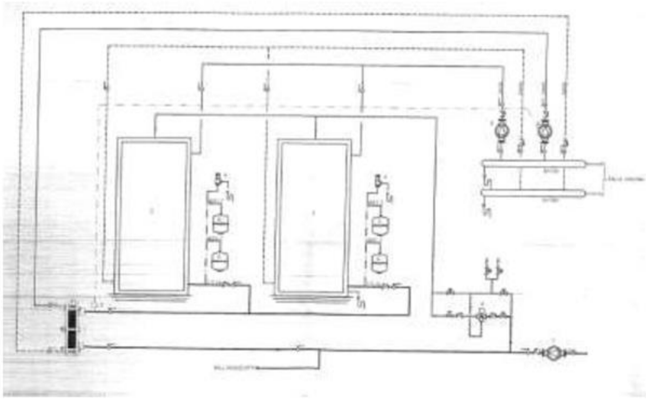


Figure 27 Deposit tanks

2.2.2 Terminal units

A terminal unit is the part of an installation which receives air or water from a centralized system acting on the conditions in a selected area.

The terminal units found in the building are:

- Radiators: Are the elements used in the building to transfer the heat generated by the two gas boilers. There are one radiator per room and the dimensions of it depends on the area to be heated: For example we can find a 1 x 0,6 m in the living room and 0,3 x 0,6 m in the bathroom.

Figure 28 Examples of radiators in living room and in bathroom

In most of the rooms they are located under the windows or near it when possible which is the most efficient place.

All radiators have a thermal valve consisted in an automatic device coupled to a thermostatic valve body that opens it controlling the flow of water flowing through the radiator and therefore its thermal power depending on the selected temperature position, and an individual meter that measure the radiator consumption (heat allocator system).

Figure 29 Thermal expansion valve and meter in a radiator

- Air conditioning: It is a cooling/heating air device for individual room based on a direct expansion system that also filter, at some extent, the air pollution.

  Air conditioning is not installed in every flat because it is a decentralised system under the decision of the tenant.

Figure 30 Air conditioning system

2.2.3 Lighting

Room lighting can be general, punctual, ambient or decorative.

Depending on the lamp:

- Incandescent: a wire filament is heated to a high temperature, by passing an electric current through it. They have a very low efficiency (5%)
- Halogen: is an incandescent lamp that has a small amount of a halogen such as iodine or bromine added. They have a lifetime around 1.500 hours of use.
- Fluorescent: is a low pressure mercury-vapor gas-discharge lamp that uses fluorescence to produce visible light. They are more expensive than incandescent but they have more efficiency and life.
- Low consumption: are also fluorescent lamps adapted to the size, shape and stands of conventional bulbs. They are more expensive but easily to be depreciated with a lifetime between 6.000 and 9.000 hours.

- LED: it is a p–n junction diode, which emits light when activated. LED lamps have a very high efficiency (around 90%)

The kind of lamps used in the building and it powers depends on the decision of the tenants. Generally the most used are:

- Incandescent: This kind of lamp is very common for the bedrooms and living-room with power range between 40 and 60 W.

Figure 31 Incandescent lamps

- Fluorescent: This kind of lamp is used for the kitchen and toilets.

Figure 32 Fluorescent lamp

- Low consumption lamp: This kind of lamp is barely used in the building.

3 Simulation analysis

3.1 Hourly analysis program software

The main goals of this simulation are:

- To help to verify that the measured U-values and gathered building information are able to explain the current energy consumption.
- Sensitivity analysis of the different parameters, seeking for those parameters that have influence on energy consumption.
- Feasibility check: This model will be the starting point for the feasibility check to be developed later on.

3.1.1 Introduction

HAP is designed for consulting engineers, design/build contractors, HVAC contractors, facility engineers and other professionals involved in the design and analysis of commercial building HVAC systems.

In addition, HAPs 8760 hour energy analysis capabilities are very useful for green building design. For instance, HAP energy analysis results are accepted by the US Green Building Council for its LEED®1 (Leadership in Energy and Environmental Design) Rating System. Visit the USGBC's website, www.usgbc.org, for more LEED info.

3.1.2 Load calculation

HAP software uses:

- ASHRAE Transfer Function cooling load calculation procedures,
- ASHRAE design heating load calculation procedures, ASHRAE design weather data.
- ASHRAE design solar calculation procedures.

Features:

- Calculates space and zone loads 24-hours a day for design days in each of the 12 months. In doing so it calculates heat flow for all room elements such as walls, windows, roofs, skylights, doors, lights, people, electrical equipment, non-electrical equipment, infiltration, floors and partitions considering time of day and time-of-year factors.
- Performs detailed simulation of air system operation to determine cooling coil loads and heating coil loads and other aspects of system performance 24-hours a day for design days in each of the 12 months.

- Analyses plenum loads.
- Considers any operating schedule for HVAC equipment from 1 hour to 24 hours in duration.
- Permits hourly and seasonal scheduling of occupancy, internal heat gains, and fan and thermostat operation.

On the following figures are displayed some examples of the type of data required in HAP simulation related to design weather inputs but also the outcomes provided by the HAP tool.

Design Parameters:

City Name	**Venice**	
Location	**Italy**	
Latitude	**45,5**	Deg.
Longitude	**-12,3**	Deg.
Elevation	**5,8**	m
Summer Design Dry-Bulb	**30,6**	°C
Summer Coincident Wet-Bulb	**23,3**	°C
Summer Daily Range	**9,1**	°K
Winter Design Dry-Bulb	**-5,0**	°C
Winter Design Wet-Bulb	**-7,1**	°C
Atmospheric Clearness Number	**1,00**	
Average Ground Reflectance	**0,20**	
Soil Conductivity	**1,385**	W/(m-°K)
Local Time Zone (GMT +/- N hours)	**-1,0**	hours
Consider Daylight Savings Time	**No**	
Simulation Weather Data	**Venice (IWC)**	
Current Data is	**2001 ASHRAE Handbook**	
Design Cooling Months	**January to December**	

Design Day Maximum Solar Heat Gains

(The MSHG values are expressed in W/m²)

