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Spanish Case Study

Part I: Spanish Case Study approach and analysis of the building initial situation

1. Case Study Approach

Spanish case study consists of analysing the energy demand and consumption, as well as proposing alternatives that improve its efficiency, of an existing single-family house, type terraced house, located in the municipality of Ceutí, Spain.

2. Description of the single-family house

2.1. Introduction

The terraced single-family house consists of a basement, first floor and second floor. The roof of the house is a flat roof. This building was built in 2023.

The basement has a space of 60 m^2 for vehicle parking and a storage room of 12 m^2.

The first floor has an interior usable area of 56 m^2, not including stairs. The spaces on the first floor are a bedroom, a living room, the kitchen and a bathroom. On the outside of the first floor, the house has a terrace of 13 m2 where the main door of the house is.

On the second floor it has an interior usable area of 54.6 m^2, not including the staircase. This floor consists of 3 bedrooms, and a bathroom. On the outside of this floor, one of the bedrooms has a balcony of 3 m^2 useful.

The width of the façade of this terraced house is 7.71 m and the depth is 11.64 m. On the main façade of the house has a fenced plot of 36 m2 where the ramp is located to go down to the basement with the vehicle.

Figure 1: Terraced houses in Spain

This detached house is located in the municipality of Ceutí, province of Murcia (Spain)

The location data of this building are the following:

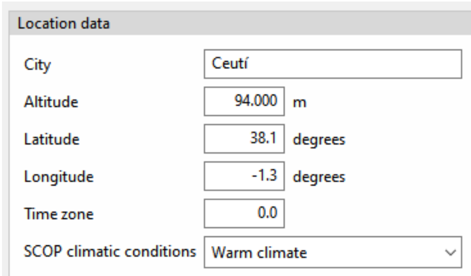


Figure 2: Location of the house

The main façade of the house faces west.

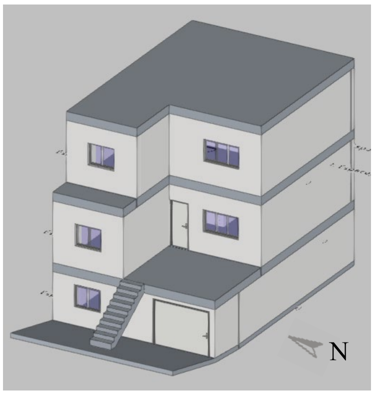


Figure 3: Orientation of the house

2.2. House Plans

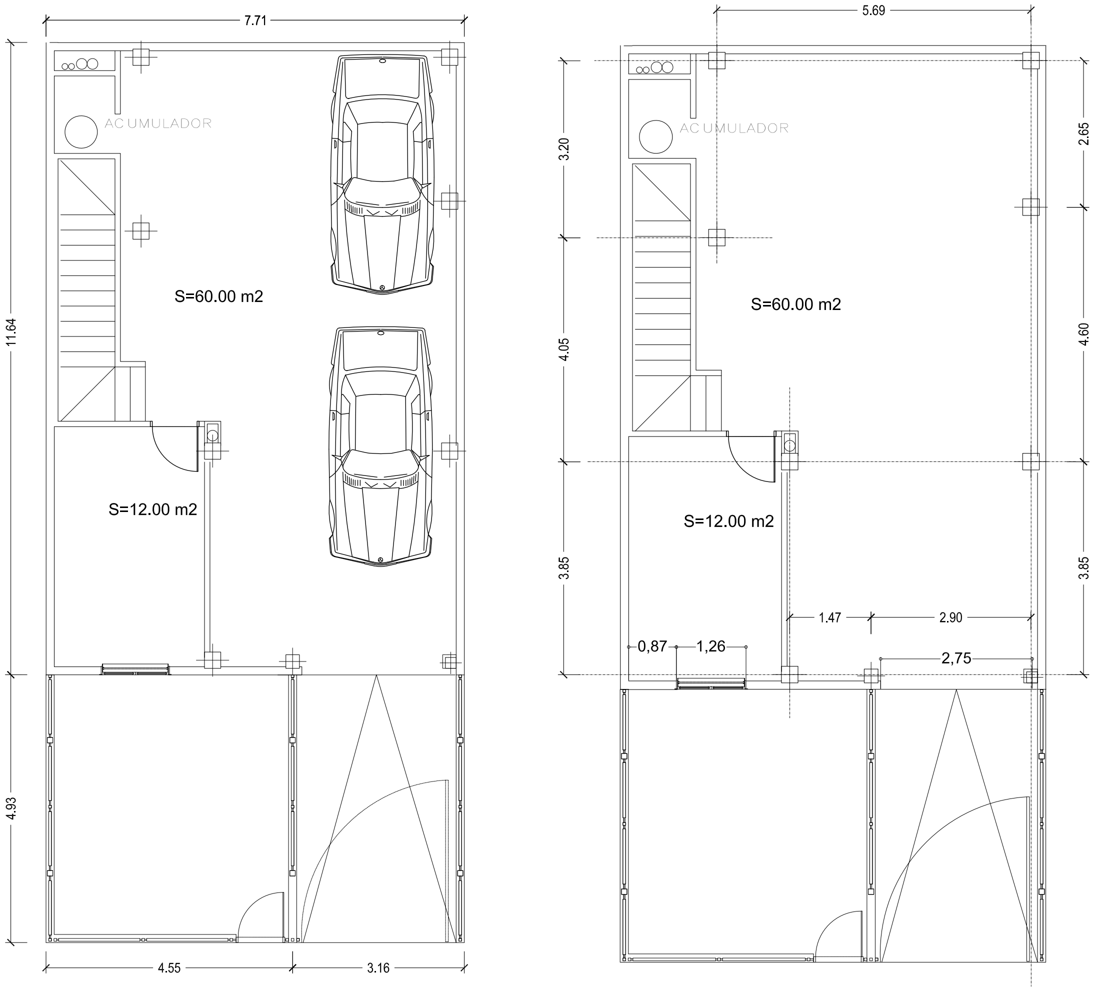


Figure 4: Basement Floor Plans

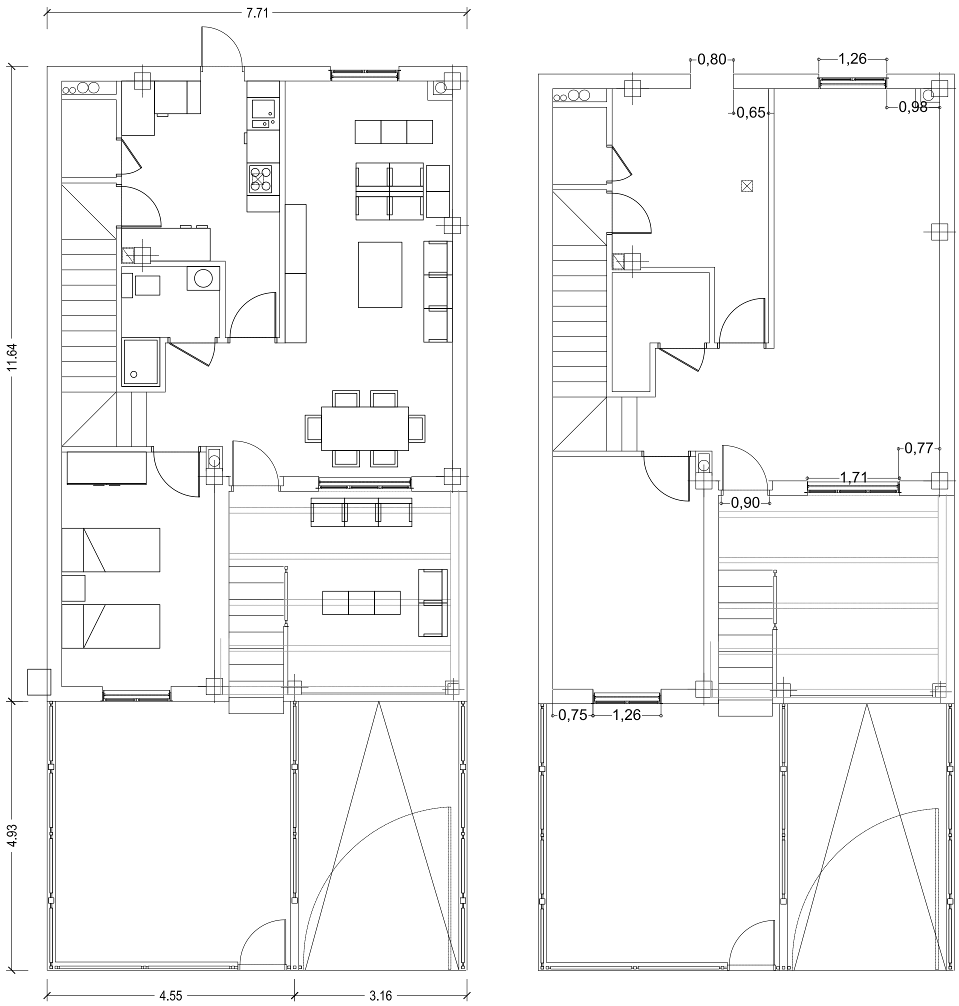


Figure 5: Ground Floor Plans

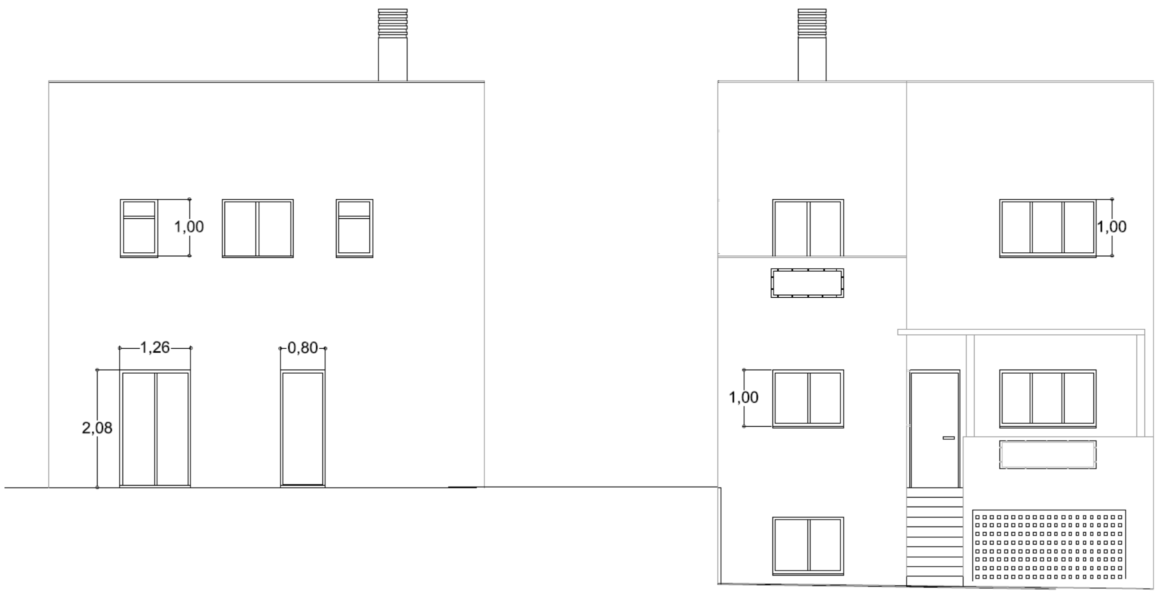


Figure 6: Rear and front elevations.

