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ESCUELA TÉCNICA SUPERIOR INGENIERÍA INDUSTRIAL VALENCIA

TRABAJO FIN DE GRADO EN INGENIERÍA DE LA ENERGÍA

STUDY, COMPARISON AND PROPOSALS TO IMPROVE THE ENERGY EFFICIENCY OF THREE INDEPENDENT BUILDINGS IN SPAIN.

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ABSTRACT

Data are available for three independent buildings in Spain: Two blocks of residential flats (one in Valencia and one in Barcelona) and a nursing home in Moguer, Huelva. From this, in the first place we will talk about energy efficiency as well as a global review of the regulatory framework both in the European Union and its adaptation to Spanish legislation. With all this, we will use the CE3X software recognized for energy certification to obtain the annual consumption per square meter and the annual emissions per square meter for each of the buildings. With all this, we will try to understand the possible differences between them from the equipment they use, their orientation, location or construction materials. Thus, an attempt will be made to improve the performance of the building with worse ratings, based on the proposal of a series of improvements.

Keywords: energy efficiency, buildings, Spain, consumption, emissions, CE3X.

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HISTORY.

1. INTRODUCTION

1.1. OBJECTIVES

In this Bachelor Thesis, we are going to work with three different buildings: a residential building located in Valencia, an individual apartment located in Barcelona and a Nursing Home located in Moguer, Huelva.

The objective is to evaluate them energetically, compare them with each other and try to understand the causes of their possible differences, later proposing improvements to the building that obtain worse results. However, to do this, we will explain, as we have already said, the European regulatory framework and its translation to the Spanish regulatory framework, as well as the different energy certification programs recognized by the Spanish government. And we will explain, in more depth, the chosen program based on the example of an independent building located in Zaragoza.

1.2. REGULATORY FRAMEWORK IN SPAIN

The regulations in Spain regarding the energy certification of buildings has evolved over the years, also influenced by European regulations. Next, we will present this chronologically.

1979 - NBE-CT79: It is the first regulation in Spain that requires a minimum of insulation in buildings. It only focuses on the insulation of buildings and is influenced by other European regulations.

1980 - RICCA: In Spain, it is the first regulation regulation of the thermal installations of buildings (heating, air conditioning and ACS). It establishes the requirements that facilities that consume energy for non-industrial thermal purposes must meet to achieve a rational use of it, taking into account the quality and safety of the same and the protection of the environment

1993 - Directive SAVE 76/93: This is a European Directive that proposed the energy certification of homes as a measure of information to the user and the achievement of more efficient homes.

1998 - RITE: This is a Regulation of Thermal Installations for Buildings. It is included in Royal Decree 1751/1998 and repeals RICCA.

2002 - **Directive 2002/91 / EC**[1]: .This Directive was inspired by the Kyoto protocol and commits the Member States of the European Union to reduce their CO2 emissions. The Directive relies on three tools: establishing requirements for the use of energy in new and existing buildings, introduction of energy performance certificates. In this way, the first two are based on a methodology for calculating the integrated energy efficiency of buildings.

As we have also said, in Spain, the European Directive is transposed through the Basic Document for Energy Saving (HE) of the Technical Building Code (CTE) which includes basic energy saving requirements in buildings (DB HE), and the Regulation of Technical Installations in Buildings (RITE), as well as by the Sustainable Economy Law.

2007 - Royal Decree 47/2007: This is a regulation that requires certifying the energy efficiency of newly constructed buildings. As of November 1, 2007, it is mandatory to make available to buyers or users of buildings an Energy Efficiency Certificate. This Royal Decree establishes the format of the label that expresses the energy efficiency of buildings, and the procedure for obtaining it. In this certificate, and through an energy efficiency label, each building is assigned an Energy Efficiency Class, which will vary from class A, for the most energy efficient, to class G, for the least efficient.

2007 - Royal Decree 1027/2007 RITE: The new RITE repeals the previous one from 1998. Aspects of the energy efficiency of conditioning facilities are reinforced and included, as well as the inspection and maintenance of boilers and air conditioning systems.

2010 - Directive 2010/31 / EU[2]: Refers to the Energy Efficiency of Buildings. The content of the Energy Efficiency Certificate is the element that is further developed with respect to the 2002 standard. It replaces the 2002 Directive. Regarding the values to be included, the certificate will have to present the energy efficiency measure, plus other benchmarks such as minimum energy efficiency requirements. Likewise, recommendations for energy improvement have to be presented and it is required to address major building reforms. Its purpose is to promote the energy efficiency of buildings located in the European Union, taking into account external climatic conditions and local particularities, as well as internal environmental requirements and profitability.

In the 2002 Directive, the exhibition of the energy performance certificate was mandatory for buildings of more than 1000 m² occupied by public authorities or institutions that present public services frequented by the public. In the 2010 Directive, said mandate is limited to buildings occupied by public authorities and frequented by the public, but the area drops to 500 m², which will be 250 m² as of July 9, 2015. In addition, you are required to show the certificate to potential buyers or tenants, and to deliver it to final buyers and tenants.

2013 - Royal Decree 235/2013: With this, Spain adapts to the new European directive 2010/31 / EU, and repeals Royal Decree 47/2007. It provides that when buildings or units thereof are constructed, sold or

[1] https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2003:001:0065:0071:EN:PDF
[2] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32010L0031

rented, the energy performance certificate or a copy thereof shall be shown to the buyer or potential new lessee and given to the buyer or new lessee.

2018 - Directive (EU) 2018/844[3]: In May 2018, the Energy Performance of Buildings Directive (EPBD) is amended again, giving rise to 'Directive (EU) 2018/844'.

1.3. ENERGY PERFORMANCE CERTIFICATE

As the project is going to be based concretely on the results that we obtain through free use programs to obtain energy certificates, we are going to explain more concretely what these energy certificates are and what they offer us.

Under European law, a building's energy performance certificate is a 'certificate recognized by a Member State or by a legal person designated by it, indicating the energy performance of a building or unit thereof, calculated from according to a methodology.'[4]

The energy certificate provides information on the energy consumption and CO2 emissions of a property and offers an evaluation of these from 'A' to 'G'.

Now, we are going to have to define different concepts that could be confused but are different:

- The certificate is the document, it is signed by a competent technician and contains both information on the energy characteristics of the building (or building's dwelling) and its energy rating. The energy certificate includes: the identification of the building, the certifier and the method and legislation, the data used for the calculation (thermal envelope, facilities, normal operating and occupancy conditions, etc.) and the energy rating. In addition, it should include recommendations for improvement and additional information.
- Certification is the process that leads to the issuance of the certificate.
- The rating is a measure of the energy efficiency of a building or part of it. It is expressed through a series of energy indicators. Possible grades can be a, b, c, d, e, f, g. As seen in the following image:

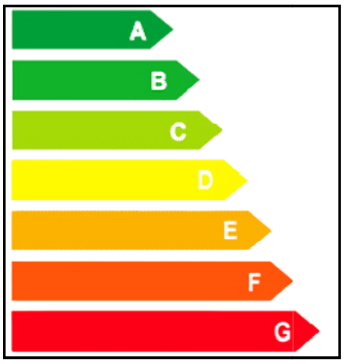

Figure 1: Notes offered by the energy certification programs. Source:

[3] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv%3AOJ.L_.2018.156.01.0075.01.ENG
[4] https://en.wikipedia.org/wiki/Energy_Performance_Certificate_(United_Kingdom)

- The energy label: It includes: building data (building address, regulations in force at the time of construction, the type of building and its use and the cadastral reference), BIDI code, energy scale (ranging from G to A) and the rating obtained by the home or building. It would look like the following figure:

Figure 2: **Energy certificate format. Source:**

In Spain, to obtain an energy efficiency certificate we can make use of different official computer programs, recognized by the Ministry of Industry, Energy and Tourism and by the Ministry of Development. These programs can be used as a verification tool for energy saving regulations and to certify either existing buildings or new buildings, both for residential use and for tertiary use. These programs can be used as a verification tool for energy saving regulations and to certify either existing buildings or new buildings, both for residential use and for tertiary use. The official computer programs for energy certification in Spain, therefore, are the following: CE3, CE3X, Cerma and Lider-Calener (HULC). And more recently, from July 5, 2018, the software 'CYPETHERM HE Plus' and 'SG SAVE' are also recognized. Now, let's explain them a little more in depth:

- The HULC (Lider-Calener)[5] program allows you to check compliance with the requirements set in DB HE0 and DB HE1. And you can work with:

    - Single family homes
    - House belonging to a block of houses
    - Complete block of flats
    - Tertiary building
    - Large tertiary building

[5] https://www.codigotecnico.org/index.php/menu-recursos/menu-aplicaciones/282-herramienta-unificada-lider-calener.html

- CE3X[6] will obtain the energy rating of the building immediately and automatically. To do this, it will compare the data entered by the user with a large database to determine the values most similar to those of the building to be rated and interpolate to obtain the energy demand. And you can work with:

    - Single family Home
    - House belonging to a block of houses
    - Complete block of flats
    - Tertiary building
    - Large tertiary building

- CE3 is also a simplified process for obtaining a building's energy certificate. It establishes seasonal correlations to estimate the energy demand of a building. It allows the certification of existing buildings of all kinds, both residential and tertiary:

    - Single family Home
    - House belonging to a block of houses
    - Complete block of flats
    - Tertiary building
    - Large tertiary building

- CERMA[7] performs an hourly simulation of both energy demand and equipment performance and allows the energy certification of:

    - Single family home
    - House belonging to a block of houses
    - Complete block of flats

1.4. CE3X IN-DEPTH EXPLANATION.

As we are going to work with CE3X, we are going to give a more detailed explanation and by means of the realization of a practical case provided by the program itself we will be able to understand better how it works.