Month	N	NNE	NE	ENE	E	ESE	SE	SSE	S
January	52,1	52,1	52,1	179,0	417,1	575,5	716,3	772,6	788,1
February	67,4	67,4	123,0	357,7	545,1	704,9	769,4	782,9	784,5
March	84,2	84,2	285,5	492,4	663,2	734,4	757,9	721,5	700,2
April	101,1	205,9	422,3	593,1	683,8	716,9	669,1	595,9	554,6
May	113,0	318,5	491,5	638,4	689,8	671,6	585,8	487,8	435,0
June	151,2	355,1	517,5	646,7	679,7	645,3	547,0	437,9	383,4
July	116,6	312,1	493,7	627,3	668,8	657,4	574,5	475,1	425,7
August	106,6	194,2	412,6	568,0	664,7	689,9	647,0	575,9	537,7
September	87,3	87,3	270,5	447,7	623,9	704,4	727,3	698,1	671,7
October	69,6	69,6	122,6	334,5	535,0	663,0	746,2	762,9	753,8
November	52,6	52,6	52,6	196,5	395,7	583,2	694,3	753,6	767,6
December	45,2	45,2	45,2	119,7	350,2	514,9	669,9	739,7	759,8
Month	**SSW**	**SW**	**WSW**	**W**	**WNW**	**NW**	**NNW**	**HOR**	**Mult**
January	774,2	711,3	589,3	406,7	198,6	52,1	52,1	316,2	1,00
February	787,3	774,5	702,3	555,0	345,4	132,0	67,4	478,0	1,00
March	720,9	751,6	748,3	647,4	503,8	273,1	84,2	628,3	1,00
April	593,5	661,6	714,1	692,0	592,9	405,0	215,1	737,1	1,00
May	485,1	582,0	666,5	695,5	631,7	500,6	316,0	795,5	1,00
June	433,0	545,9	635,6	685,5	633,1	530,0	347,8	811,3	1,00
July	469,1	572,0	646,8	681,4	614,0	497,9	309,5	789,6	1,00
August	573,2	638,0	688,4	667,5	572,0	394,2	211,6	726,5	1,00
September	698,2	726,9	708,2	621,1	456,7	269,9	87,3	602,8	1,00
October	760,5	741,2	671,1	527,7	342,6	105,4	69,6	466,0	1,00
November	750,4	697,5	581,7	400,7	191,7	52,6	52,6	310,6	1,00
December	735,1	663,6	532,4	342,0	135,8	45,2	45,2	248,0	1,00

Mult. = User-defined solar multiplier factor.

Figure 33 Design weather data.

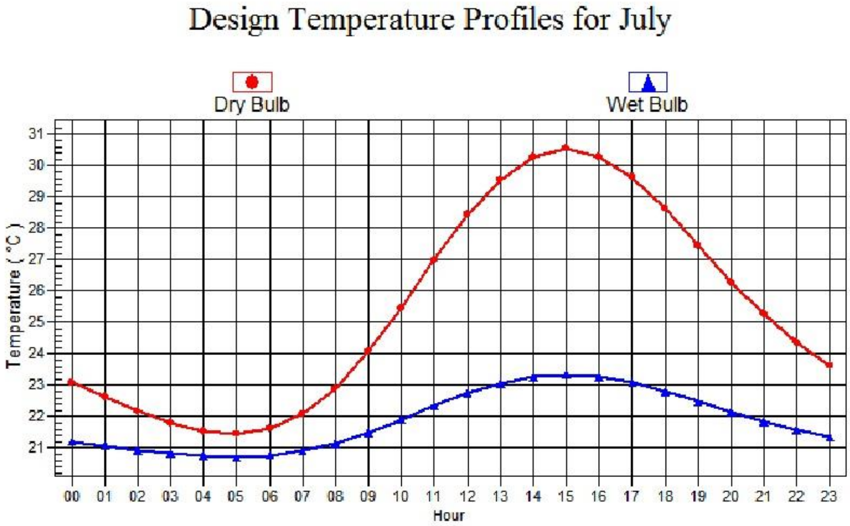


Figure 34 example of July daily temperature.

3.1.3 Simulation approach in Treviso

In Treviso each floor has been defined as a different space made up of two apartments. According to the data provided by the Building owner, in our simulation we took into account all the building and not only the two typologies subject of renovation within the project scope, because we have real energy consumption data related to all the building.

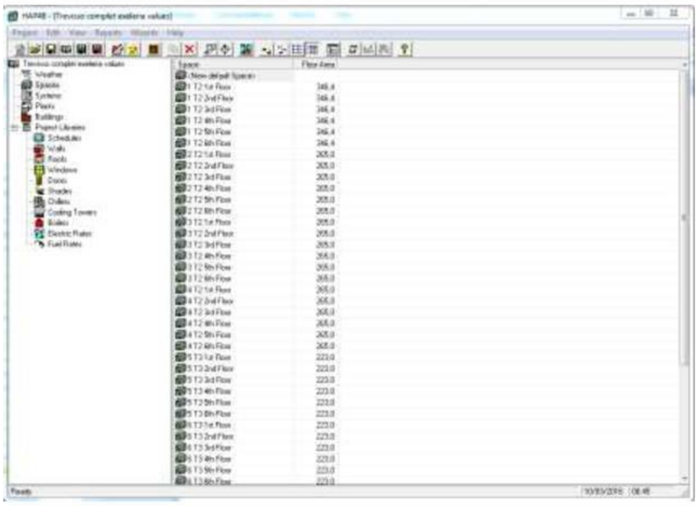


Figure 35 Spaces definition.

In Treviso we have defined three different walls composition with different U-values, separating between walls faces to NE, SW and walls below windows and also three different windows. I In this first approach we have estimated the occupancy in each space, defining 4 people in each apartment due to there are three rooms so 8 people by space (Two apartments). According to construction and energy codes we also assume 8 W/m^2 for lighting and 5 W/m^2 for electrical equipment.

Ventilation parameters are really significant in residential sector to assess the energy demand (Heating and Cooling) at the buildings. In Trevisso according to construction and energy codes we have estimated an infiltration of 0,20 ACH (Air Changes per Hour) which means a low level of infiltration.