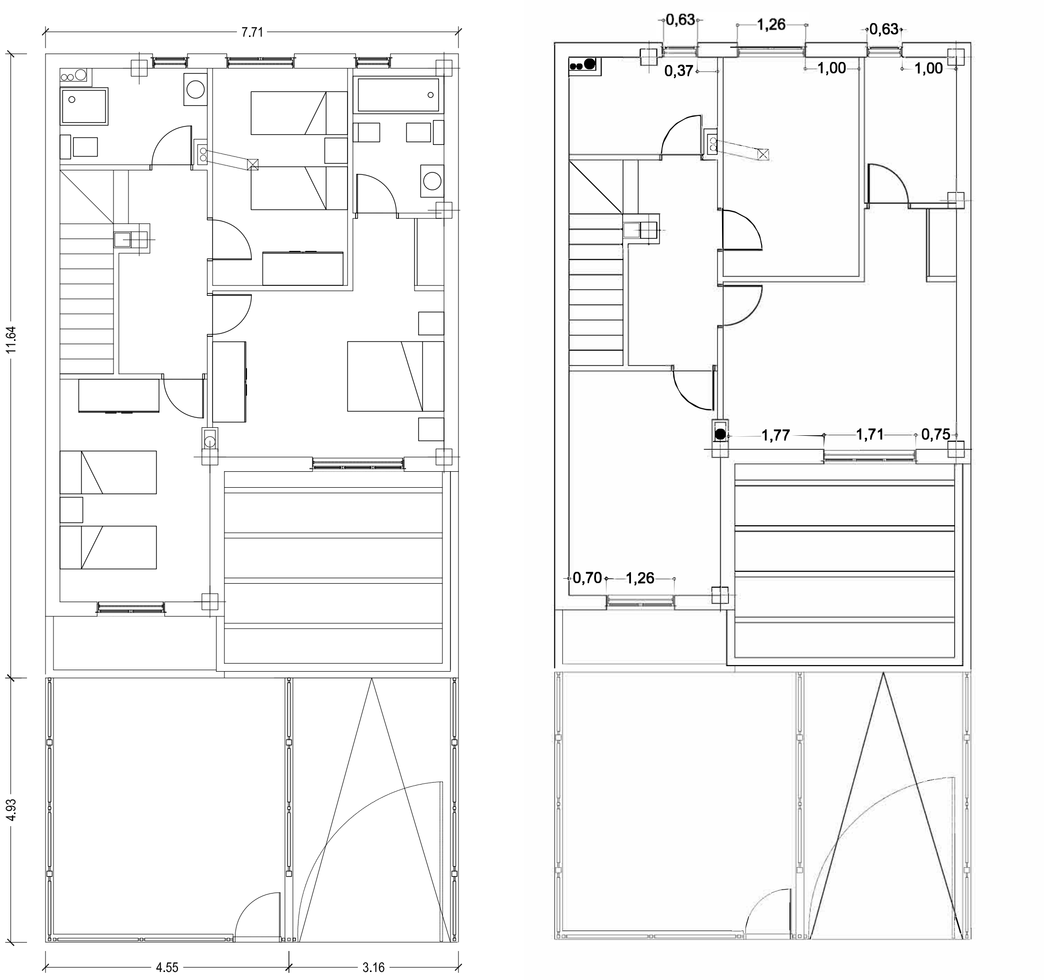


Figure 7: First Floor Plans

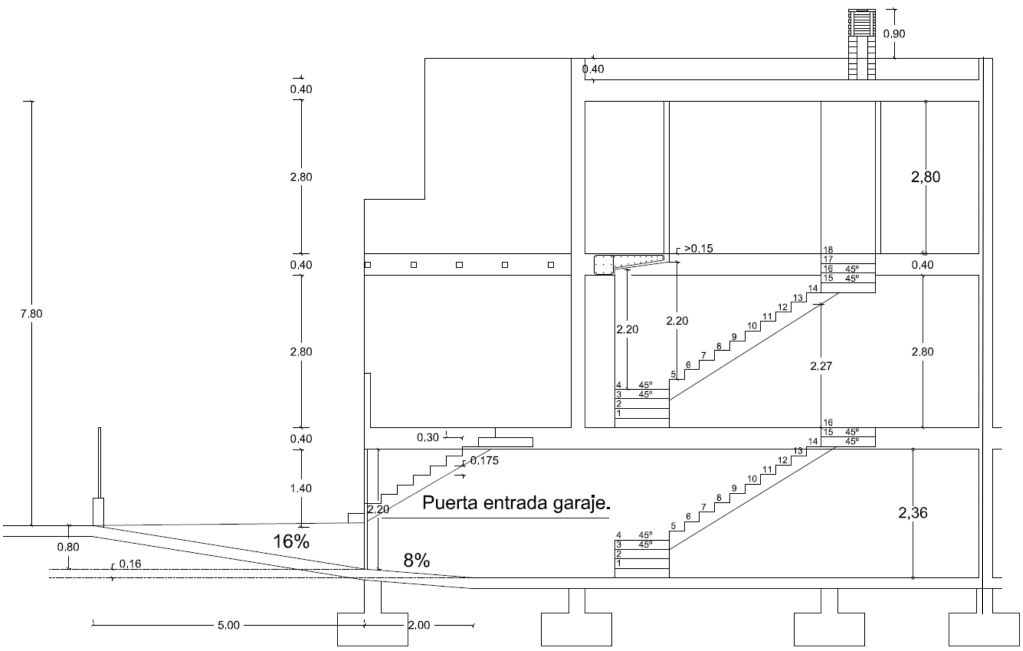


Figure 8: Building section.

2.3. Thermal Envelope Materials

The thermal envelope of a building refers to the collective system of elements that separate the conditioned interior spaces from the unconditioned exterior environment. It includes exterior walls, roofs, floors (particularly those in contact with unconditioned areas or the ground), as well as windows and exterior doors.

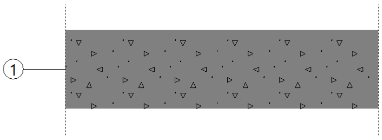
The primary function of the thermal envelope is to regulate the flow of heat, air, and moisture, thereby minimizing heat loss during cold seasons and heat gain during warm seasons. It also reduces air infiltration and exfiltration, contributing significantly to occupant thermal comfort and the overall energy efficiency of the building.

The performance of the thermal envelope is typically evaluated through its thermal resistance (R-value), thermal transmittance (U-value), and airtightness.

A well-designed and properly constructed thermal envelope is essential for achieving high energy performance standards, reducing operational energy costs, and maintaining indoor environmental quality.

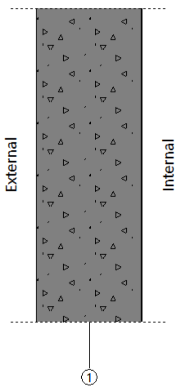
The characteristics of the elements that belong to the thermal envelope of the studied building are described below.

Floors in contact with the ground (screed)



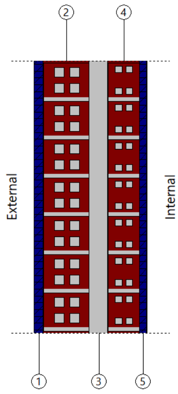
Layers
1 - Concrete. Medium density (density 1800): 15.00 cm Total thickness: 15.00 cm
Thermal description
Thermal resistance: 0.13 (m²·K)/W

Walls in contact with soil



Layers
1 - Concrete. Medium density (density 2200): 20.00 cm Total thickness: 20.00 cm
Thermal description
Thermal resistance: 0.12 (m²·K)/W

Façades



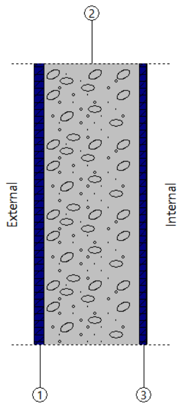
Layers
1 - Cement, sand: 2.00 cm
2 - M01 - 100 mm brick: 10.16 cm
3 - F04 - Wall air space resistance: 4.00 cm
4 - M007 - 70 mm brick: 7.00 cm
5 - Gypsum (density 600): 1.60 cm
Total thickness: 24.76 cm
Thermal description
Heat transfer coefficient (U): 1.61 W/(m²·K)
Thermal capacity: 53714.62 J/m²·K

Façade openings

Windows with aluminum frame and monolithic glass

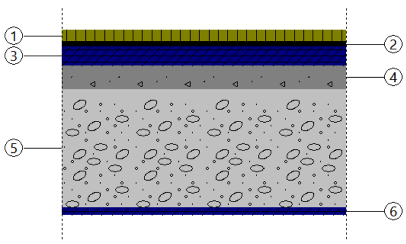
Heat transfer coefficient (U)	5.70	W/(m²·K)
Solar heat gain coefficient	0.70	

Party walls



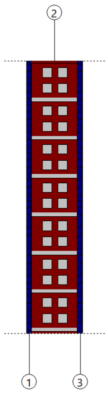
Layers
1 - Cement, sand: 2.00 cm
2 - M03 - 200 mm LW concrete block: 20.32 cm
3 - Gypsum (density 600): 1.50 cm
Total thickness: 23.82 cm
Thermal description
Heat transfer coefficient (U): 1.29 W/(m²·K)
Thermal capacity: 37649.65 J/m²·K

Roofs



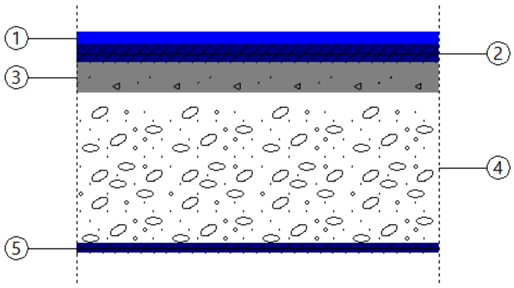
Layers
1 - F18 - Terrazzo: 2.54 cm
2 - Asphalt: 1.00 cm
3 - Cement, sand: 4.00 cm
4 - Concrete. Reinforced (with 2% of steel): 5.00 cm
5 - M04 - 300 mm LW concrete block: 25.00 cm
6 - Gypsum (density 600): 1.50 cm
Total thickness: 39.04 cm
Thermal description
Heat transfer coefficient (cooling): 1.36 W/(m²·K)
Heat transfer coefficient (heating): 1.51 W/(m²·K)
Thermal capacity: 145567.19 J/m²·K

Interior partitions



Layers
1 - Gypsum (density 600): 1.00 cm
2 - M01 - 100 mm brick: 10.16 cm
3 - Gypsum (density 600): 1.00 cm
Total thickness: 12.16 cm
Thermal description
Heat transfer coefficient (U): 2.06 W/(m²·K)
Thermal capacity: 53129.19 J/m²·K

Intermediate slabs



Layers
1 - Ceramic/porcelain: 2.00 cm
2 - Cement, sand: 3.00 cm
3 - Concrete. Medium density (density 2200): 5.00 cm
4 - M03 - 200 mm LW concrete block: 25.00 cm
5 - Gypsum (density 600): 1.50 cm
Total thickness: 36.50 cm
Thermal description
Ceiling slab
Heat transfer coefficient (cooling): 1.00 W/(m²·K)
Heat transfer coefficient (heating): 1.16 W/(m²·K)
Floor slab
Heat transfer coefficient (cooling): 1.16 W/(m²·K)
Heat transfer coefficient (heating): 1.00 W/(m²·K)
Floor slab exposed to open air
Heat transfer coefficient (cooling): 1.25 W/(m²·K)
Heat transfer coefficient (heating): 1.15 W/(m²·K)
Thermal capacity: 141371.08 J/m²·K

2.4. Heating and air conditioning systems

The heating and air conditioning system is a multi-split direct expansion system with the properties shown in the following Figure.