CE3X[8] is a free software defined as a "Recognized Document for the Energy Certification of Existing Buildings" in Spain. It has been developed by Efinovatic and the National Center for Renewable Energies (CENER). The program is owned by IDEA (Institute for Diversification and Energy Savings) and its

[6] https://www.efinova.es/CE3X
[7] https://www.five.es/tienda-ive/cerma/

distribution is free. Through this program, any type of building can be certified in a simplified form: residential, small tertiary or large tertiary, being able to obtain any qualification from "A" to "G" (with A being the best result and G being the worst result).

It serves to:

- Obtain energy efficiency certificates.
- Justify compliance with the CTE.

The following will explain what they are and how the inputs are introduced into the program:

- First of all we will have to define the type of building that we are going to study. It can be: residential, small commercial or large comercial:

Figure 3: First step to make an energy certificate of a building using the CE3X program. Source: CE3X

- Then, for all the different options, we have to identify the building that we are going to study: The name of the Project, Adress, autonomous community, city, and postal code.

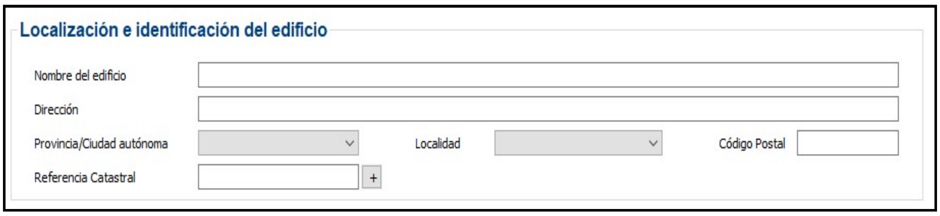

Figure 4: Second step to make an energy certificate of a building using the CE3X program. Source: CE3X

- In addition, it offers the possibility of entering the client's data (if it exists) and the certifying

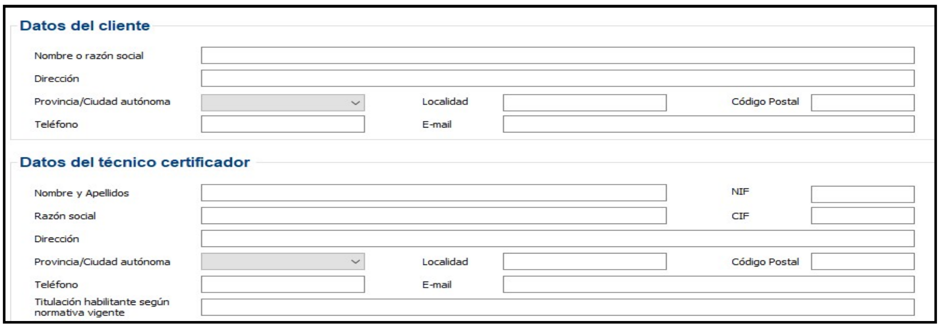

Figure 5: Third step to make an energy certificate of a building using the CE3X program. Source: CE3X

technician. Since they will later appear in the final report. This data consist in: Name, Adress, Autonomous Comunity, City, postal code, phone number, and e-mail.

- Then, both general data and data that allow the definition of the building will have to be entered: The general data consists of the regulations in force in the building (which definitely depends on its construction year), the type of building (Single-family, block of flats or individual dwelling), as well as again the city and town in which it is located with the aim of finding the climatic zone[9] in which we find ourselves since in Spain climatic zones are defined by localities and heights above sea level according to the CTE (Technical Building Code). Also, the data that allow the definition on the building consists in: useful living area (m2), free height of each floor (m), number of floors, building ventilation (renovations / hour) and daily demand for domestic hot water (l / day). It would be important to define domestic hot water as that which is intended for human consumption that has been heated. It is used for sanitary uses (baths, showers, etc.) and for other cleaning uses (dishwashing, washing machine, dishwasher, floor scrubbing). Normally the water comes from the building's water installation.

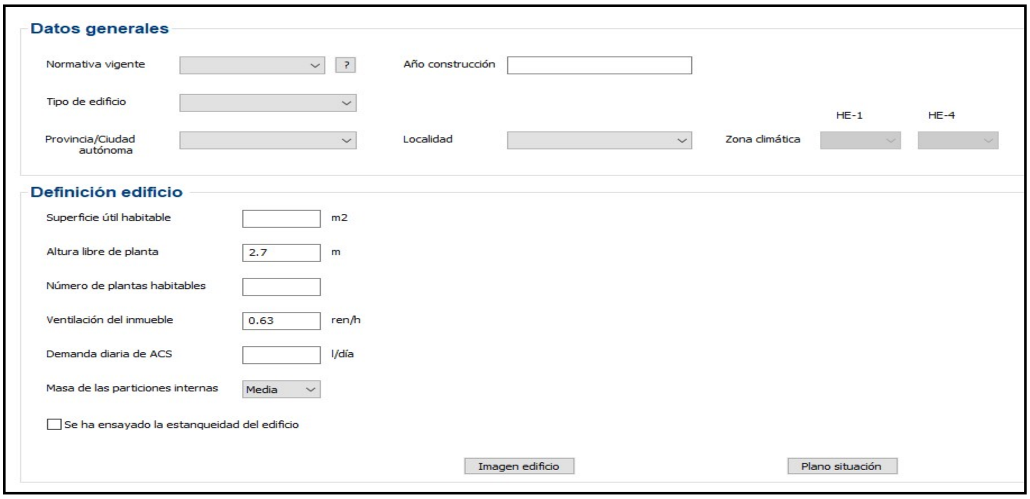

Figure 6: Fourth step to make an energy certificate of a building using the CE3X program. Source: CE3X

As an aside, it is also important to mention that the demand for domestic hot water can be a known data or can be estimated from from section 4.1 of section HE4 [10](in the CTE), which explains how the DHW reference energy demand is calculated for a temperature of 60ºC. For this, it includes table 4.1, which, depending on the use of the building, determines the value of the demand in liters / day per unit:

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[9] http://www.apici.es/wp-download/legislacion/CTE/CTE%20Parte%202%20DB%20HE-DA%201%20Zonas-climaticas-solar_v01.pdf
[10] https://www.terra.org/data/cteseccionhe4.pdf

Tabla 4.1. Demanda de referencia a 60 °C[1]

Criterio de demanda	Litros/día·unidad	unidad
Vivienda	28	Por persona
Hospitales y clínicas	55	Por persona
Ambulatorio y centro de salud	41	Por persona
Hotel *****	69	Por persona
Hotel ****	55	Por persona
Hotel ***	41	Por persona
Hotel/hostal **	34	Por persona
Camping	21	Por persona
Hostal/pensión *	28	Por persona
Residencia	41	Por persona
Centro penitenciario	28	Por persona
Albergue	24	Por persona
Vestuarios/Duchas colectivas	21	Por persona
Escuela sin ducha	4	Por persona
Escuela con ducha	21	Por persona
Cuarteles	28	Por persona
Fábricas y talleres	21	Por persona
Oficinas	2	Por persona
Gimnasios	21	Por persona
Restaurantes	8	Por persona
Cafeterías	1	Por persona

Table 4.1: Reference demand at 60ºC.