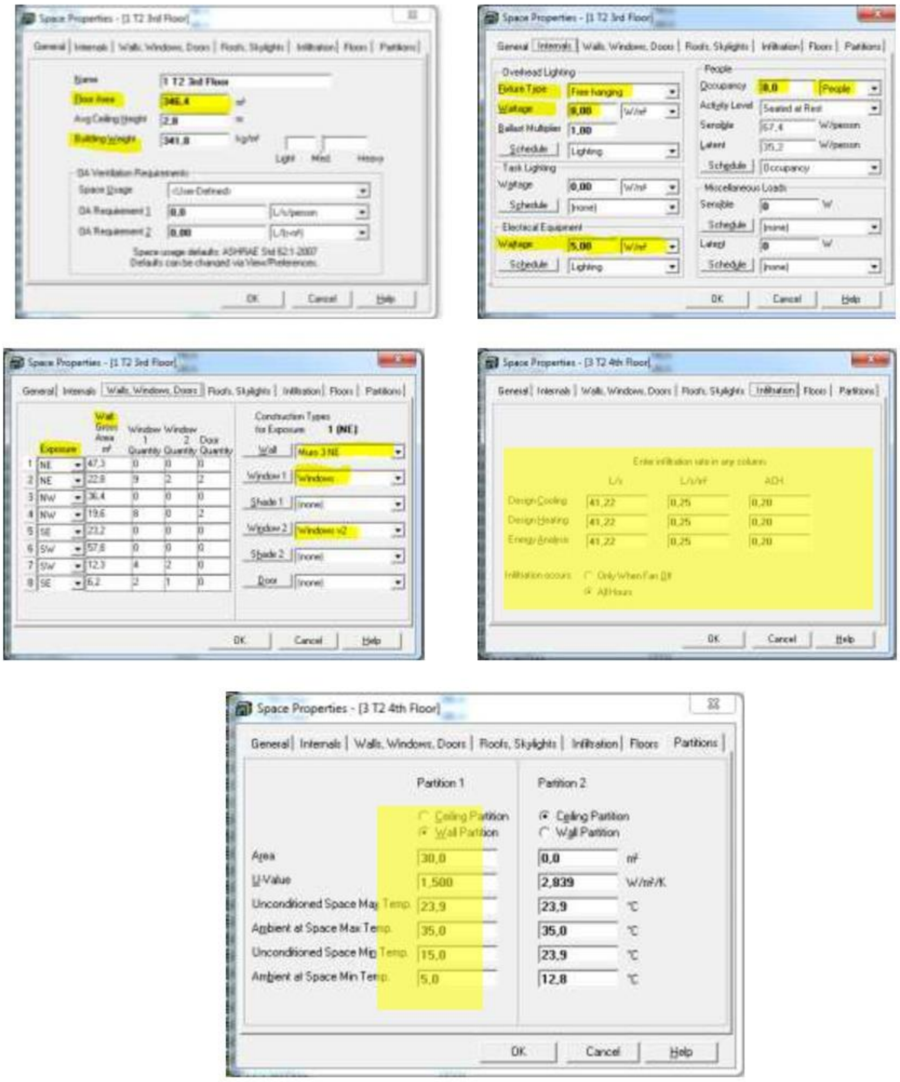
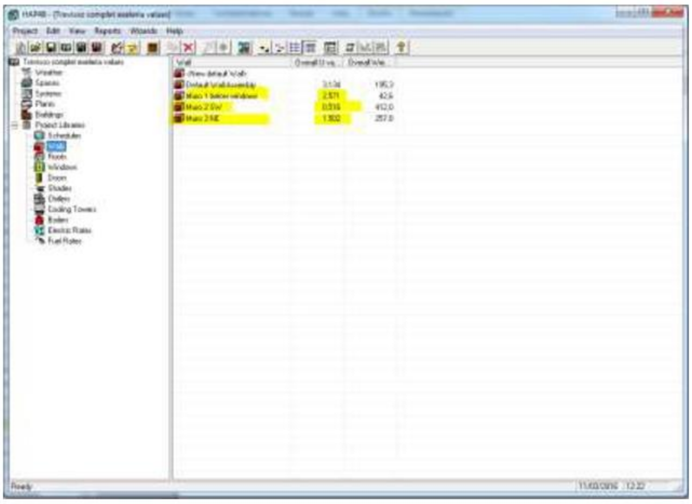
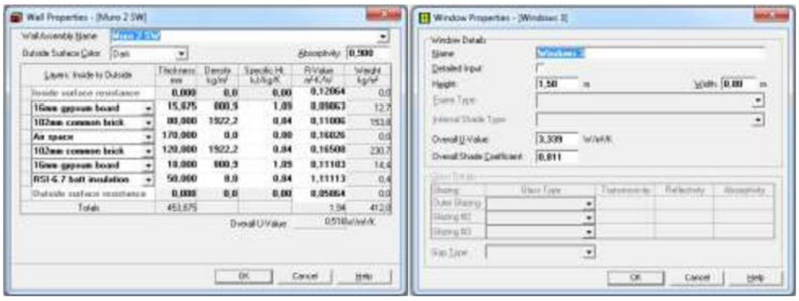


Figure 36 Spaces definition.

In the next figures we have the different walls and windows defined as well as an example of the type of input required by the tool.





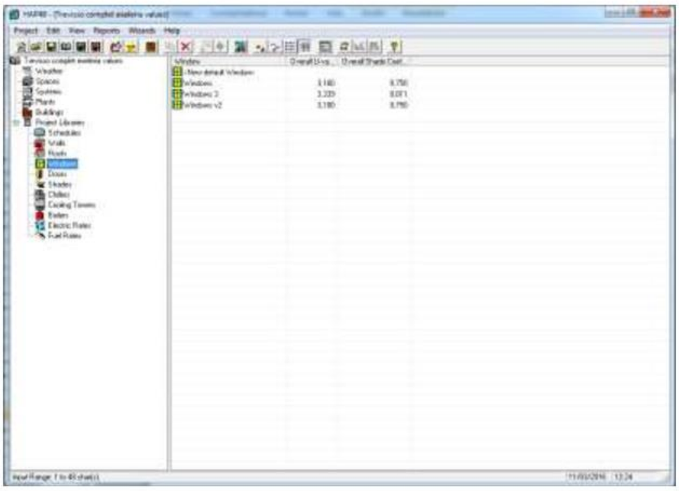


Figure 37 Walls and windows definition.

While defining a space, information about the construction of walls, roofs, windows, doors and external shading devices is needed, as well as information about the hourly schedules for internal heat gains. This construction and schedule data can be specified directly from the space input form (via links to the construction and schedule forms), or alternately can be defined prior to entering space data. In this first approach we have define three different schedules, once we get data related to real occupancy and people behavior from WP4 we will introduce these information in our simulation.