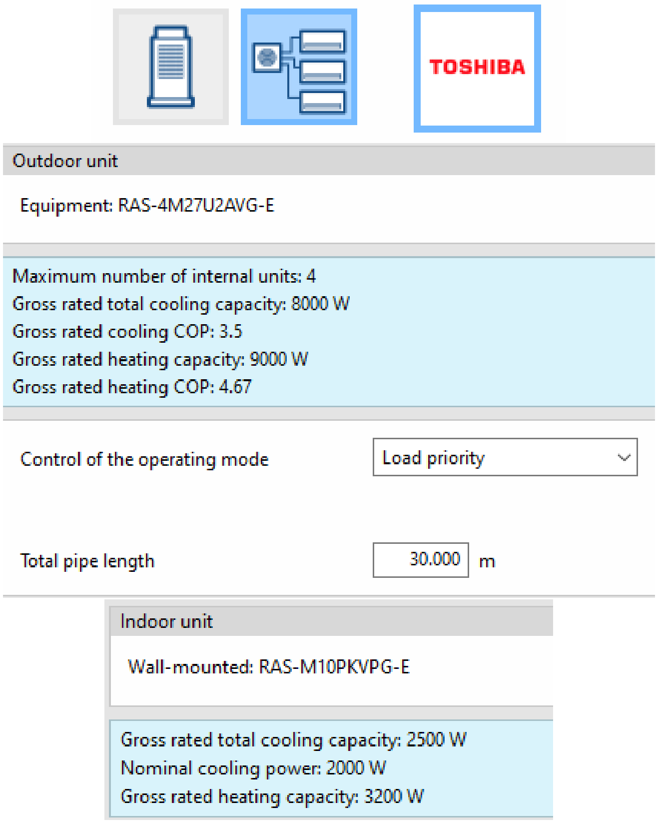


Figure 9: Heating and air conditioning system: multi-split direct expansion system properties.

The System has 4 indoor units

2.5. Domestic hot water system

The domestic hot water system consists of an Electric hot water boiler.

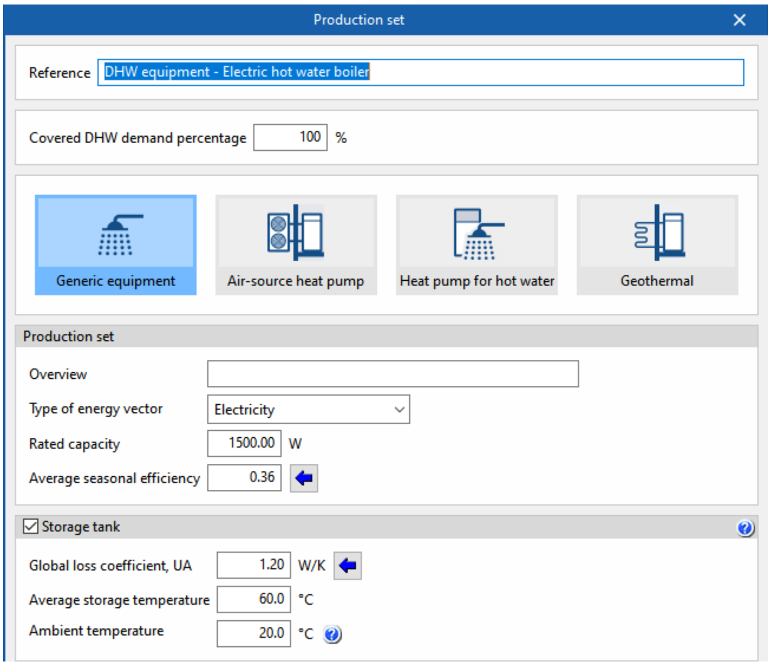


Figure 10: Electric hot water boiler properties.

In this study of the Spanish single-family house, it has been assumed that the temperature of the water for domestic use in the network, before heating it, varies between **10.2 in December** and January and **19.9 °C in August.**

The occupancy considered in the building for the purposes of calculating the need for domestic hot water has been **4 people** in this case study. Domestic hot water needs: **28 litres per person and per day**.

3. Development of the Spanish Case Study

3.1. Building BIM model

A **Building Information Model** (BIM) for energy analysis is a digital representation of a building that integrates both geometric and semantic data, enabling detailed simulations of the building's energy performance. Unlike a standard 3D model, a BIM includes information about materials, thermal properties, occupancy schedules, lighting systems, HVAC equipment, and more.

When used for energy analysis, the BIM serves as a data-rich foundation that can be exported to energy simulation software (EnergyPlus in this case study). This allows energy consultants to evaluate heating and cooling loads, daylighting, thermal comfort, and overall energy consumption.

Key benefits include:

- **Automated data transfer** from design to simulation
- **Improved accuracy** due to consistent and detailed inputs
- **Integrated design workflows** between architects, engineers, and energy analysts

The following figures show several views of the building's geometric BIM model.