Building type	Liters/day person
Single family Home	28
Hospitals and clinics	55
Ambulatory	41
5 star hotel	69
4 star hotel	55
3 star hotel	41
2 star hotel	34
1 star hotel	28
Camping	21
Nursing home	41
Penitentiary center	28
Hostel	24
Changing rooms / Showers	21
School without showers	4
School with showers	21
Quarters	28
Factories	21
Offices	2
Gyms	21
Restaurants	8
Coffee shops	1

Table 1: Reference demand at 60ºC depending on the type of building. Source: Section 4.1 of section HE4 (in the CTE)

If we refer to a building with apartments, or rooms (as it would be in the case of a hotel), depending on the number of bedrooms in each apartment, we will have to attend the following table to calculate the number of persons:

Tabla a-Anejo F. Valores mínimos de ocupación de cálculo en uso residencial privado

Número de dormitorios	1	2	3	4	5	6	≥6
Número de Personas	1,5	3	4	5	6	6	7

Number of bedrooms:	1	2	3	4	5	6	>6
Number of persons:	1,5	3	4	5	6	6	7

Table 2: Minimum calculation occupancy values in private residential use. Source: Section 4.1 of section HE4 (in the CTE)

Then, we will have to consider a factor depending on the apartments of the whole building:

Number of single-houses	[0,3]	[4,10]	[11,20]	[21,50]	[51,75]	[76,100]	>101
Centralization factor	1	0,95	0,9	0,85	0,8	0,75	0,7

Table 3: Multiplication factor according to the number of individual apartments. Source: Section 4.1 of section HE4 (in the CTE)

Multiplying this terms would be the method to estimate the demand for domestic hot water in case we did not have the data.

- Then we have the thermal envelope section in which we would have to define our building. For this, we will have to define the facades (North, Northwest, South, East, West, etc), the roof, the ground, the thermal bridges, windows, etc. All this depending on the dimensions, materials, etc.

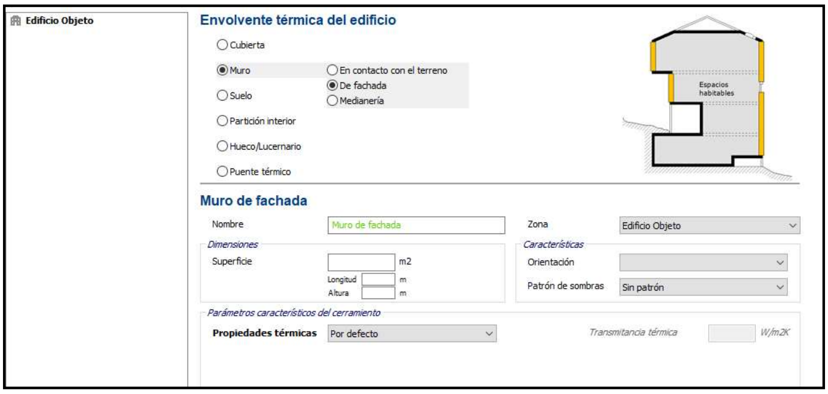


Figure 8: Fifth step to make an energy certificate of a building using the CE3X program. Source: CE3X

- In addition, we will have to define the building's air conditioning facilities: DHW equipment, heating equipment, refrigeration equipment, mixed heating and cooling equipment, mixed heating and cooling equipment, etc.

Figure 7: Sixth step to make an energy certificate of a building using the CE3X program. Source: CE3X

1.5. CE3X: PRACTICAL CASE AND BRIEF STUDY OF THE INFLUENCE OF INPUTS ON OUTPUTS.

Next, we will work with one of the example buildings that the program makes available to the user to understand the operation of the program. Subsequently, we will carry out an analysis using an Excel sheet to raise different cases and how the building's energy efficiency responds to possible variations.

In this way, the building in question is a block of flats located in Zaragoza. We have the following information to enter into the program:

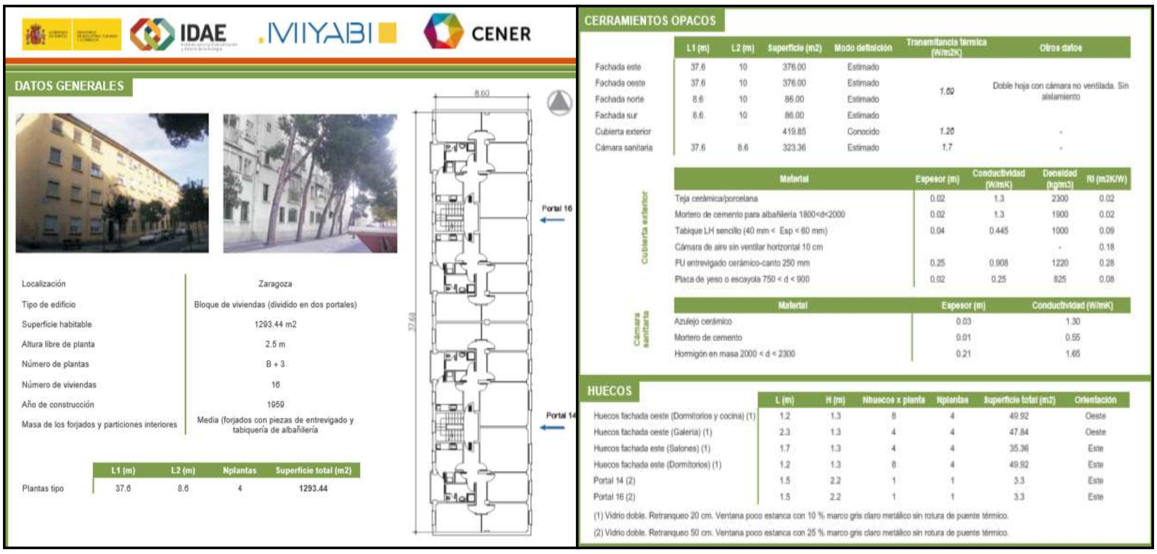


Figure 9: Information about the CE3X example building. Source: CE3X

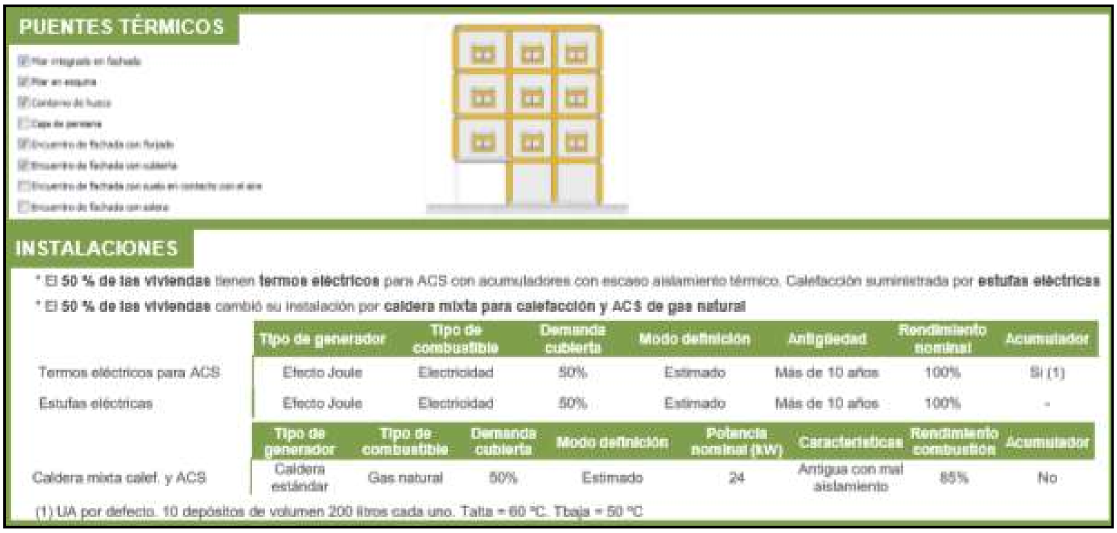


Figure10: Information about the CE3X example building. Source: CE3X

In summary, we have the following information:

Location:	**Zaragoza**		**Width (m)**	**High (m)**
Building type:	Block of flats	**East facade**	37.6	10
Living area:	1293,44 m2	**West facade**	37.6	10
Free height of plant:	2.5 m	**North facade**	8.6	10
Number of floors:	4	**South facade**	8.6	10
Number of homes:	16			
Year of construction:	1959			
50% of the houses have electric thermoses with accumulators for DHW with little thermal insulation. Heating supplied by electric stoves.				
50% of the houses changed their installation for a mixed boiler for heating and DHW using natural gas.				

Table 4: **Summary of Information on the CE3X example building. Source: CE3X**

So we have entered all this data into the software, as we have explained in the previous section.