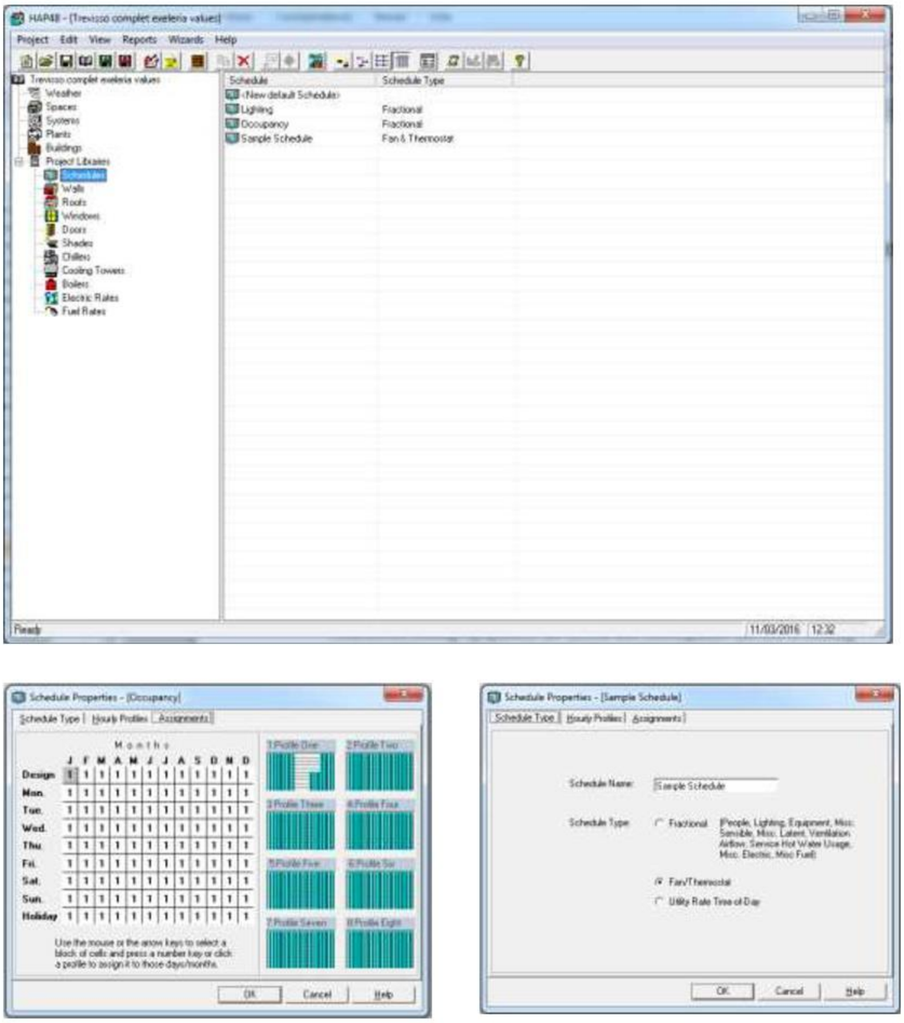


Figure 38 Schedule definition.

In Treviso we have radiators as terminal units (Heating system) so the design supply temperature must be quite close to 50 ºC. Heating T-stat Set points is 22ºC.

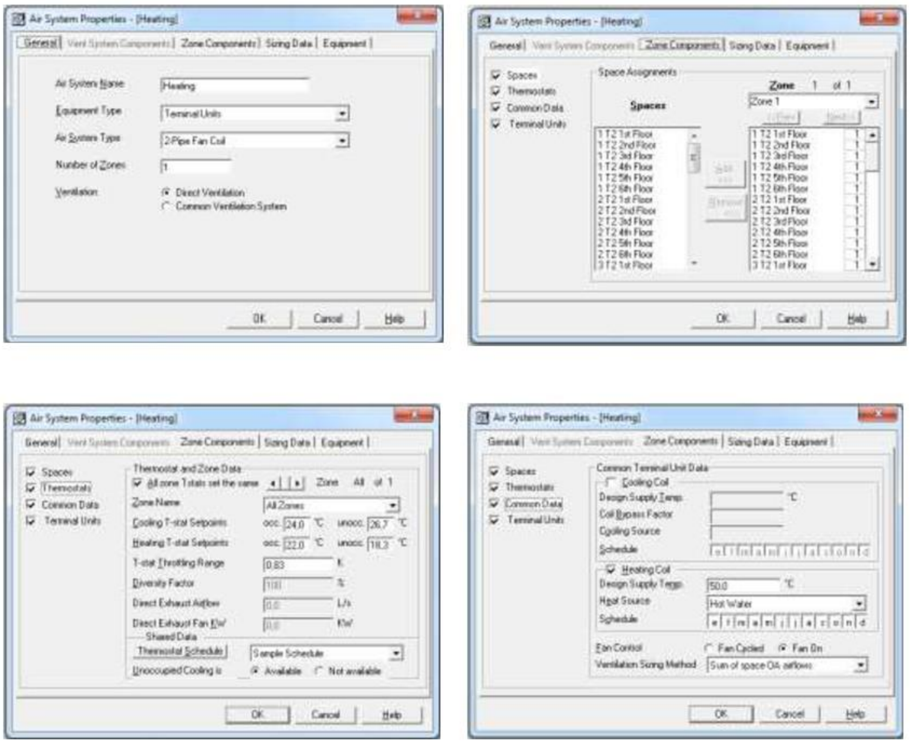


Figure 39 System definition.

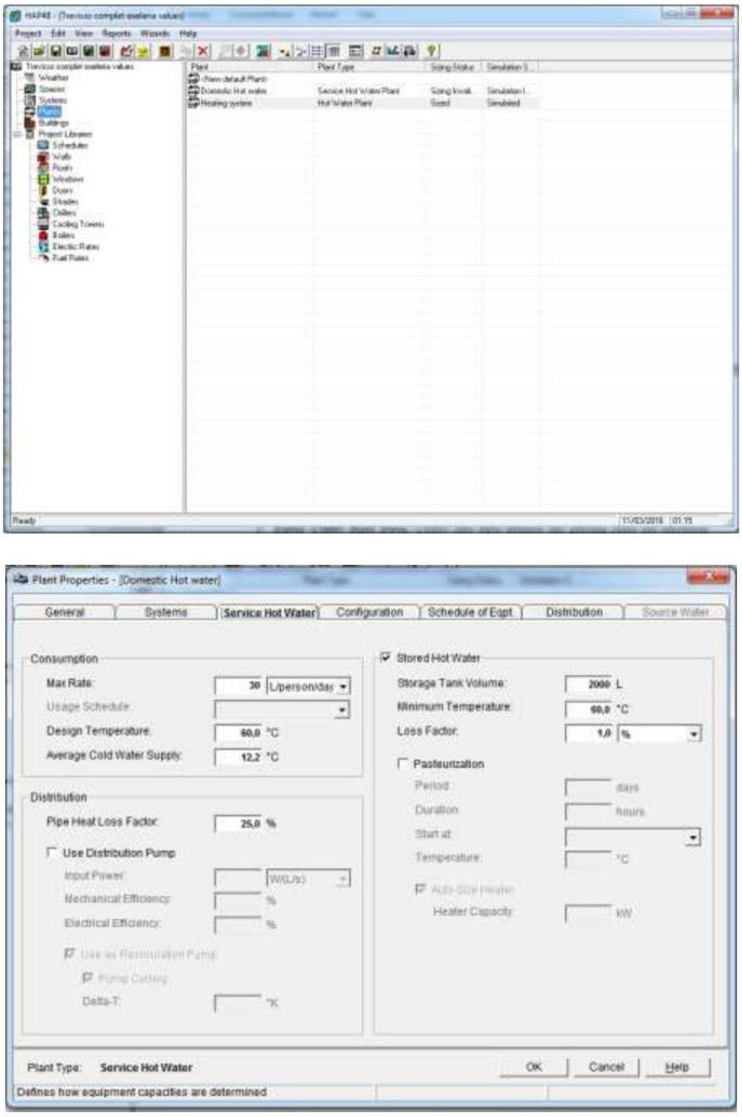


Figure 40 Plant definition.

The Domestic Hot Water plant has been simulated taking into account 30 l/person/day, distribution losses of 25% and a design temperature of 60ºC.