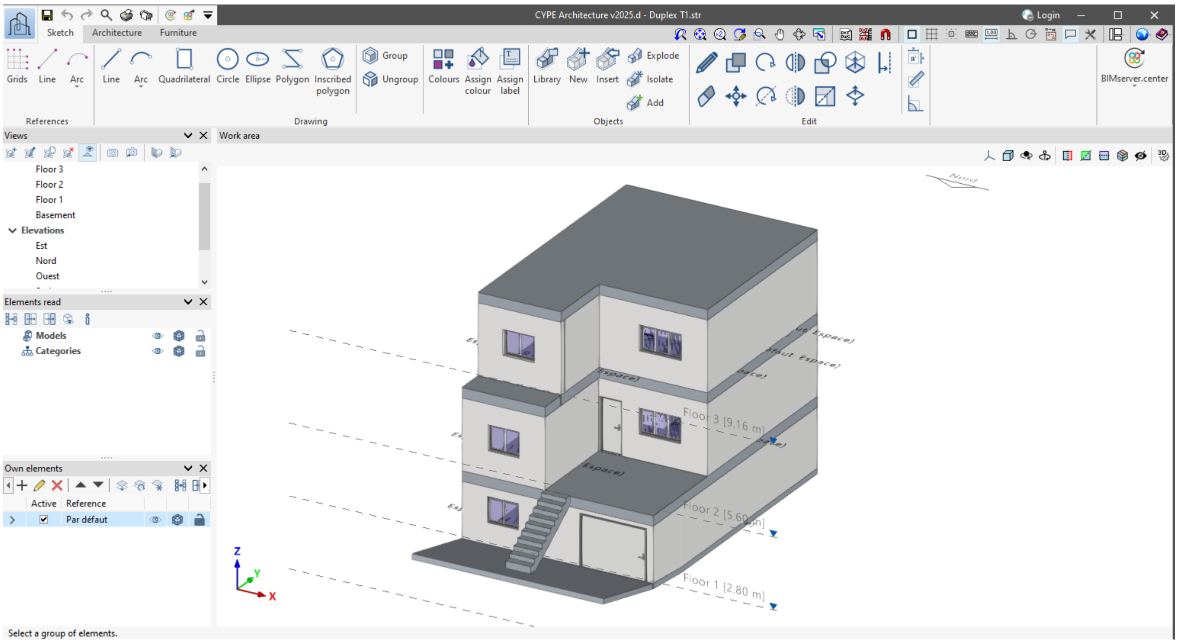


Figure 11 BIM model

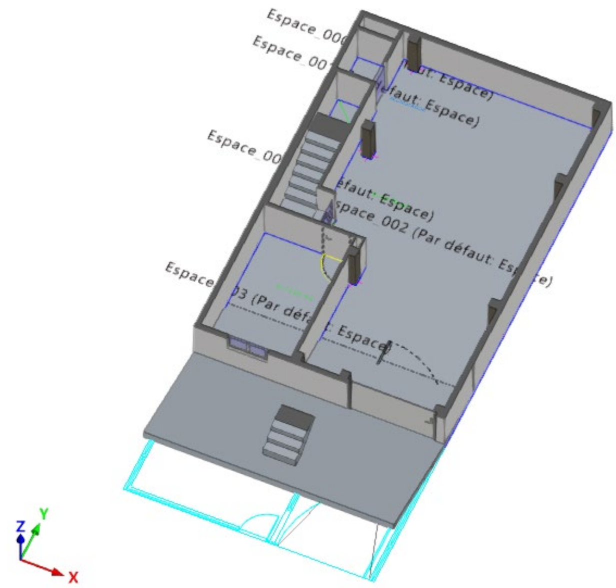


Figure 12 Basement floor in BIM model

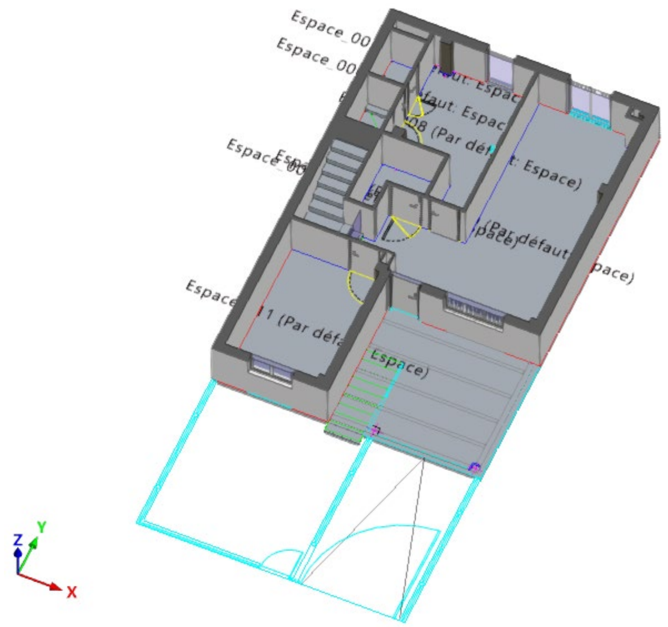


Figure 13 Ground floor in BIM model

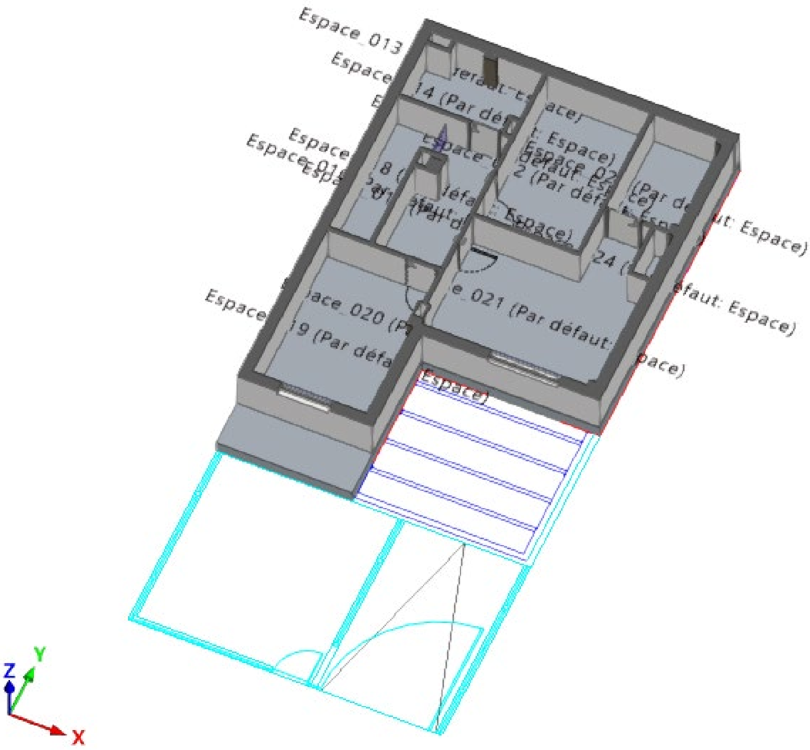


Figure 14 Fist floor in BIM model

3.2. Analytical model of the building.

The **analytical model of the building** is made up of the interior spaces of the building into which the interior volume of the building is divided with its characteristics (volume of space, surfaces that eliminate the space...).

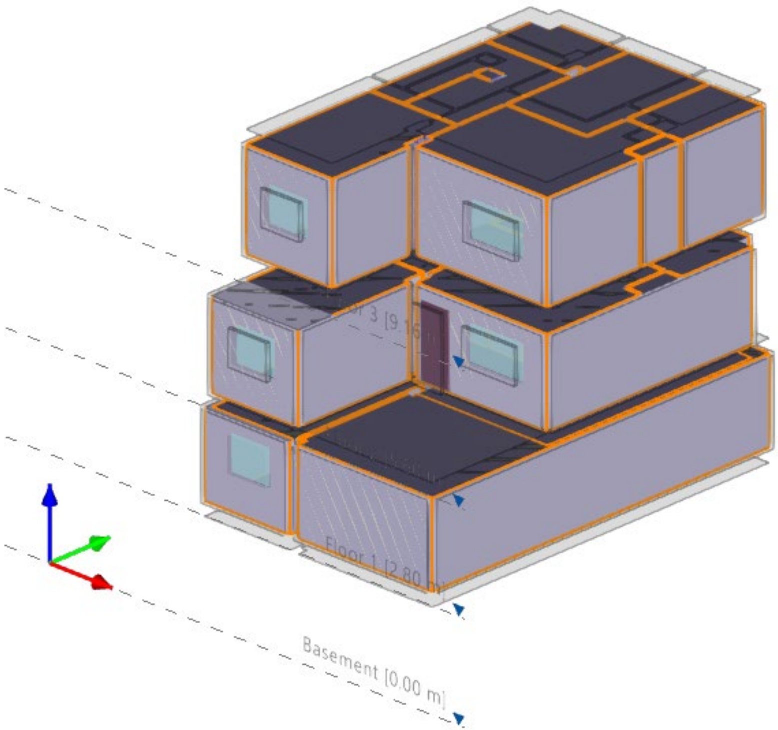


Figure 15 Analytical model of the building.

In this work, the interior spaces of the building have been grouped into 2 different zones.

These zones are:

- Z01 - House
- Z02 - Basement

Zone 1 (House) is the dwelling. It is the conditioned area of the building.

Zone 2 (Basement) is not habitable

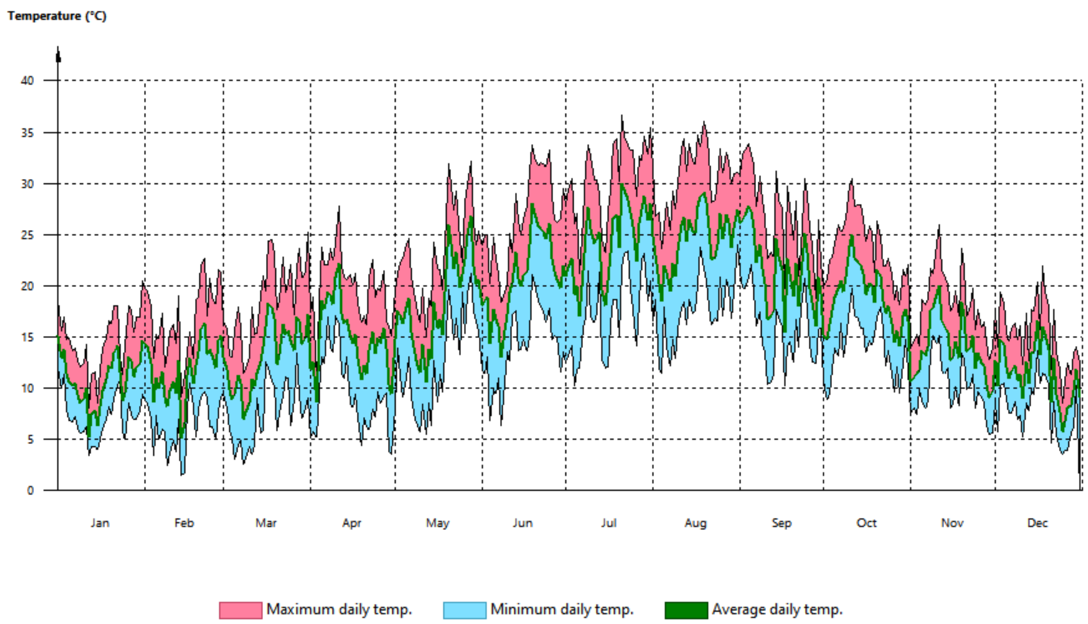
The ventilation of the existing building consists of natural ventilation.

The ventilation needs introduced in the model have been **0.63 interior air renovations per hour** for dwellings, common areas, and kitchens and bathrooms, and 1 renovation per hour for the basement.

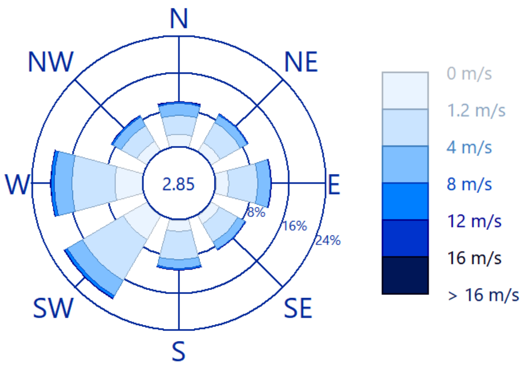
3.3. Climatic zone

The climatic zone in which the house is located is B3 according to the Spanish standard of energy efficiency in the building. B3 corresponds to a climatic zone with a mild winter and a hot summer.

The data of the **outside temperature** considered in this case study in this climatic zone are as follows:

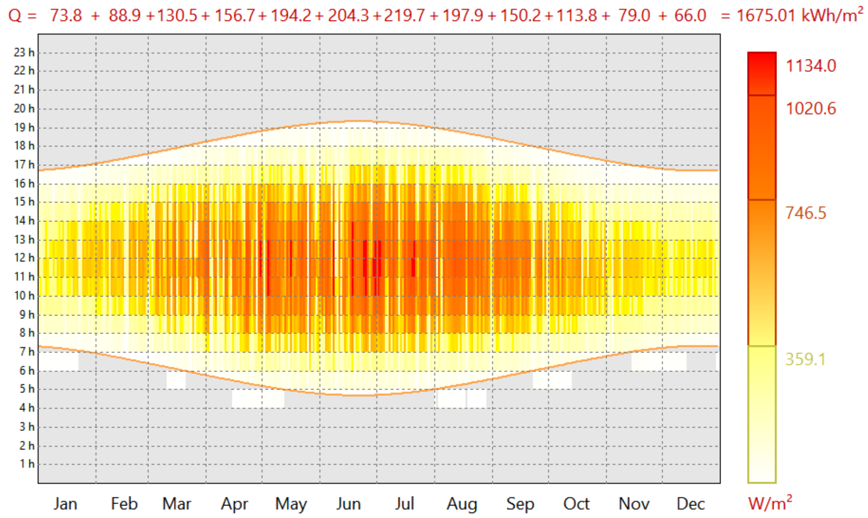


Wind distribution:



Solar irradiation on the site of the house:

The graph below shows the global irradiance on a horizontal surface



3.4. Operational conditions of conditioned spaces for private residential use

For the energy analysis of the building, the operational conditions of the conditioned spaces of the building have been used, which are indicated in the following table.

Table 1: Operational conditions of the conditioned spaces of the building for private residential use

		Schedule (typical week)			
		0:00-6:59	7:00-14:59	15:00-22:59	23:00-23:59
High setpoint temperature (ºC)	January to May	--	--	--	--
	June to September	25	--	25	27
	October to December	--	--	--	--
Low setpoint temperature (ºC)	January to May	17	20	20	17
	June to September	--	--	--	--
	October to December	17	20	20	17

3.5. Building Energy Model

A building energy model is a detailed digital simulation of a building's energy use, created to analyse and predict its energy performance. It includes inputs such as the building's geometry, orientation, construction materials, insulation levels, HVAC systems, lighting, occupancy patterns, and local climate data. The model uses this information to calculate energy consumption for heating, cooling, lighting, ventilation, and plug loads over time.