- Identification of the building to be studied:

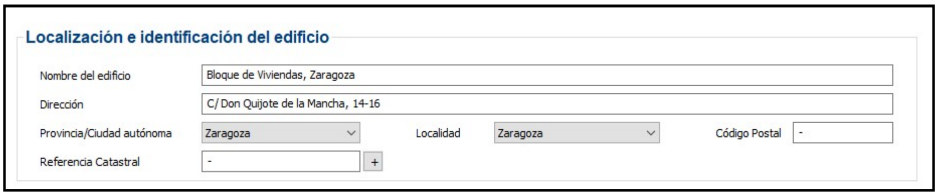

Localización e identificación del edificio
Nombre del edificio: Bloque de Viviendas, Zaragoza
Dirección: C/ Don Quijote de la Mancha, 14-16
Provincia/Ciudad autónoma: Zaragoza | Localidad: Zaragoza | Código Postal: -
Referencia Catastral: -

Figure 10: **First step to make an energy certificate of a building using the CE3X program. Source: CE3X**

- General data and data that allow the definition of the building:


Datos generales
Normativa vigente: Anterior
Año construcción: 1960
Tipo de edificio: Bloque de Viviendas
Provincia/Ciudad autónoma: Zaragoza
Localidad: Zaragoza
Zona climática: HE-1 D3, HE-4 IV
Definición edificio
Superficie útil habitable: 1293.44 m2
Altura libre de planta: 2.5 m
Número de plantas habitables: 4
Ventilación del inmueble: 0.63 ren/h
Demanda diaria de ACS: 1612.8 l/día
Masa de las particiones internas: Media
Se ha ensayado la estanqueidad del edificio

Figure 11: **Second step to make an energy certificate of a building using the CE3X program. Source: CE3X**

- Thermal envelope:

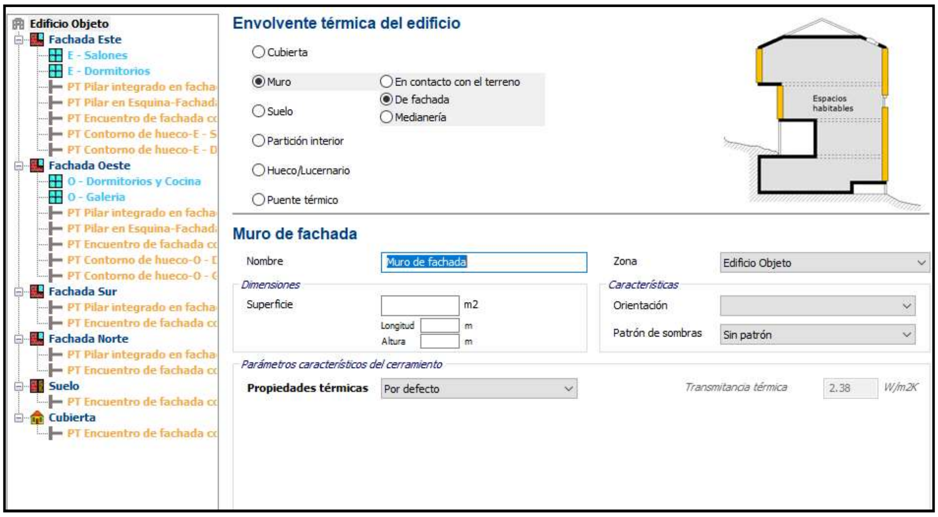


Figure 12: **Third step to make an energy certificate of a building using the CE3X program. Source: CE3X**

- Building's air conditioning facilities:

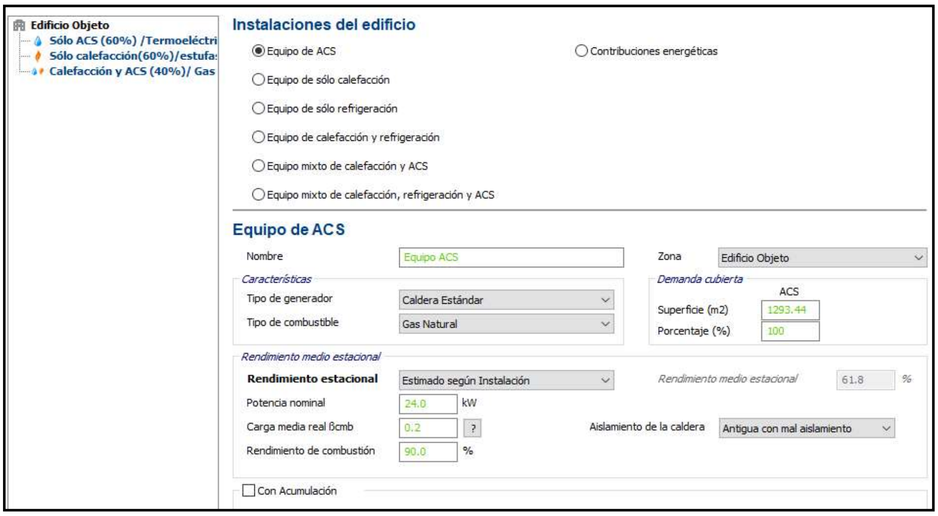


Figure 13: **Fourth step to make an energy certificate of a building using the CE3X program. Source: CE3X**

So, after entering all these inputs in the program, we get the following outputs:

- ENERGY RATING OF THE BUILDING IN EMISSIONS

Total Indicator		Partial Indicators			
<8.4 A 8.4-13.6 B 13.6-21.1 C 21.1-32.4 D 32.4-66.3 E 66.3-79.6 F ≥ 79.6 G	53,0 E	Heating (kgCO2/m2 year)		DHW (kgCO2/m2 year)	
		41,02	E	8,9	G
		Cooling (kgCO2/m2 year)		Illumination (kgCO2/m2 year)	
		3,07	C	-	-

	kgCO2/m2 year	kgCO2/m2 year
CO2 emissions from electricity consumption	30,48	39422,11
CO2 emissions from other fuels	22,51	29118,4

Figure 14: **Energy rating of the building in emissions. Source: CE3X**

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

Total Indicator		Partial Indicators			
< 26.8 A 26.8-43.4 B 43.4-67.3 C 67.3-103.5 D 103.5-212.9 E 212.9-240.5 F ≥ 240.5 G	286,2 E	Heating (kWh/m2 year)		DHW (kWh/m2 year)	
		220,33	E	47,79	G
		Cooling (kWh/m2 year)		Illumination (kWh/m2 year)	
		18,11	D	-	-

Figure 15: **Energy rating of the building in non-renewable primary energy consumption. Source: CE3X**

- PARTIAL RATING OF THE ENERGY DEMAND FOR HEATING AND COOLING

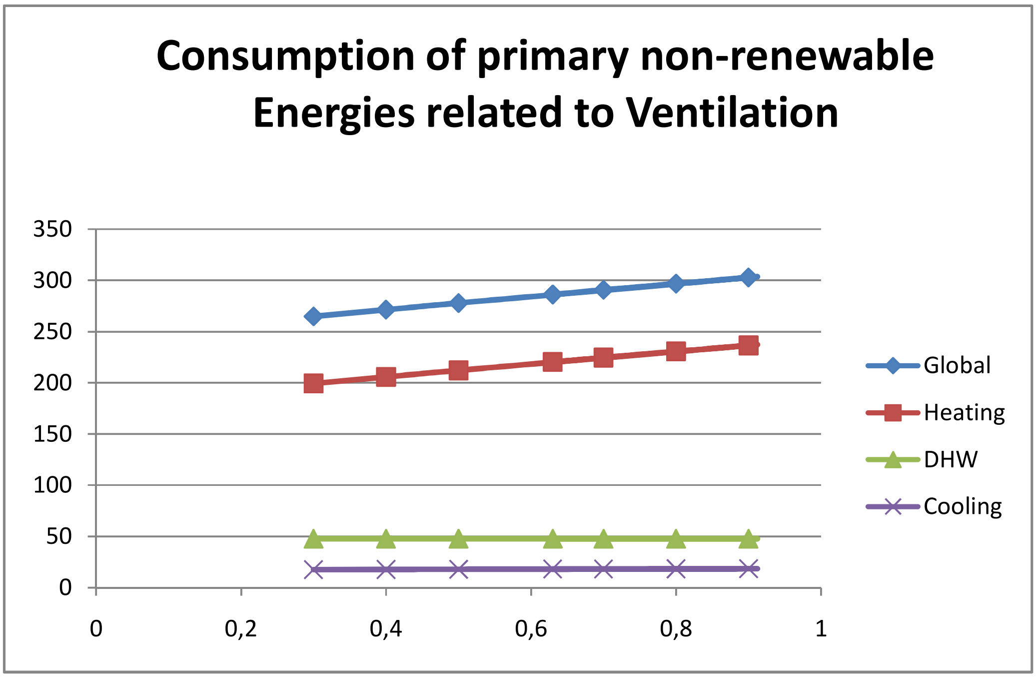
Heating demand (kWh/m2 year)		Cooling demand (kWh/m2 year)	
<7.7 A 7.7-17.9 B 17.9-32.4 C 32.4-54.2 D 54.2-99.8 E 99.8-108.8 F ≥ 108.8 G	113,4 E	<2.1 A 2.1-3.9 B 3.9-6.6 C [illegible] D 10.6-12.8 E 12.8-15.7 F ≥ 15.7 G	18,5 D

Figure 16: **Partial rating of the energy demand for heating and cooling. Source: CE3X**

As we have seen, the program calculates the energy consumption of non-renewable primary energy used in heating, cooling and domestic hot water, as well as the corresponding CO2 emissions and the energy demand for heating and cooling. It also offers us a rating based on the standards that we have explained previously.