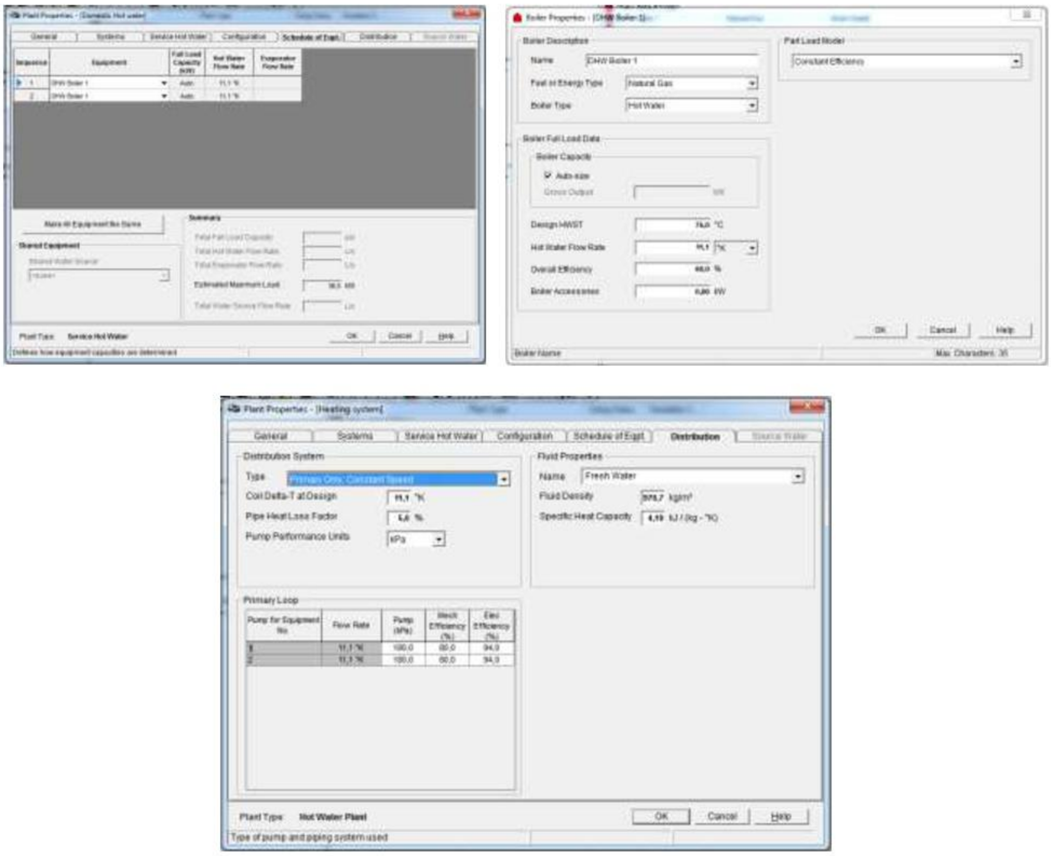


Figure 41 Plant definition.

In our simulation 4 boilers that provide DHW and hot water for heating systems has been defined with the same features that they have in the real situation by using the real seasonal energy efficiency ratio (SCOP) given by the meters installed in the building.

In the following figures we have the results that comes from the simulation tool. On one hand the energy consumption related to DHW which it is really similar throughout the year as it is possible to observe in the figure 43, on the other hand the heating consumption as figure 44 displays there is no energy demand related to heating consumption during summer time.

Monthly Simulation Results for Domestic Hot water

Trevisso complet exeleria values v2 — 03/28/2016
Exeleria — 05:21

Plant Simulation Results (Table 1):

Month	Service HW Load (kWh)	HW Storage Tank Losses (kWh)	SHW Piping Losses (kWh)	Plant Heating Load (kWh)	Boiler Output (kWh)	Boiler Input - Gas (kWh)	Boiler Misc. Electric (kWh)
January	18530	803	3545	18530	18530	30883	0
February	16737	725	3202	16737	16737	27894	0
March	18530	803	3545	18530	18530	30883	0
April	17932	777	3431	17932	17932	29887	0
May	18530	803	3545	18530	18530	30883	0
June	17932	777	3431	17932	17932	29887	0
July	18530	803	3545	18530	18530	30883	0
August	18530	803	3545	18530	18530	30883	0
September	17932	777	3431	17932	17932	29887	0
October	18530	803	3545	18530	18530	30883	0
November	17932	777	3431	17932	17932	29887	0
December	18530	803	3545	18530	18530	30883	0
Total	218175	9453	41744	218175	218175	363624	0

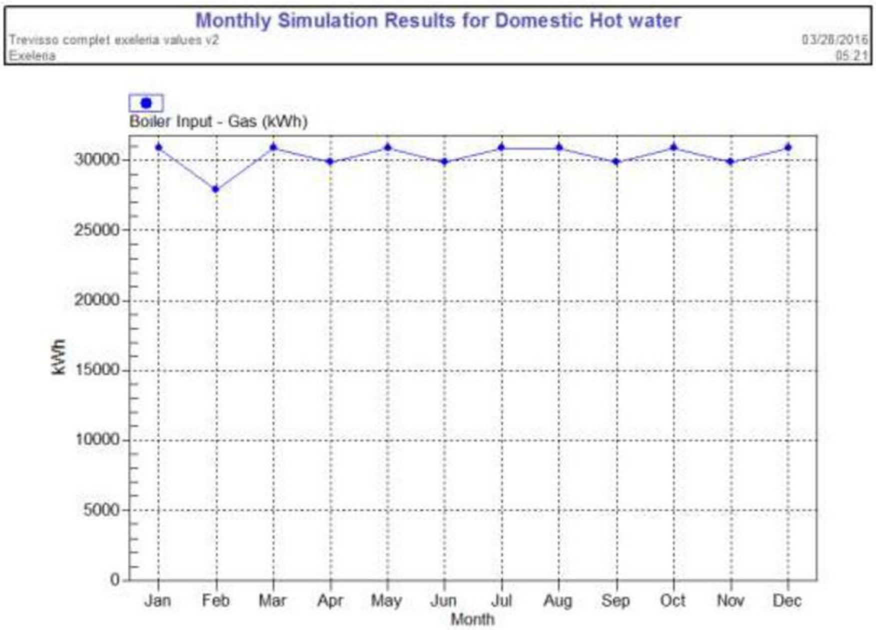


Figure 42 DHW simulation results.

Monthly Simulation Results for Heating system

Trevisso complet exeleria values v2 — 03/28/2016
Exeleria — 04:22

Plant Simulation Results (Table 1):

Month	Heating Coil Load (kWh)	Plant Heating Load (kWh)	Boiler Output (kWh)	Boiler Input - Gas (kWh)	Boiler Misc. Electric (kWh)	Primary Water Dist. Pump (kWh)
January	152461	158119	158119	225884	0	2091
February	105469	108976	108976	155680	0	1880
March	58938	60359	60359	86227	0	1644
April	8149	8090	8090	11557	0	559
May	0	0	0	0	0	0
June	0	0	0	0	0	0
July	0	0	0	0	0	0
August	0	0	0	0	0	0
September	0	0	0	0	0	0
October	4792	4693	4693	6704	0	413
November	78367	80606	80606	115152	0	1790
December	133325	138068	138068	197241	0	2046
Total	541501	558911	558911	798444	0	10422