This model is essential for:

- Evaluating design alternatives
- Estimating energy savings
- Complying with building codes
- Supporting green building certifications (e.g., LEED, BREEAM)
- Performing cost-benefit analysis of energy efficiency measures

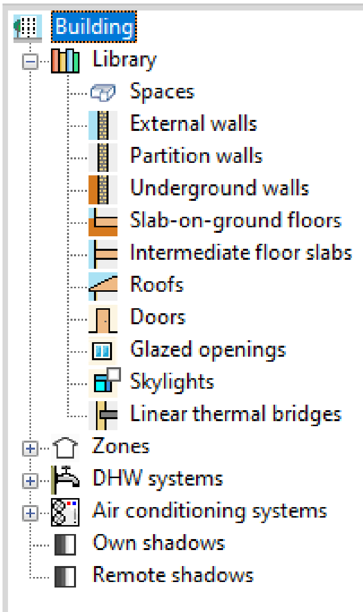


Figure 16: Some components of the Building Energy Model

3.6. Spanish single family house project in BIMServer.center

The BIM model of the building, the analytical model and the energy model of the current situation of the building are shared on the **BIM platform**. BIMServer.center.

This project can be visited using the following link:

https://bimserver.center/es/project/604611?tab=0

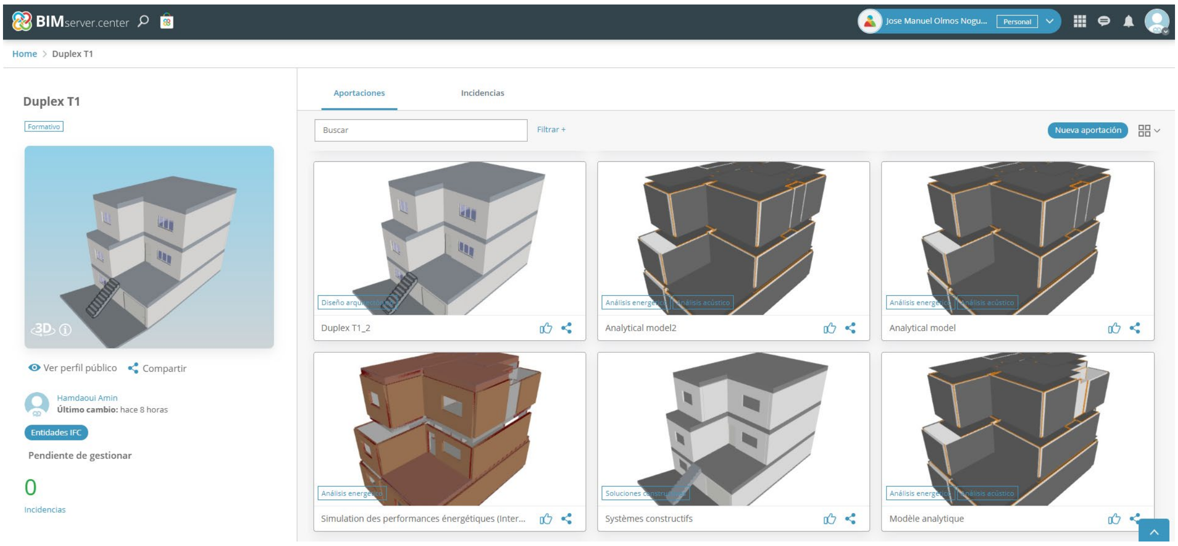
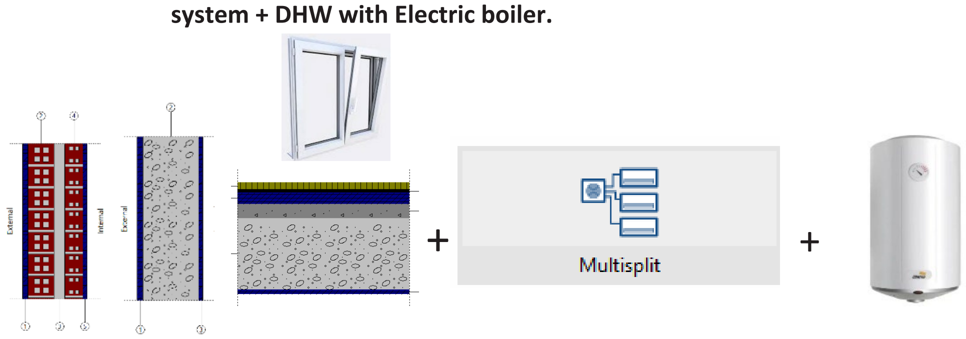


Figure 17: Single family house in BIMServer.center

3.7. Cases analysed. Description

- **Case 1: Initial situation 1: Envelope without isolation + H & AC direct expansion system + DHW with Electric boiler.**



(Façade party wall + roof)
(Single glass windows with aluminum frame. U=5.7 W/(m^2·K))
Envelope without insolation + HVAC direct expansion system + DHW with Electric boiler

- **Case 2: Initial situation 2: Envelope without isolation + Gas Boiler & radiators for heating and DHW + Cooling system multi-split direct expansion system.**

(Façade party wall + roof)
(Single glass windows with aluminum frame. U=5.7 W/m^2·K)

Envelope without insolation + Heating and DHW gas boiler and radiators + AC with direct expansion multisplit system.

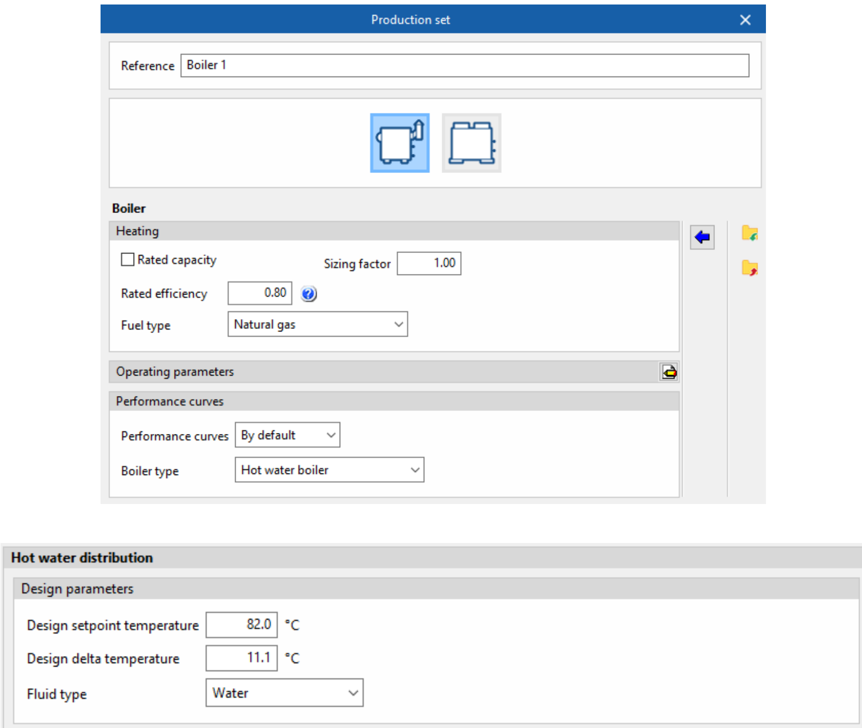
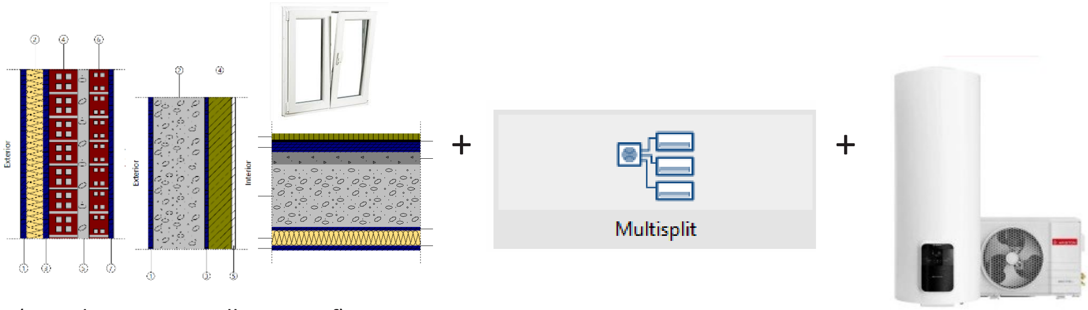


Figure 18: Heating and DHW gas boiler features

- **Case 3: Improvement 1 of the Initial situation case 1. Improved envelope 6 cm Insolation + PVC Double glazed windows with argon gas + H & AC direct expansion multisplit System + DHW heat pump.**



(Façade party wall roof)
(PVC Double glazed windows with argon gas. U= 1.7 W/m²·K)

Improved envelope 6 cm Insolation layer + H & AC direct expansion multisplit System + DHW heat pump.

Features of the DHW heat pump:

- Rated Power 1500 W
- SCOP: 3.57 in accordance with EN-16147
- Accumulation capacity: 200 liters.