After doing the example, we have tried to understand a little more how the program works, and how we can vary the outputs from the inputs. For this, we have worked on an excel sheet, Coming to the following conclusions:

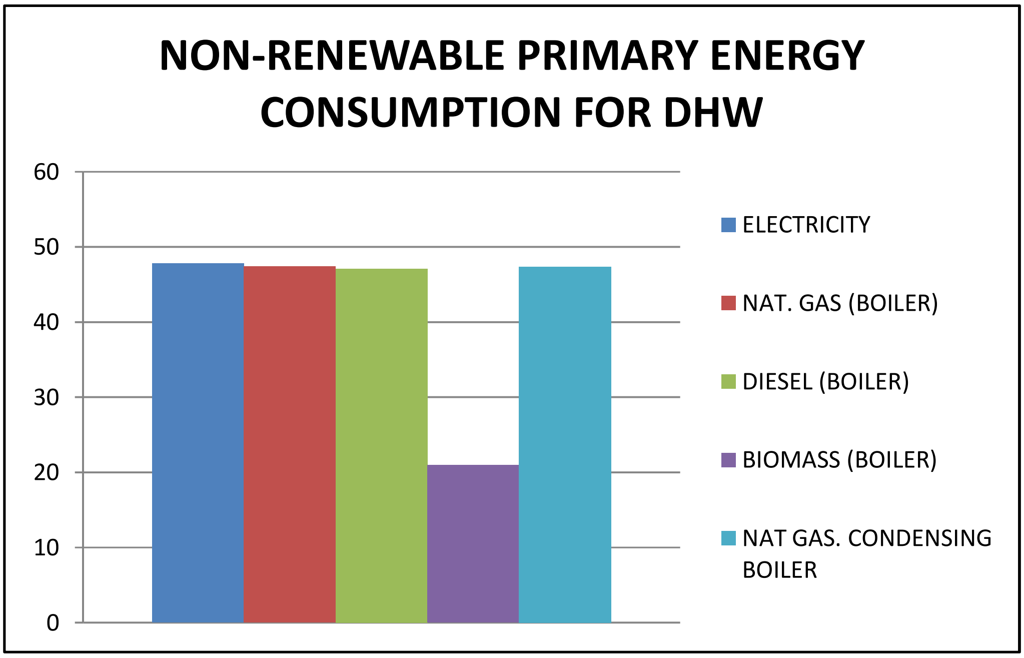
- As the ventilation factor increases (measured in renovations per hour), the consumption of non-renewable primary energy used for both heating and cooling increases. The consumption of non-renewable primary energy for domestic hot water is not influenced. CO2 emissions also increase accordingly, without influencing those that would correspond to the demand for domestic hot water.



Graph 1: Consumption of primary non-renewable Energies related to Ventilation. Source: Amutio, J.

However, as we can see the effect of ventilation does not have a special impact since the variations are small. The biggest changes will be reflected when changing the equipment for heating, cooling and domestic hot water.

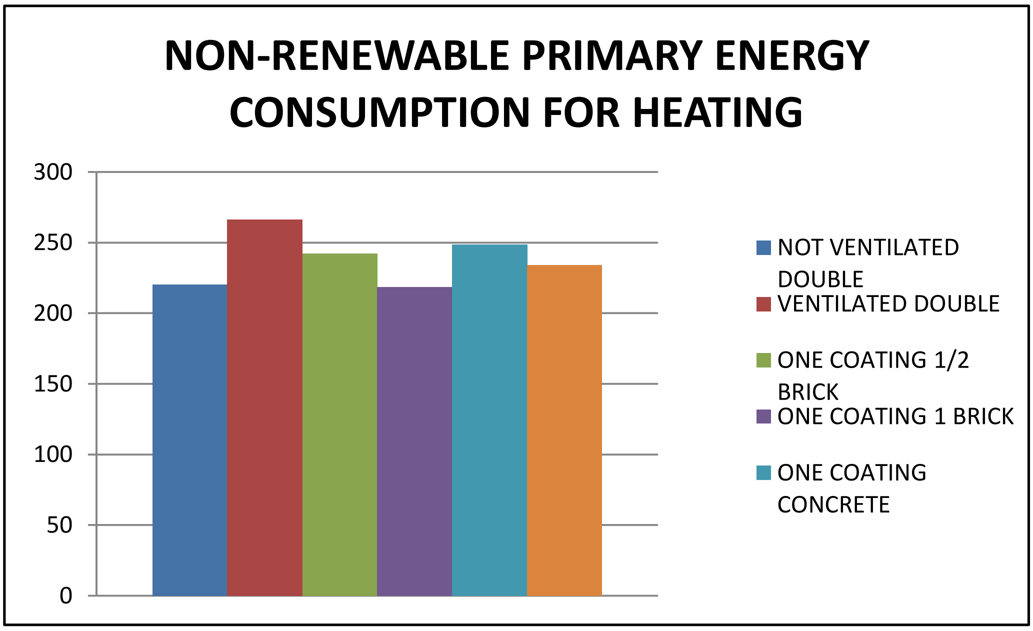
- Depending on the fuel or technology we use, the consumption of non-renewable primary energy also varies. In this case we have made the example with the DHW of the building.



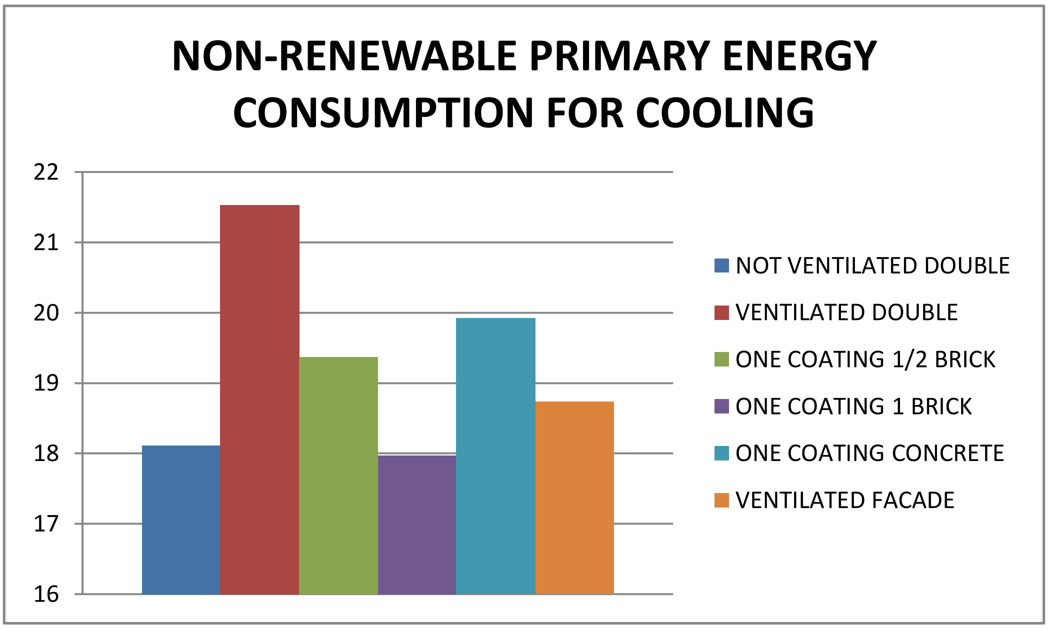
Graph 2: Non-renewable primary energy consumption for DHW depending on the equipment used. Source: Amutio, J.

For example, in this case we can see that the non-renewable primary energy consumption does not vary especially, except in the case where the fuel is biomass.

- If we now compare among the facade materials that we can choose, we will find greater differences, which will only affect the energy consumption for heating and cooling, since it is understood that the consumption of domestic hot water will be the same.



Graph 3: Non-renewable primary energy consumption for heating depending on the walls. Source: Amutio, J.



Graph 4: Non-renewable primary energy consumption for cooling. Source: Amutio, J.

2. STUDY OF THE BUILDINGS

2.1. BLOCK OF FLATS IN VALENCIA

The first building we are going to work with is a block of flats built in 1963 in the heart of the city of Valencia. This is located on Avenida Primado Reig, 125. First of all, we access the Electronic Office of the Cadastre in Spain, since we have the cadastral reference of the building in question (6840312YJ2764B). From this, we can access data on surfaces, plans, etc.