Monthly Simulation Results for Heating system

Trevisso complet exeleria values v2 — 03/28/2016
Exeleria — 04:22

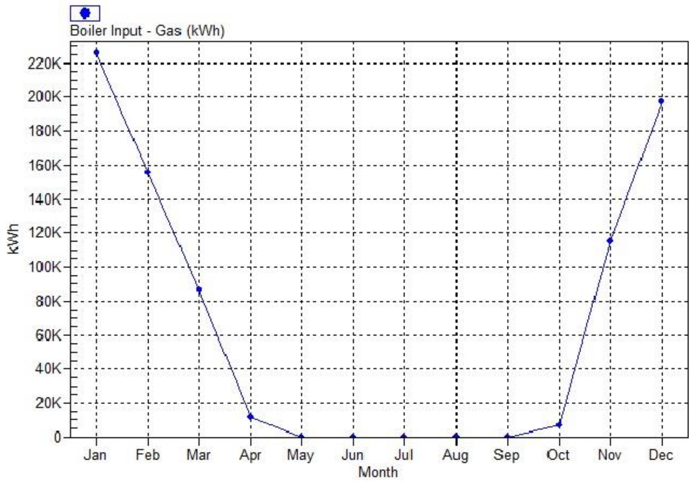


Figure 43 Heating system simulation results.

Month	ATER Real Data [kWh]	Simulation [kWh]	Difference [kWh]	Difference [%]
October	0	6.704,00	-6.704,00	
November	60.571,96	115.152,00	-54.580,04	-90%
December	137.025,38	197.241,00	-60.215,62	-44%
January	211.757,17	225.884,00	-14.126,83	-7%
February	151.886,99	155.680,00	-3.793,01	-2%
March	93.211,07	86.227,00	6.984,07	7%
April	67.749,86	11.557,00	56.192,86	83%
Total	**722.202,43**	**798.445,00**	**-76.242,57**	**-10,6%**

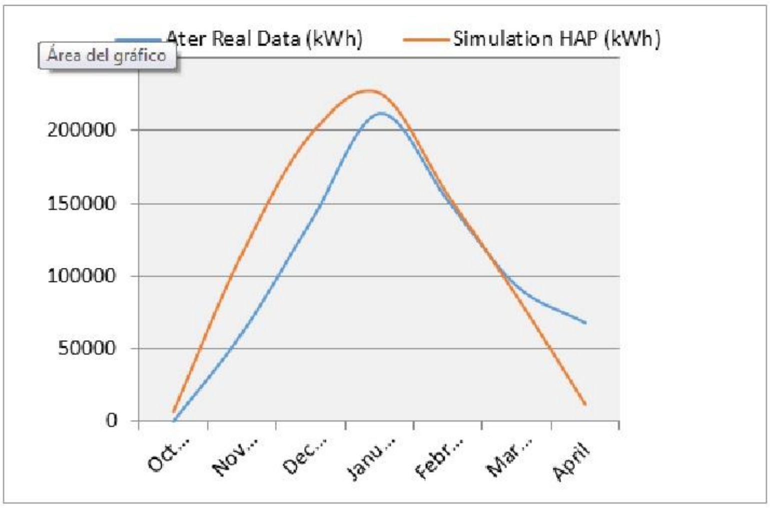


Figure 44 Comparison between Simulation and Real Data.

As it is possible to look at the figure 45, the simulation explain quite well the current energy consumption at the building, taking into account the measured U-values the simulation result is really close to the real situation.

3.2 Analysis of sensitivity

After the simulation analysis with the HAP tool, the following parameters have been modified to see how they affect to the result of the consumption:

3.2.1 Room temperature

For the current analysis calculated before, it has been considered a room temperature of 22 ºC while heated. An increment and a decrease of 1 ºC on this temperature has been modified and checked the variation on the heating energy demand.

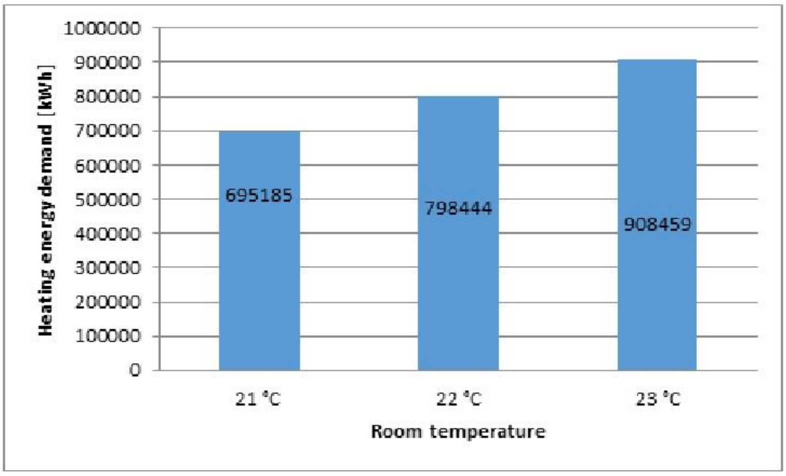


Figure 45 Heating energy demand in relation to room temperature

The variation in percentage produced is:

Temperature	Heating energy demand [kWh]
-1 ºC	-12,9 %
21 ºC	798.444
+1 ºC	+13,8 %

3.2.2 U-Value

In the following analysis the U-Values measured are compared with the values calculated theoretically in relation to the heating energy demand.

- Wall with windows situated in the balcony oriented to NE. The U-Value measured is 2,604 and the calculated 1,622 W/m²K:

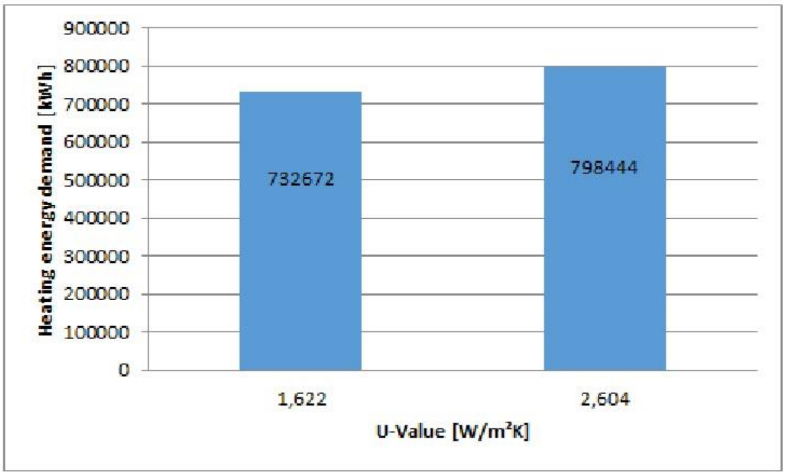


Figure 46 Heating energy demand in relation to the U-Value

U-Value	Heating energy demand [kWh]
Measured (Exeleria)	798.444
Theoretical (Ater)	732.672
Difference	-8 %

- Wall against outside oriented to SW. The U-Value measured is 0,53 and the calculated 0,439 W/m²K:

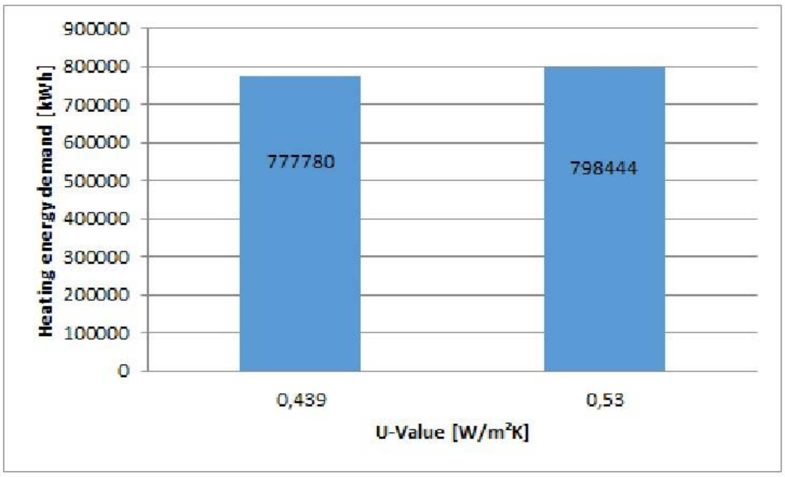


Figure 47 Heating energy demand in relation to the U-Value

U-Value	Heating energy demand [kWh]
Measured (Exeleria)	798.444
Theoretical (Ater)	777.780
Difference	-3 %

- Wall with windows oriented to NE. The U-Value measured is 1,553 and the calculated 0,637 W/m²K:

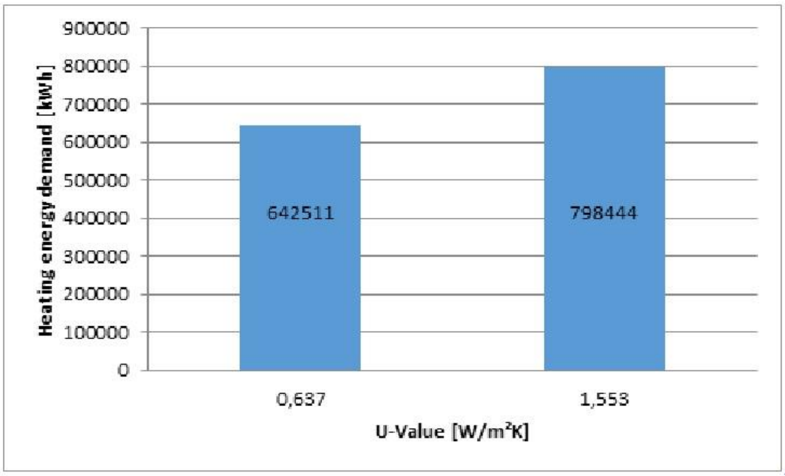


Figure 48 Heating energy demand in relation to the U-Value

U-Value	Heating energy demand [kWh]
Measured (Exeleria)	798.444
Theoretical (Ater)	642.511
Difference	-20 %

- Roof located on the sixth floor against an small unheated loft. The U-Value measured is 2,526 and the calculated 1,335 W/m²K:

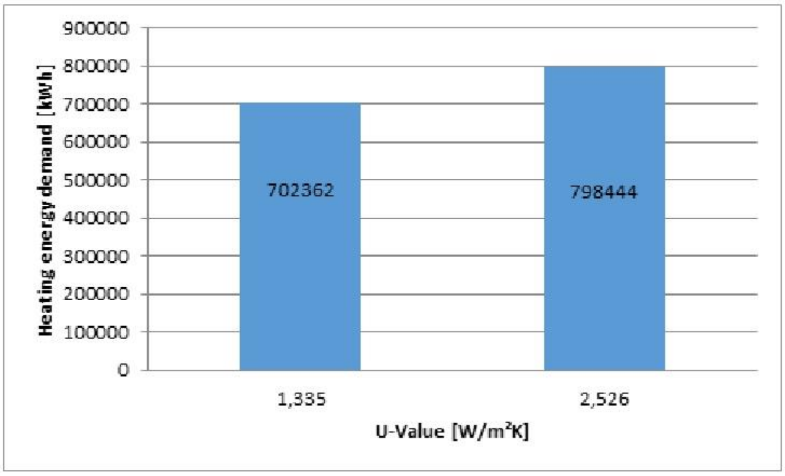


Figure 49 Heating energy demand in relation to the U-Value

U-Value	Heating energy demand [kWh]
Measured (Exeleria)	798.444
Theoretical (Ater)	702.362
Difference	-12 %

- **All the U-Values measured by Exeleria compared with the theoretical values by ATER Treviso:**

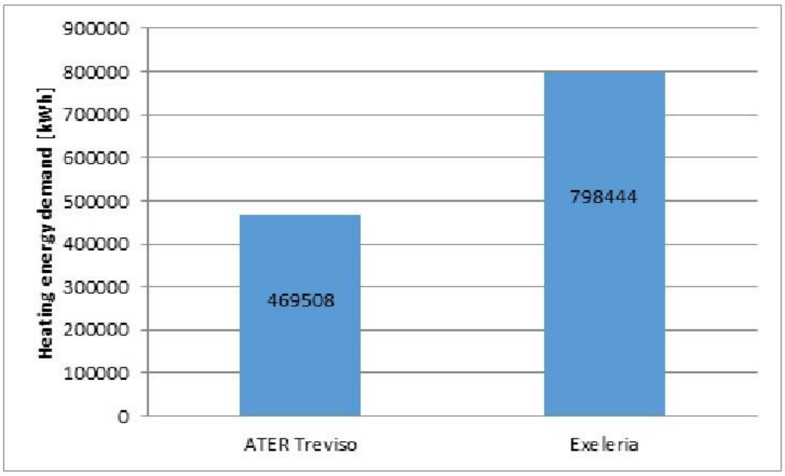


Figure 50 Heating energy demand in relation to the U-Value

U-Value	Heating energy demand [kWh]
Measured (Exeleria)	798.444
Theoretical (Ater)	469.508
Difference	-41 %

3.2.3 Infiltration

For the current analysis calculated before, it has been considered an infiltration of 0,2 air changes per hour. An increment of it modify the heating energy demand:

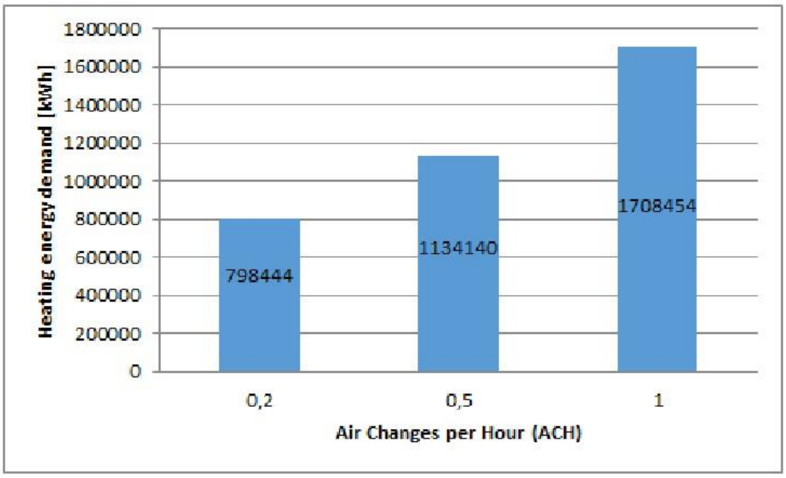


Figure 51 Heating energy demand in relation to the infiltration

Air Changes per Hour (ACH)	Heating energy demand [kWh]
0,2	798.444
0,5	+42 %
1	+114 %

A discussion on how to use for this simulation analysis is done in the conclusions section.