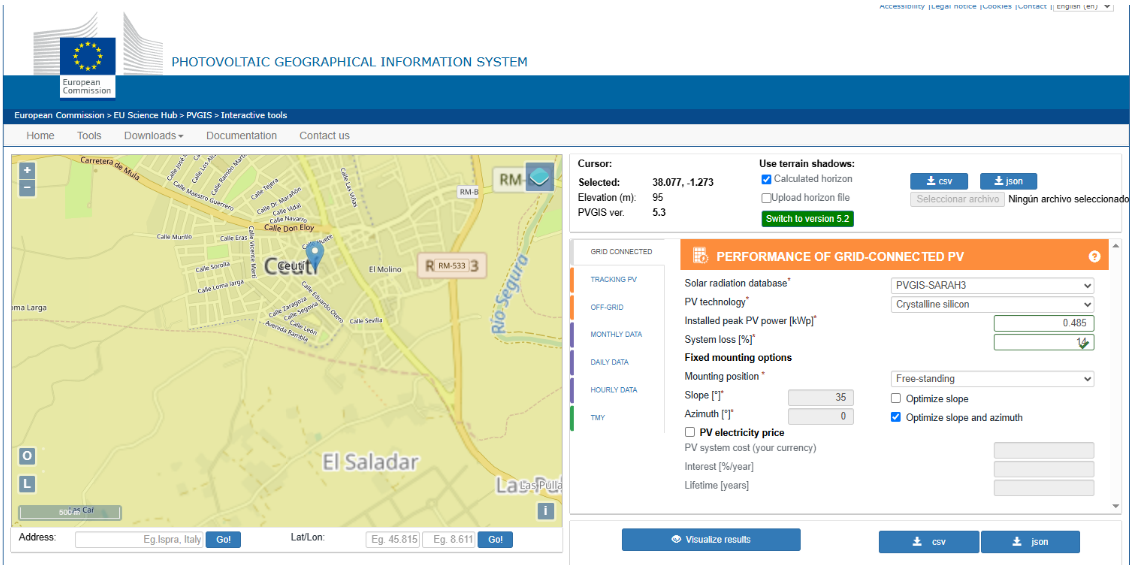
-

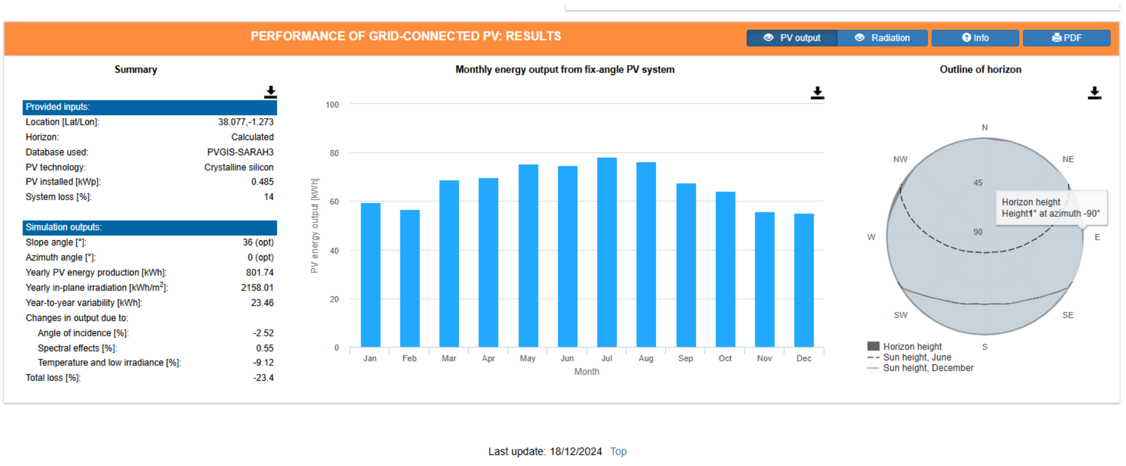
- **Case 4: Improvement 2 of the Initial situation case 1. Improved envelope 6 cm Insolation + PVC Double glazed windows with argon gas +H & AC direct expansion multi-split System + DHW heat pump + Photovoltaic panels.**

Case 3+  12 m2 of photovoltaic panels of (161.6 W/m2)

Characteristics of Photovoltaic Panels:

The power of the module is 485W, efficiency – 22.4%.
Size of the panel (module): 3 m^2.
Orientation (azimuth angle) : 0º
Slope angle: 35º
Number of panels used: 4



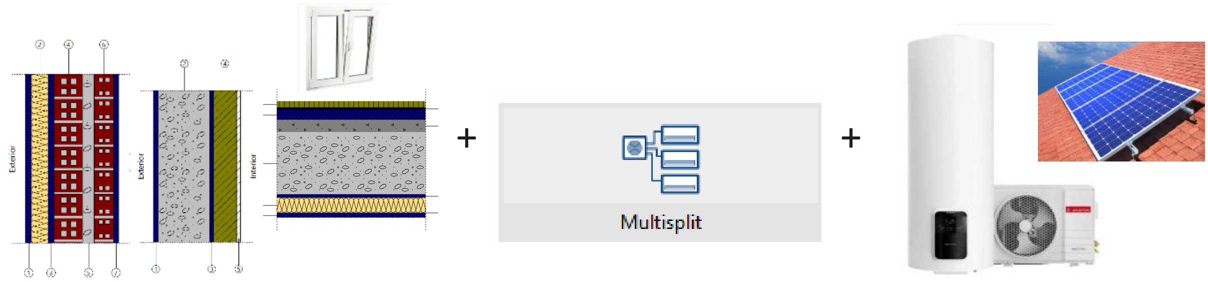


Energy production of the photovoltaic system by month in Ceutí (Spain):

	Energy production per panel kwh	Number of panels	Energy production kwh
January	59,6	4	238,4
February	56,8	4	227,2

	Energy production per panel	Number of panels	Energy production
	kwh		**kwh**
march	68,7	4	274,8
April	69,7	4	278,8
may	75,4	4	301,6
June	74,9	4	299,6
July	78,1	4	312,4
August	76,3	4	305,2
September	67,5	4	270
October	64	4	256
November	55,8	4	223,2
December	55	4	220
Total	**801,8**		**3207,2**

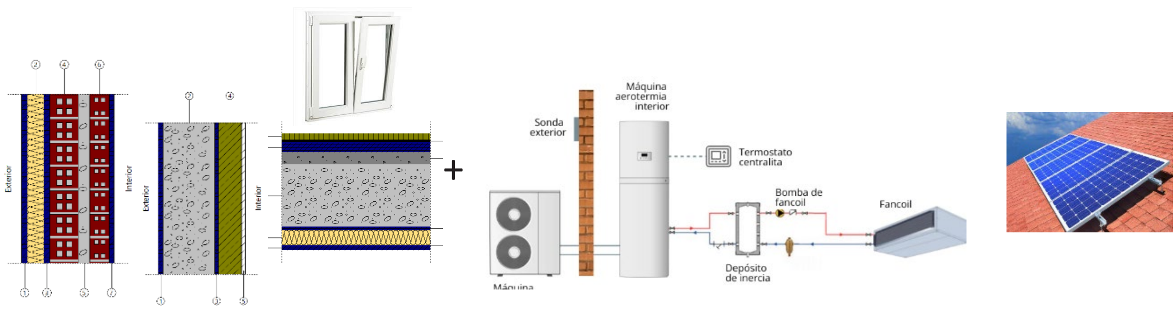
- **Case 5: Improvement 3 of the Initial situation case 1. Improved envelope 10 cm Insolation + PVC Double glazed windows with argon gas + H & AC direct expansion multisplit System + DHW heat pump + Photovoltaic panels. (Case 4 but with 10 cm of insulation layer in the enveloped) .**



(Façade party wall roof)
(PVC Double glazed windows with argon gas. U= 1.7 W/m²·K)

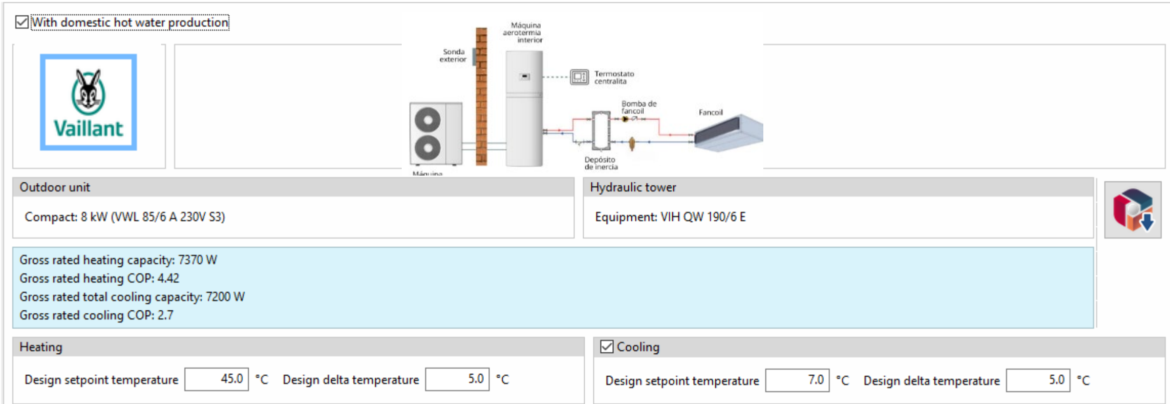
(Case 4 but with 10 cm of insulation layer in the enveloped) .

- **Case 6 : Improvement 4 of the Initial situation case 1. Improved envelope 6 cm Insolation + PVC Double glazed windows with argon gas + H & AC and DHW Aerothermal with fan coil + Photovoltaic panels**



(Façade party wall roof) Aerothermal system with fan coils
(PVC Double glazed windows with argon gas. U= 1.7 W/m²·K)

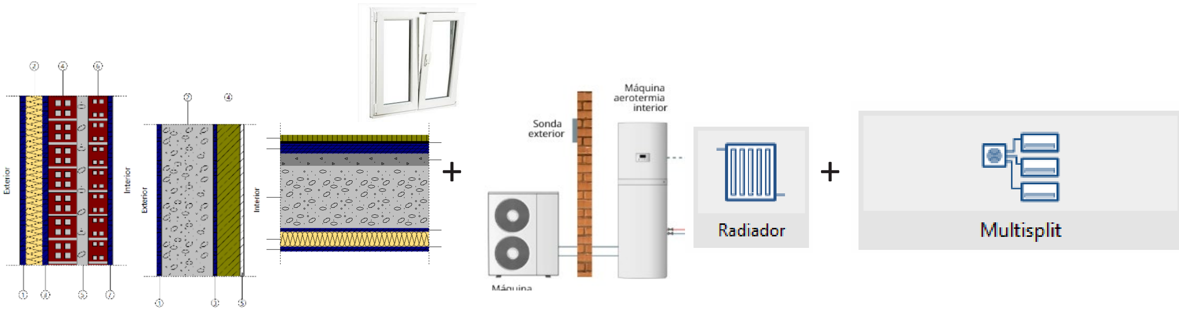
Characteristics of Aerothermal system with fan coils for heating and cooling.



Fan coil unit:

Equipment
Wall-mounted: VA 1-025 WN
Gross rated total cooling capacity: 2700 W Nominal cooling power: 2150 W Gross rated heating capacity: 2940 W Supply air flow: 136.667 l/s

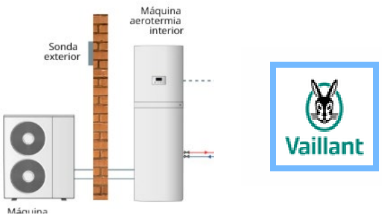
- **Case 7 : Improvement 1 of the Initial situation case 2. Improved envelope 6 cm Insolation + Aerothermal with radiators for Heating and DHW + Cooling with direct expansion multi-split system.**



(Façade party wall roof) + Aerothermal heating system with radiators + AC direct expansion system.
(PVC Double glazed windows with argon gas. U= 1.7 W/m²·K)

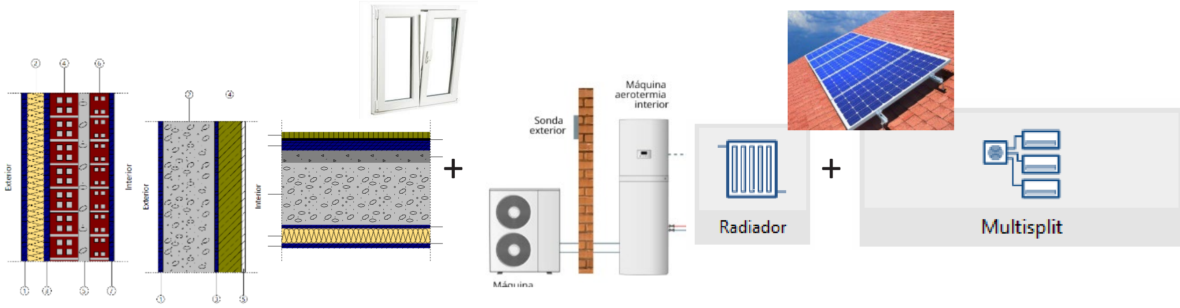
Characteristics of the Aerothermal system for heating and DHW:

Outdoor unit
Compact: 8 kW (VWL 85/6 A 230V S3)
Gross rated heating capacity: 7370 W Gross rated heating COP: 4.42 Gross rated total cooling capacity: 7200 W Gross rated cooling COP: 2.7



Hydraulic tower
Equipment: VIH QW 190/6 E

- **Case 8 : Improvement 2 of the Initial situation case 2. Improved envelope 6 cm Insolation + Aerothermal with radiators for Heating and DHW + Cooling with direct expansion multi-split system + Photovoltaic panels.**



(Façade party wall roof) + Aerothermal heating system with radiators + Cooling multisplit direct expansion system.
(PVC Double glazed windows with argon gas. U= 1.7 W/m²·K)

Table 2: Summary of the cases studied. Initial situations and improvements

Initial situation of the house	**House with impovement**
Case 1: Initial situation 1: Envelope without isolation + H & AC direct expansion system + DHW with Electric boiler.	**Case 3:** Improvement 1 of the Initial situation case 1. Improved envelope 6 cm Insolation + PVC Double glazed windows with argon gas + H & AC direct expansion multi-split System + DHW heat pump
	Case 4: Improvement 2 of the Initial situation case 1. Improved envelope 6 cm Insolation + PVC Double glazed windows with argon gas +H & AC direct expansion multi-split System + DHW heat pump + Photovoltaic panels. (case 3+ PV panels)
	Case 5: Improvement 3 of the Initial situation case 1. Improved envelope 10 cm Insolation + PVC Double glazed windows with argon gas + H & AC direct expansion multi-split System + DHW heat pump + Photovoltaic panels. (Case 4 but with 10 cm of insulation layer in the enveloped)
	Case 6: Improvement 4 of the Initial situation case 1. Improved envelope 6 cm Insolation + PVC Double glazed windows with argon gas + H & AC and DHW Aerothermal with fan coil + Photovoltaic panels
Case 2: Initial situation 2: Envelope without isolation + Heating and DHW Sys: Gas Boiler & radiators + Cooling system: multisplit direct expansion system	**Case 7:** Improvement 1 of the Initial situation case 2. Improved envelope 6 cm Insolation + Aerothermal with radiators for Heating and DHW + Cooling with direct expansion multi-split system.
	Case 8: Improvement 2 of the Initial situation case 2. Improved envelope 6 cm Insolation + Aerothermal with radiators for Heating and DHW + Cooling with direct expansion multi-split system + Photovoltaic panels. (Case 7 + PV Panels)

3.8. Case Results. Energy Consumption and Energy rating of the existing building.

In this section and in the following one, the annual consumption of final energy, primary energy and non-renewable primary energy corresponding to the different technical services of the building are shown for the 2 initial situation of the building and for the 5 alternatives to improve its energy performance. The consumption of heating and cooling services includes the electricity consumption of the auxiliary equipment of the air conditioning systems.

In addition, the energy rating of the cases studied (2 initial situations and the 5 improvement alternatives) is also shown. This rating has been calculated following Spanish standards considering climate zone: B3

In order to clarify concepts, some definitions are introduced here:

Total primary energy consumption.

Total Primary Energy Consumption in the context of a building energy efficiency analysis refers to the total amount of energy from all sources (like electricity, gas, oil, or renewables) that is required to operate the building, including the energy used to produce and deliver that energy.

More specifically:

- **"Primary energy"** means the energy in its original, raw form—before it is converted into electricity or heat. For example, coal, natural gas, crude oil, or sunlight.
- This includes energy **used on-site** (like gas for heating) and **converted energy** (like electricity), but it also accounts for the **losses that occur during generation, transmission, and distribution**.

So, Total Primary Energy Consumption tells you how much raw energy is ultimately needed to run the building, giving a full picture of its environmental impact.

Primary energy consumption of non-renewable origin.

Primary energy consumption of non-renewable origin refers to the **total amount of non-renewable primary energy** used to operate a building, including:

- **Fossil fuels**: coal, natural gas, and oil
- **Nuclear energy**
- **Any other non-renewable energy sources**

This measurement includes:

- Energy **directly used on-site**, like natural gas for heating
- Energy **used indirectly**, such as electricity generated from coal or gas (including losses from generation and transmission)

Energy consumption at the point of consumption (final energy).

Energy consumption at the point of consumption, also known as **final energy consumption**, refers to the **amount of energy actually used by the building** for its various functions, such as:

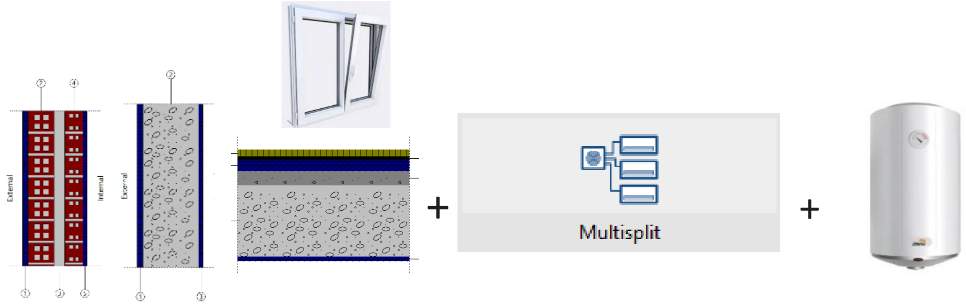
- **Heating**
- **Cooling**
- **Lighting**
- **Hot water**
- **Appliances and equipment**

This is the **energy delivered to the building** and **measured at the meter**, such as electricity bills or gas usage. It **does not include energy losses** that occurred during production, conversion, or transmission (which are included in *primary energy*).

In summary:

- **Final energy** = Energy used **inside the building**, as seen by the user.
- **Primary energy** = Final energy **plus upstream losses** (e.g. power plant efficiency, grid transmission losses).

- **Case 1: Initial situation 1: Envelope without isolation + H & AC direct expansion system + DHW with Electric boiler.**



(Façade party wall + roof)
(Single glass windows with aluminum frame. U=5.7 W/(m²·K))
Envelope without insolation + HVAC direct expansion system + DHW with Electric boiler

Energy consumption of the building's technical services

BUILDING (S_u = 116.38 m²)

Technical Services	**EF** (kWh/year)	**EF** (kWh/m²·year)	**EP$_{tot}$** (kWh/year)	**EP$_{tot}$** (kWh/m²·year)	**EP$_{nren}$** (kWh/year)	**EP$_{nren}$** (kWh/m²·year)
Heating	6509.13	55.93	8858.99	76.12	3356.51	28.84
Cooling	473.72	4.07	1121.75	9.64	925.65	7.95
DHW	7469.42	64.18	17687.61	151.99	14595.27	125.42
	14452.27	124.19	27668.47	237.75	18877.44	162.21
Requirements of the Spanish standard kWh/m²·year				<80.00 **NO!**	kWh/m²·year	<55.00 **NO!**

where:

S_u: Living area included in the thermal envelope, m².
EF: Final energy consumed by the technical service at the point of consumption.
EP_{tot}: Total primary energy consumption.
EP_{nren}: Primary energy consumption of non-renewable origin.

Final energy consumption of the building. Monthly results.

		Jan (kWh)	Feb (kWh)	Mar (kWh)	Apr (kWh)	May (kWh)	Jun (kWh)	Jul (kWh)	Aug (kWh)	Sep (kWh)	Oct (kWh)	Nov (kWh)	Dec (kWh)	Year (kWh/year)	Year (kWh/m²·año)
BUILDING (S_u = 116.38 m²)															
Energy demand	**Heating**	**1529.5**	**1108.3**	**909.5**	**486.1**	**253.7**	**--**	**--**	**--**	**--**	**48.1**	**640.7**	**1378.7**	**6354.6**	**54.6**
	Cooling	**--**	**--**	**--**	**--**	**--**	**180.7**	**488.1**	**539.1**	**211.4**	**--**	**--**	**--**	**1419.3**	**12.2**
	DHW	**244.3**	**220.7**	**240.1**	**227.6**	**226.8**	**211.2**	**209.8**	**205.6**	**207.2**	**223.1**	**228.2**	**244.3**	**2689.0**	**23.1**
	TOTAL	**1773.8**	**1329.0**	**1149.5**	**713.7**	**480.5**	**392.0**	**697.9**	**744.8**	**418.5**	**271.3**	**869.0**	**1623.0**	**10462.9**	**89.9**
Electricity	**Heating**	409.5	298.8	246.5	132.8	69.1	0.8	2.0	2.2	0.9	13.2	172.1	369.9	1717.8	14.8
	Cooling	3.1	2.3	1.8	1.0	0.5	59.8	157.9	174.4	68.9	0.1	1.2	2.8	473.7	4.1
	DHW	678.6	613.0	666.9	632.3	629.9	586.8	582.9	571.2	575.5	619.9	634.0	678.6	7469.4	64.2
	Ventilation	--	--	--	--	--	--	--	--	--	--	--	--	--	
	Humidity control	--	--	--	--	--	--	--	--	--	--	--	--	--	
	Lighting	--	--	--	--	--	--	--	--	--	--	--	--	--	
Environment	**Heating**	1155.6	835.4	684.4	365.0	189.9	--	--	--	--	36.0	483.1	1042.0	4791.4	41.2
	Cooling	--	--	--	--	--	--	--	--	--	--	--	--	--	
	DHW	--	--	--	--	--	--	--	--	--	--	--	--	--	
	$C_{ef,total}$	**2246.8**	**1749.4**	**1599.6**	**1131.0**	**889.4**	**647.3**	**742.7**	**747.8**	**645.3**	**669.1**	**1290.4**	**2093.3**	**14452.3**	**124.2**

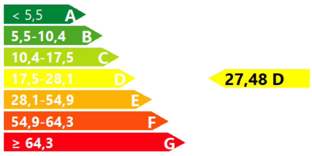
where:

S_u: Living area included in the thermal envelope, m².
$C_{ef,total}$: Energy consumption at the point of consumption (final energy), kWh/m²·year.

Energy rating of the building: Case1. Initial situation 1.