Figure 17: Representation of the building to be worked on. Source: Cadastre and Google Maps.

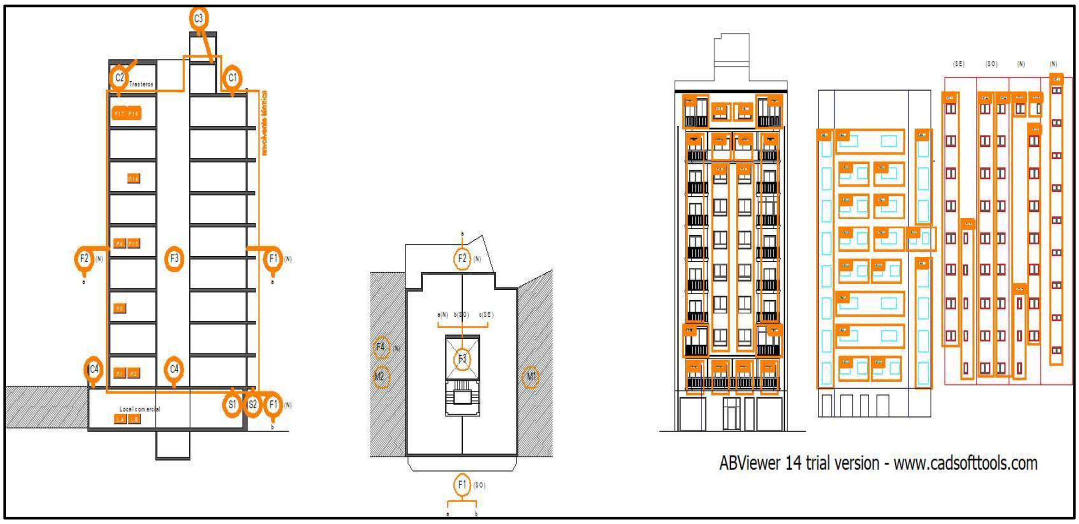


Figure 18: **AutoCAD plans of the building to be worked on. Source: AutoCAD.**

From the information of the cadastre and the AutoCAD plans, we obtain the following data:

	Orientation	Width (m)	Height (m)	Area (m2)
Facade 1	Southwest	14	28,35	396,9
Facade 2	Northwest	15,84	28,35	449,064
Facade 3	Southeast	15,84	28,35	449,064
Facade 4	Northeast	14	28,35	396,9
Floor	-			205,76
Cover	-			205,76
Yard	-			16

Table 5: **Dimensions of the facades. Source: Cadastre and Google Maps.**

We enter the data of our building in the CE3X program:

- Identification of the building to be studied:

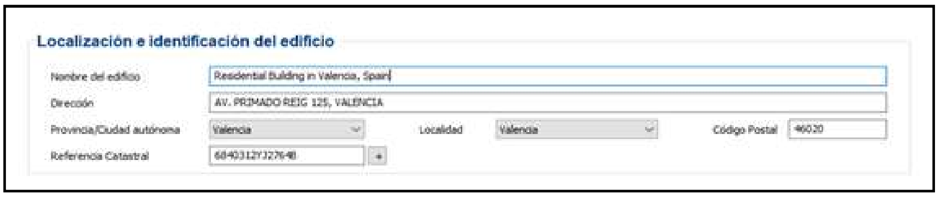


Figure 19: **First step to make an energy certificate of a building using the CE3X program. Source: CE3X**

Here we enter the location data of the building: The street, the town, the postal code and the cadastral reference.

- General data and data that allow the definition of the building:

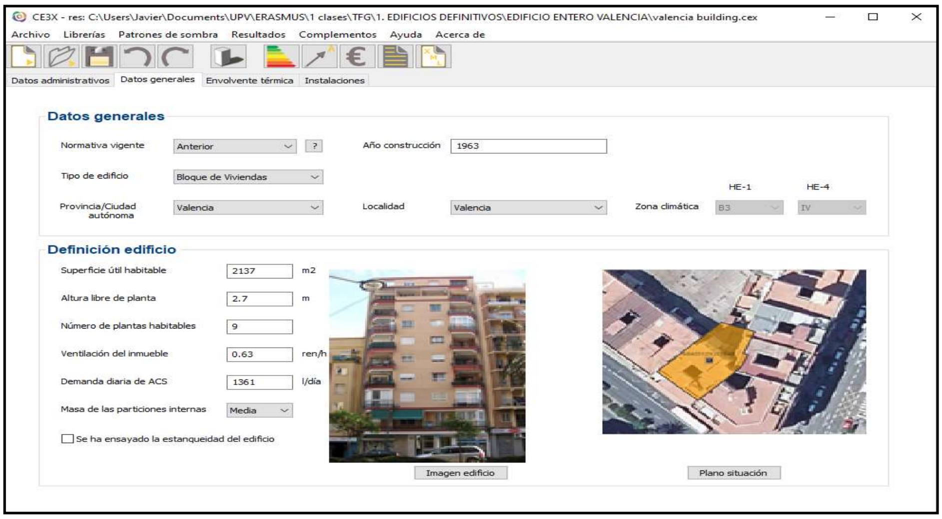


Figure 20: Second step to make an energy certificate of a building using the CE3X program. Source: CE3X

In the second image, we enter the year of construction of the building, 1963. With this, the current regulations will appear automatically the year of construction of the building. In our case, it is prior to NBE-CT-79[11]. We also specify that it is a block of flats and with the province and the town and will place us in the climatic zone B3-IV

Then we have to add certain building data. We introduce the useful living area, the free height of the plant (2.7 m), the number of habitable floors (9), the ventilation of the building (0.63 renovations / hour) that we have assumed and the DHW demand, which We have calculated it according to what was previously explained.

$$18\ houses * 28 \frac{liters}{person\ day} * 3 * persons * 0{,}9 = 1361\ l/day$$

Equation 1: Calculation of the domestic hot water demand. Source: CTE.

[11] https://w3.ual.es/Depar/proyectosingenieria/descargas/Normas_Edificacion/NBE-CT-79.pdf

- Thermal envelope:

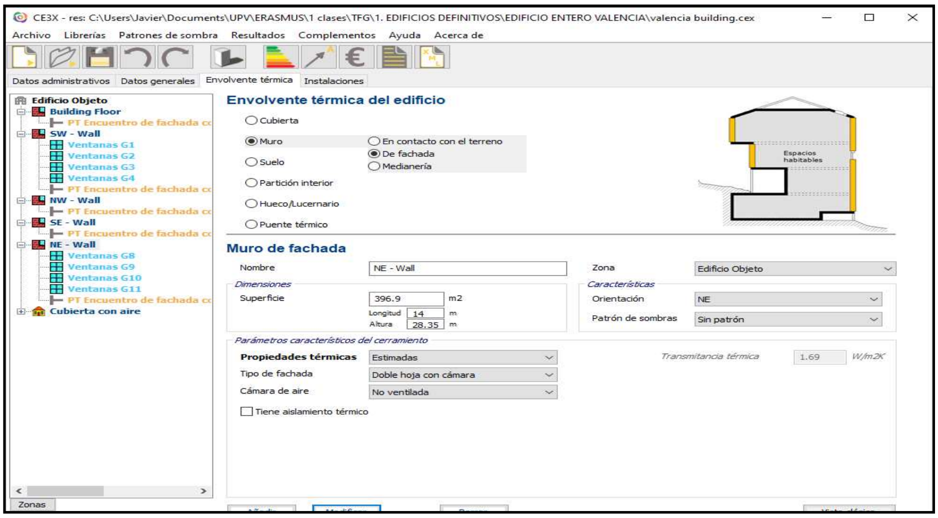


Figure 21: Third step to make an energy certificate of a building using the CE3X program. Source: CE3X

For the following section, regarding the thermal envelope, we have taken measurements with the cadastre and with the plans that we had. In addition, we have simplified the geometry of the building a little. The building has windows on the southwest facade (facing the avenue) and on the northeast facade. The other two facades are attached to two other buildings and have no windows. We have assumed that the facade of the building is double-leaf without a ventilation chamber.