4 Summary and conclusions

4.1 Passive Components

4.1.1 Thermographic analysis

From the thermographic analysis we can get the conclusion that generally, there is no presence of humidity, leaks of energy systems or significant differences in the envelope components. Despite of this, there are areas where exist thermal bridges as for example in the joint between wall and ceiling (Figure 8) or especially in the roof (Figure 7) which is in a current bad condition due to the presence of possible dumps on it. Therefore, the insulation in the building must be improved.

4.1.2 U-Value analysis

Generally, the values obtained are very high with significant differences within the same type of component as in the façade wall that ranges between 2,6 – 0,53 W/m^2K. Also, those values are higher than the calculated and it must be checked. Possible reasons for the differences could be:

- Non ideal measurement conditions because temperature difference were below 15 ºC and some walls had been exposed to the solar radiation.
- Component insulation and other layers conductivity not well estimated (walls make-up has been determined by drilling).
- Also in some cases the difference between the measured and theoretical U-Values are small (SW wall) and others (NE) present big differences which indicates that the solar radiation could be a relevant factor.

To tackle and try to explain these differences several approaches has been taken:

- Use of energy simulation software and compare the results with real consumption data. As is explained in the simulation conclusions (section 4.3) due to high uncertainty in relevant input data (room set points, ventilation rates, etc) this method does not provide sufficient certainty about the U-values. Despite this is a powerful analysis tool and gives very good qualitative insights and will be an essential tool in the feasibility check developed in the next phases of the project.
- Typical U-Values from studies (BPIE[4])

Figure 52 Typical U-Values in Italy

This table shows that typical wall U-values for buildings built in seventies range between 1-1,25 so values as given in some walls bases on the composition (0,4 and 0,6) seems too optimistic and close to current values.

On this basis, and taking advantage of the hot-spot analysis to be done at Treviso, another U-values measurements will be made to try to come up with coherent and trustfully values. This measurements will be done ensuring the best conditions possible.

4.1.3 Windows

There are five different windows in the building with similar U-value, all of them are around 3,1 W/m^2K, that is a high value comparing with the current windows that can be found in the market. A high U-Value implies heat losses and therefore a higher heating consumption in the building.

4.2 Active Components

4.2.1 Heating & DHW production

The conclusions about heating and DHW production were obtained after the analysis of the real energy consumption provided by the building owner. The efficiency obtained for the boilers are 70 % for heating and 60 % for the DHW approximately. These values are low in comparison with new systems so retrofitting the production system will leads to huge energy savings.

Another conclusion obtained after the simulation using the software is that the installation is oversized. The values generated by the software are 450 kW for heating (1050 kW installed) and 36,5 kW for the DHW (266 kW). That could be part of the reason for the low production efficiency level due to several turns on and off.

4.2.2 Terminal units

In the case of the radiators, the control of the heating depends on the user which can do that regulating the thermostatic valve depending on their thermal comfort (not on the room temperature or the outside temperature). This system can be only efficient when the user is taught from an efficiency point of view, but in practice they are normally used in an ON/OFF position.

4.2.3 Lighting

There are installed a significant number of lamps that suppose a waste of energy comparing with the newest kind of lamps as LED or low consumption lamps. The use of lamps with a high nominal power in a dwelling increase significantly the power consumption considering the total amount and the number of hours they are working.

4.3 Simulation analysis.

4.3.1 Results obtained

The simulation results matches quite good with the real consumptions so assumptions made in the input data (internal loads, ventilation rates, set points) should be close to reality:

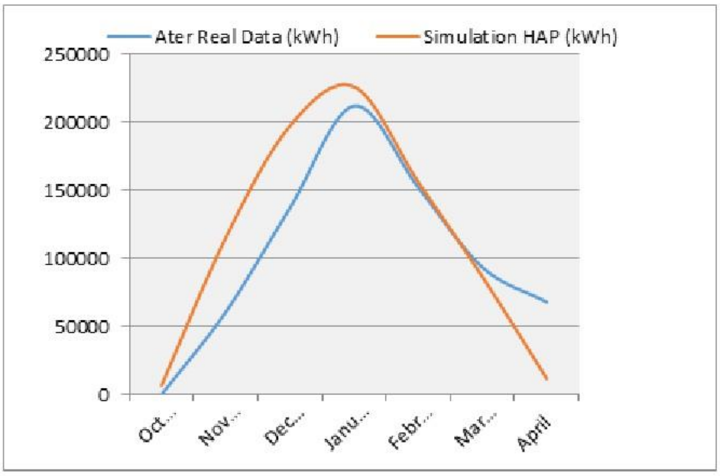


Figure 53 Monthly consumption comparisson

4.3.2 Analysis of sensitivity

Despite of the good coincidence between real and simulated data a sensitivity analysis has been done showing the influence of changes in the most relevant parameters.

Room temperature

An increment or a decrease of 1 ºC on the room temperature produces a variation around 13% in the heating energy demand. A temperature of 21 - 22 ºC during the day ensures a minimum of habitability conditions.

It can be considered that the temperature vary from one room to another. For example, in the bathroom can exceed this temperature to 23 °C and the rooms that are not usually used up to 18 °C.

To heat the building with a room temperature above 22 ºC implies a significant waste of energy.

U-Value

The variation of each component of the envelope of the building does not seem very significant in every case at the first sight, but after the analysis of all of the components together with a better U-Value it is shown the importance of having a good insulation system.

Using the U-Values calculated theoretically, which are in most of the cases much better than the measured, the heating energy demand obtained is around 40% less than the one calculated with the U-Values measured.

Infiltration

Through the analysis of the infiltrations in the building it can be shown that they have a very important impact not only in the comfort of its users but also in the level of energy efficiency of the building. It is obvious that when the outside temperature is low, have an income of cold air inside the building increases the heating energy demand.

As we can see in the Figure 45, a small increment in in the value of air changes per hour produces a significant higher heating energy demand. For example the heating energy demand from 0,5 to 1 air changes per hour is increased a 50%.

14 References

1. electricalencyclopedia.blogspot.com
2. Wikipedia
3. Universidad de Navarra
4. BPIE (Buildings Performance Institute Europe)