Climatic zone (eq.)	B3	**Use**	Private residential

1. ENERGY RATING OF THE BUILDING IN EMISSIONS

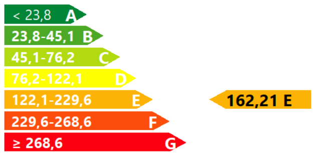
GLOBAL INDICATOR	PARTIAL INDICATORS			
	**HEATING**		**DHW**	
	Heating emissions [$kgCO_2/m^2\cdot year$]	**A**	DHW emissions [$kgCO_2/m^2\cdot year$]	**C**
	4.89		**21.25**	
	COOLING		**LIGHTING**	
Global emissions[$kgCO_2/m^2\cdot year$][1]	Cooling emissions [$kgCO_2/m^2\cdot year$]	**A**	Lighting emissions [$kgCO_2/m^2\cdot year$]	**-**
2.	**1.35**		**-**	

The overall rating of the building is expressed in terms of carbon dioxide released into the atmosphere as a result of its energy consumption.

	$kgCO_2/m^2\cdot year$	**$kgCO_2\cdot year$**
CO2 emissions from electricity consumption	27.48	3197.76
CO2 emissions from other fuels	0.00	0.00

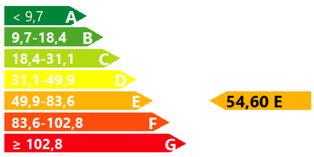
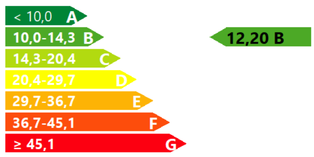
3. ENERGY RATING OF THE BUILDING IN NON-RENEWABLE PRIMARY ENERGY CONSUMPTION

Non-renewable primary energy refers to the energy consumed by the building from non-renewable sources that has not undergone any conversion or transformation process.
4.

GLOBAL INDICATOR	PARTIAL INDICATORS			
	**HEATING**		**DHW**	
	Primary energy heating [$kWh/m^2\cdot year$]	**A**	DHW Primary energy [$kWh/m^2\cdot year$]	**E**
	28.84		**125.42**	
	COOLING		**LIGHTING**	
Global consumption of non-renewable primary energy[$kWh/m^2\cdot year$][1]	Primary energy cooling [$kWh/m^2\cdot year$]	**A**	Primary energy lighting [$kWh/m^2\cdot year$]	**-**
	7.95		**-**	

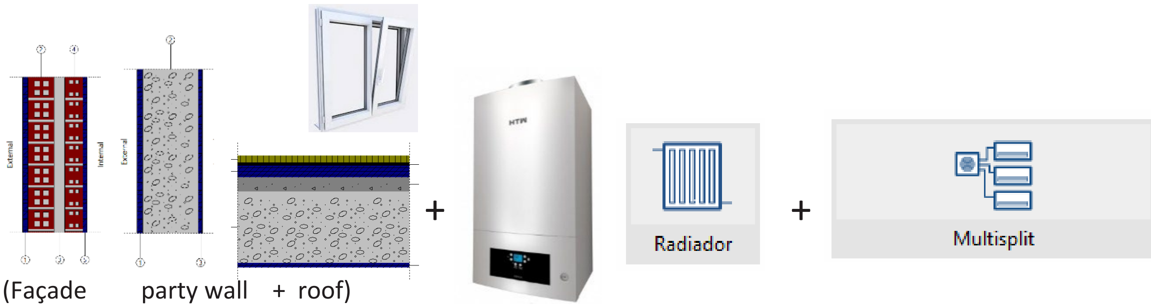
PARTIAL RATING OF HEATING AND COOLING ENERGY DEMAND

The energy demand for heating and cooling is the energy needed to maintain the building's internal comfort conditions.
5.

HEATING DEMAND	COOLING DEMAND
	
6. Heating demand[$kWh/m^2\cdot year$]	Cooling demand[$kWh/m^2\cdot year$]

1 The global indicator is the result of the sum of the partial indicators plus the value of the indicator for auxiliary consumption, if any (only tertiary buildings, ventilation, pumping, etc...). Self-consumed electricity is only deducted from the global indicator, not from the partial values.

- **Case 2: Initial situation 2: Envelope without isolation + Gas Boiler & radiators for heating and DHW + Cooling system multi-split direct expansion system.**



(Façade party wall + roof)
(Single glass windows with aluminum frame. U=5.7 W/m²·K)

Envelope without insolation + Heating and DHW gas boiler and radiators + AC with direct expansion multisplit system.

Energy consumption of the building's technical services

BUILDING (S_u = 116.38 m²)

Technical Services	EF (kWh/year)	EF (kWh/m²·year)	EP_{tot} (kWh/year)	EP_{tot} (kWh/m²·year)	EP_{nren} (kWh/year)	EP_{nren} (kWh/m²·year)
Heating	7986.61	68.63	9631.15	82.76	9524.55	81.84
Cooling	529.43	4.55	1253.60	10.77	1034.46	8.89
DHW	2835.66	24.37	3388.63	29.12	3374.43	29.00
	11351.69	97.54	14273.38	122.65	13933.44	119.73
Requirements of the Spanish standard kWh/m²·year				<80.00 **NO!**	kWh/m²·year	<55.00 **NO!**

where:

S_u: Living area included in the thermal envelope, m².
EF: Final energy consumed by the technical service at the point of consumption.
EP_{tot}: Total primary energy consumption.
EP_{nren}: Primary energy consumption of non-renewable origin.

Final energy consumption of the building. Monthly results.

		Jan (kWh)	Feb (kWh)	Mar (kWh)	Apr (kWh)	May (kWh)	Jun (kWh)	Jul (kWh)	Aug (kWh)	Sep (kWh)	Oct (kWh)	Nov (kWh)	Dec (kWh)	Year (kWh/year)	Year (kWh/m²·año)
EDIFICIO (S_u = 116.38 m²)															
Energy demand	**Heating**	**1529.0**	**1107.9**	**909.1**	**485.9**	**253.6**	**--**	**--**	**--**	**--**	**48.1**	**640.5**	**1378.3**	**6352.3**	**54.6**
	Cooling	**--**	**--**	**--**	**--**	**--**	**180.7**	**488.1**	**539.1**	**211.4**	**--**	**--**	**--**	**1419.3**	**12.2**
	DHW	**208.6**	**188.4**	**204.4**	**193.1**	**191.0**	**176.7**	**174.1**	**169.9**	**172.6**	**187.4**	**193.7**	**208.6**	**2268.5**	**19.5**
	TOTAL	**1737.6**	**1296.3**	**1113.5**	**678.9**	**444.6**	**357.4**	**662.2**	**709.0**	**384.0**	**235.5**	**834.1**	**1586.9**	**10040.1**	**86.3**
Electricity	**Heating**	14.1	11.6	10.4	6.7	3.9	1.3	3.4	3.8	1.5	1.2	8.6	13.4	80.0	0.7
	Cooling	11.9	9.7	8.9	5.8	3.5	60.6	161.1	177.4	70.3	1.2	7.5	11.5	529.4	4.5
	DHW	--	--	--	--	--	--	--	--	--	--	--	--	--	
	Ventilation	--	--	--	--	--	--	--	--	--	--	--	--	--	
	Humidity control	--	--	--	--	--	--	--	--	--	--	--	--	--	
	Lighting	--	--	--	--	--	--	--	--	--	--	--	--	--	
Natural Gas	**Heating**	1899.5	1372.9	1126.1	600.0	312.9	--	--	--	--	58.6	791.3	1711.3	7872.5	67.6
	Cooling	--	--	--	--	--	--	--	--	--	--	--	--	--	
	DHW	260.7	235.5	255.4	241.3	238.8	220.9	217.6	212.4	215.8	234.3	242.1	260.7	2835.6	24.4
Environment	**Heating**	7.5	6.4	4.8	3.1	1.4	--	--	--	--	0.1	4.1	6.9	34.1	0.3
	Cooling	--	--	--	--	--	--	--	--	--	--	--	--	--	
	DHW	--	--	--	--	--	--	--	--	--	--	--	--	--	
	$C_{ef,total}$	**2193.7**	**1636.1**	**1405.7**	**856.9**	**560.5**	**282.8**	**382.1**	**393.6**	**287.6**	**295.4**	**1053.5**	**2003.8**	**11351.7**	**97.5**

where:

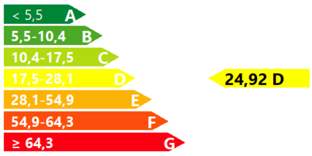
S_u: Living area included in the thermal envelope, m².
$C_{ef,total}$: Energy consumption at the point of consumption (final energy), kWh/m²·year.

Energy rating of the building: Case2. Initial situation 2.

Climatic zone (eq.)	B3	Use	Private residential

ENERGY RATING OF THE BUILDING IN EMISSIONS

1.

GLOBAL INDICATOR	PARTIAL INDICATORS			
	HEATING		DHW	
	Heating emissions [kgCO₂/m²·year]	A	DHW emissions [kgCO₂/m²·year]	C
	17.28		6.14	
	COOLING		LIGHTING	
Global emissions[kgCO₂/m²·year][1]	Cooling emissions [kgCO₂/m²·year]	A	Lighting emissions [kgCO₂/m²·year]	-
	1.51		-	

2.

The overall rating of the building is expressed in terms of carbon dioxide released into the atmosphere as a result of its energy consumption.

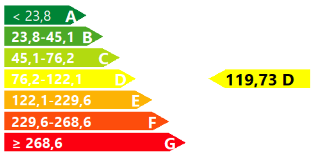
	kgCO₂/m²·year	kgCO₂·year
CO2 emissions from electricity consumption	1.73	201.71
CO2 emissions from other fuels	23.19	2698.47

ENERGY RATING OF THE BUILDING IN NON-RENEWABLE PRIMARY ENERGY CONSUMPTION

3.

Non-renewable primary energy refers to the energy consumed by the building from non-renewable sources that has not undergone any conversion or transformation process.

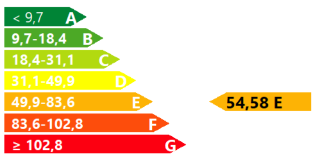
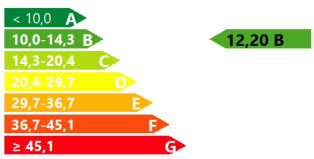
4.

GLOBAL INDICATOR	PARTIAL INDICATORS			
	HEATING		DHW	
	Primary energy heating [kWh/m²·year]	A	DHW Primary energy [kWh/m²·year]	E
	81.84		29	
	COOLING		LIGHTING	
Global consumption of non-renewable primary energy[kWh/m²·year][1]	Primary energy cooling [kWh/m²·year]	A	Primary energy lighting [kWh/m²·year]	-
	8.89		-	

PARTIAL RATING OF HEATING AND COOLING ENERGY DEMAND

The energy demand for heating and cooling is the energy needed to maintain the building's internal comfort conditions.

5.

HEATING DEMAND	COOLING DEMAND
	
Heating demand[kWh/m²·year]	Cooling demand[kWh/m²·year]

6.

1 The global indicator is the result of the sum of the partial indicators plus the value of the indicator for auxiliary consumption, if any (only tertiary buildings, ventilation, pumping, etc...). Self-consumed electricity is only deducted from the global indicator, not from the partial values.