- Building's air conditioning facilities:

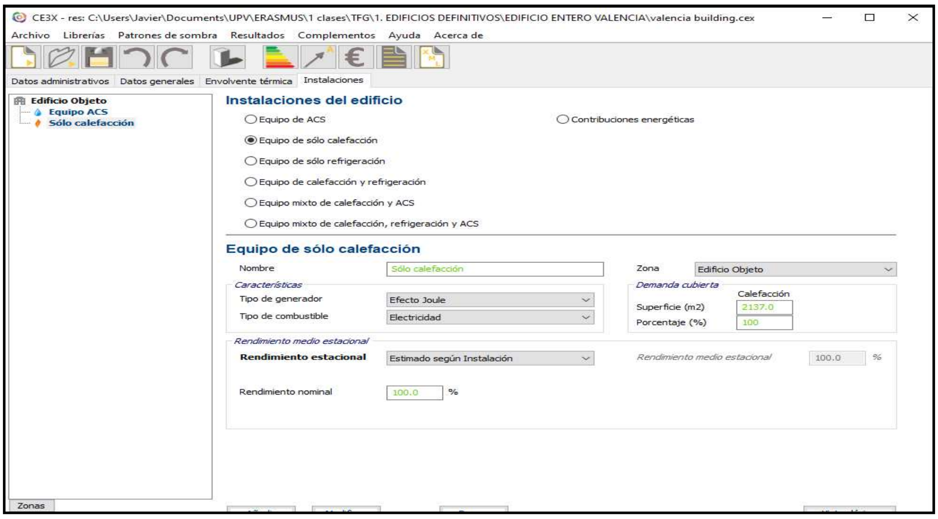


Figure 22: Fourth step to make an energy certificate of a building using the CE3X program. Source: CE3X

We have also added the building's air conditioning installations: a 24 kW natural gas boiler for the DHW and the heating demand.

Obtaining the following results:

- ENERGY RATING OF THE BUILDING IN EMISSIONS

Total Indicator		Partial Indicators			
<3.6 A 3.6-6.8 B 6.8-11.5 C D E 41.5-46.9 F ≥46.9 G	18,9 E	Heating		DHW	
		(kgCO2/m2 year)		(kgCO2/m2 year)	
		12,54	E	4,74	F
		Cooling		Illumination	
		(kgCO2/m2 year)		(kgCO2/m2 year)	
		1,63	B	-	-

	kgCO2/m2 year	kgCO2/m2 year
CO2 emissions from electricity consumption	1,63	3491,12
CO2 emissions from other fuels	17,28	36928,63

Figure 23: Energy rating of the building in emissions. Source: CE3X

We obtained an E rating for CO2 emissions. This is divided into emissions from heating, domestic hot water and cooling. Being that these separately obtain a rating of E, F and B respectively. In this way, domestic hot water emissions obtain the most negative rating and cooling emissions obtain the most positive rating.

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

Regarding non-renewable primary energy consumption, we obtained an overall rating of E.

Total Indicator		Partial Indicators			
<3.6 A 3.6-6.8 B 6.8-11.5 C D E 41.5-46.9 F ≥46.9 G	91,2 E	Heating		DHW	
		(kWh/m2 year)		(kWh/m2 year)	
		59,21	E	22,39	G
		Cooling		Illumination	
		(kWh/m2 year)		(kWh/m2 year)	
		9,64	C	-	-

Figure 24: Energy rating of the building in non-renewable energy consumption. Source: CE3X

Individually, we obtain an E, G and C for heating, domestic hot water and refrigeration respectively.

- PARTIAL RATING OF THE ENERGY DEMAND FOR HEATING AND COOLING

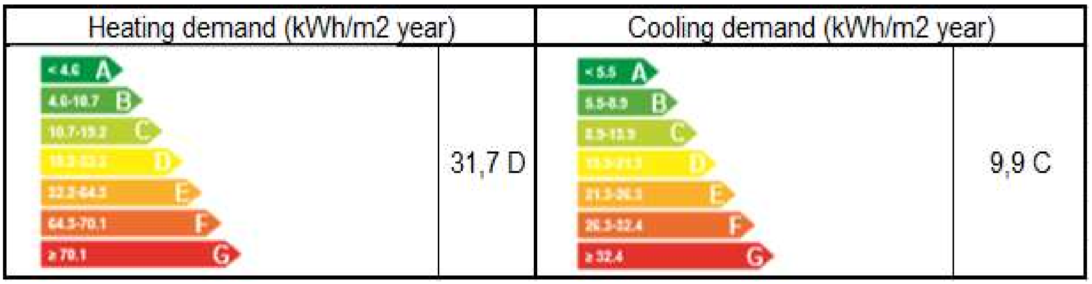


Figure 25: **Partial rating of the energy demand for heating and cooling. Source: CE3X.**

2.2. NURSING HOME IN MOGUER, HUELVA

The next building we are going to work with is a nursing home located in Moguer, Huelva. This is located on Divina Pastora Street, 3. First of all, we access the Electronic Office of the Cadastre in Spain, since we have the cadastral reference of the building in question, (1577022PB9217N). From this, we can access data on surfaces, plans, etc.

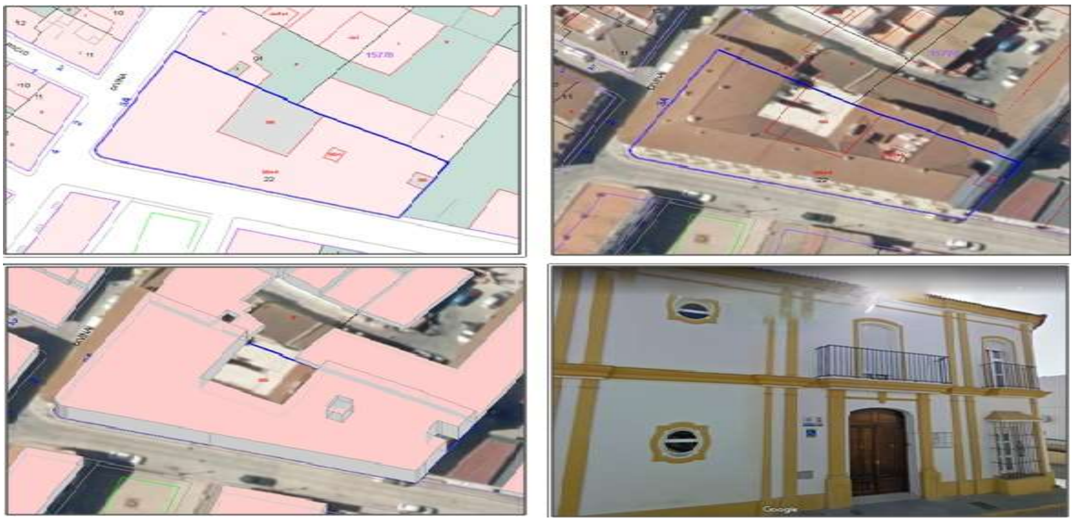


Figure 26: **Representation of the building to be worked on. Source: Cadastre and Google Maps.**

We obtain the following data:

For heating and cooling, in the building, there are 3 YORK water-water chillers / heat pumps that supply heating and cooling through fan coils. The characteristics are shown below:

Brand	Model	Heating Power	Cooling Power
YORK	BRAW-40G-38	76	28

Table 6: **Heating and cooling equipment. Source: 'Auditoria Energética' - UPV.**

For domestic hot water, a boiler located in the basement that consumes diesel is used. It is a FERROLI PREX THERMIX with 125 kW of nominal useful power.

Type of establishment	Geriatric
Number of beds	40
Location	Moguer, Huelva
Type and characteristics of the building	Two-sided attached building
Structure	Reinforced concrete
Exterior enclosure	Brick
Interior divisions	Brick
Total area	2119 m2
Number of floors	3
Semi-basement floor area	255 m2
Ground floor area	932 m2
First floor area	932 m2
Free height between floors	2,8 m
Roof	Tile, pitched
Floor	40x40 porcelain tiles

Table 7: **Information about the building. Source: 'Auditoria Energética' - UPV.**

Regarding electricity consumption, it is intended to:

	kWh/year	kWh/m2year
Air conditioning (heating and cooling)	67086,68	35,99
ACS	59880,00	32,12
Illumination	-	-

Table 8: **Electricity consumption. Source: 'Auditoría Energética' - UPV.**

Regarding the fuel consumer facilities , ithas been common in recent years to place two orders of 3,000 liters per year.

Also, through the Cadastre, we have measured (from the online application itself) the size of the facades, as well as heights and surfaces.

	Orientation	Width (m)	Height (m)	Area (m2)
Facade 1	South	46,3	6	277,8
Facade 2	West	25,4	6	152,4
Facade 3	North	48,3	6	289,8
Facade 4	East	14,8	6	88,8
Floor	-			932
Cover	-			932

Table 9: **Dimensions of the facades. Source: Cadastre and Google Maps.**

We enter the data of our building in the CE3X program:

- Identification of the building to be studied:

Figure 27: **First step to make an energy certificate of a building using the CE3X program. Source: CE3X**

- General data and data that allow the definition of the building:

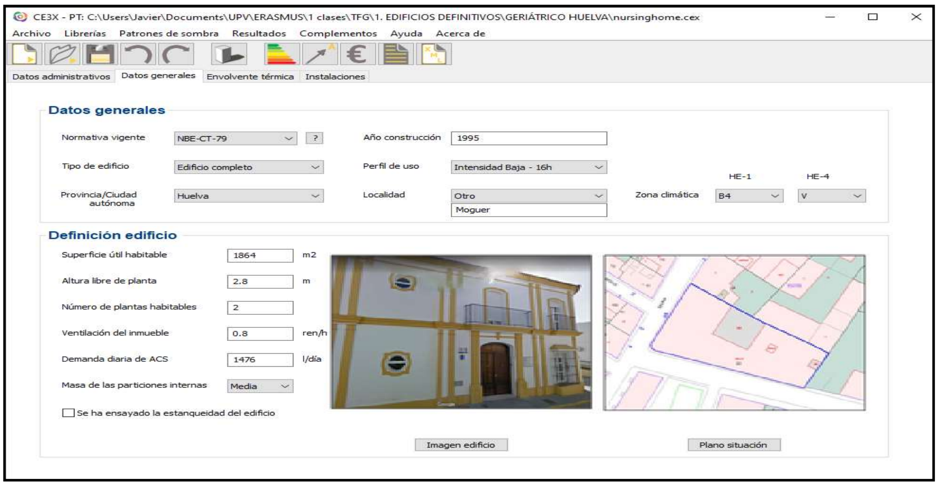


Figure 28: **Second step to make an energy certificate of a building using the CE3X program. Source: CE3X**

In the second image, we enter the year of construction of the building, 1995. With this, the current regulations will appear automatically the year of construction of the building. In our case, it is the NBE-CT-79[12]. We also specify the province and the town. As we have said, Moguer doesn't appear on the software but we have selected 'Other city' and we have manually checked the Moguer climate zone (B4-V)

Then we have to add certain building data. We introduce the useful living area (1864 m2). The building also has a 255 m2 basement that we have not included as habitable.We have also added the free height of the floor (2.8 m), the number of habitable floors (2), the ventilation of the building (0.8 renovations / hour) that we have assumed and the DHW demand, which we have calculated it according to what was previously explained.

$$41 \frac{liters}{person\ day} * 40 * persons * 0{,}9 = 1476\ l/day$$

Equation 2: Calculation of the domestic hot water demand. Source: CTE.

- Thermal envelope:

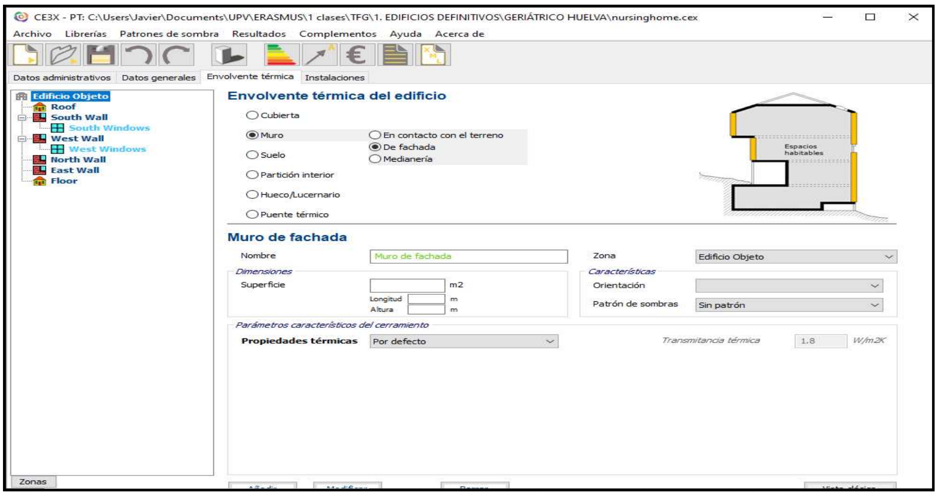


Figure 29: Third step to make an energy certificate of a building using the CE3X program. Source: CE3X

For the following section, regarding the thermal envelope, we have taken measurements with the cadastre and with the plans that we had. In addition, we have simplified the geometry of the building a little. The building has 26 windows on the south facade (facing the avenue) and 11 windows on the west facade. The other two facades are attached to two other buildings and have no windows. From

[12] https://w3.ual.es/Depar/proyectosingenieria/descargas/Normas_Edificacion/NBE-CT-79.pdf

the data we have on the building, we know that the facade is made of brick. We have two options to select and we have assumed the one that offers us better results.

- Building's air conditioning facilities:

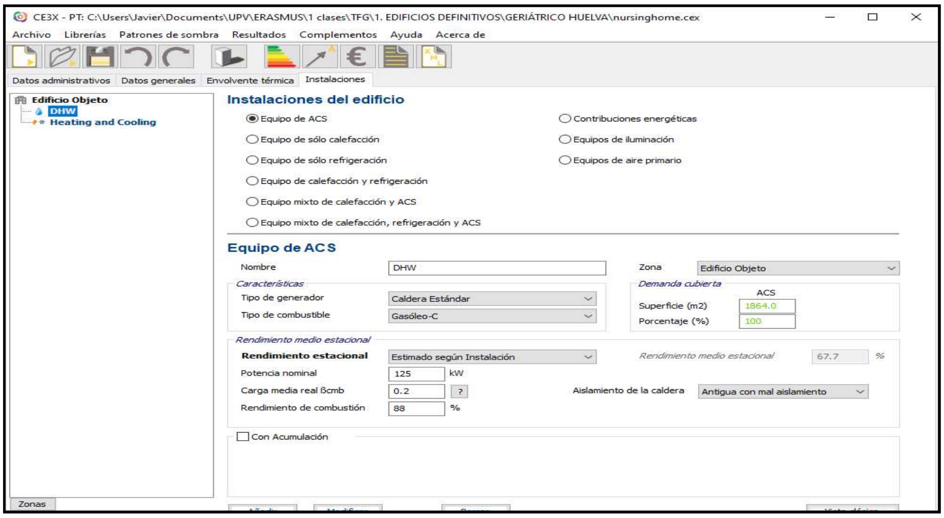


Figure 30: **Fourth step to make an energy certificate of a building using the CE3X program. Source: CE3X**

We have also added the building's air conditioning installations: A standard C-diesel boiler used for domestic hot water. We have the data and we have entered it, it has a nominal power of 125 kW and an efficiency of 88%.

And we obtain the following results:

- ENERGY RATING OF THE BUILDING IN EMISSIONS

Total Indicator	Partial Indicators			
	Heating		DHW	
	(kgCO2/m2 year)		(kgCO2/m2 year)	
15,6 F	3,9	E	6,78	G
	Cooling		Illumination	
	(kgCO2/m2 year)		(kgCO2/m2 year)	
	4,91	D	-	-

	kgCO2/m2 year	kgCO2/m2 year
CO2 emissions from electricity consumption	8,81	16426,41
CO2 emissions from other fuels	6,78	12640,64

Figure 31: **Energy rating of the building in emissions. Source: CE3X.**

We obtained an F rating for CO2 emissions. This is divided into emissions from heating, domestic hot water and cooling. Being that these separately obtain a rating of E, G and D respectively. In this way, domestic hot water emissions obtain the most negative rating and heating emissions obtain the most positive rating.

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

Regarding non-renewable primary energy consumption, we obtain an overall rating of F.

Total Indicator		Partial Indicators			
	77,7 F	Heating (kWh/m2 year)		DHW (kWh/m2 year)	
		23,04	G	25,71	G
		Cooling (kWh/m2 year)		Illumination (kWh/m2 year)	
		28,98	D	-	-

Figure 32: **Energy rating of the building in non-renewable primary energy consumption. Source: CE3X.**

Individually, we obtain an G, G and D for heating, domestic hot water and refrigeration respectively. The worst score is obtained in the consumption for domestic hot water and the best score is obtained in the consumption for refrigeration.

- PARTIAL RATING OF THE ENERGY DEMAND FOR HEATING AND COOLING

Heating demand (kWh/m2 year)		Cooling demand (kWh/m2 year)	
	29,8 G		28,2 D

Figure 33: **Partial rating of the energy demand for heating and cooling. Source: CE3X.**

2.2.1. COMMENT AND COMPARISON WITH CALCULATIONS MADE MANUALLY

From the data we had (real 2014) regarding the electricity consumption of the residence and knowing that two 3000-liter diesel-C orders are placed each year which is used in domestic hot water. Assuming that all are used and from the lower calorific value of Diesel-C, we manually obtain the kWh / m2 year in heating, cooling and DHW. So we have obtained the following results using an excel sheet:

	kWh/year	kWh/m2year
Air conditioning (heating and cooling)	67086,68	35,99
Illumination	-	-
DHW	59880,00	32,12

Table 10: **Electricity consumption. Source: 'Auditoría Energética' - UPV.**

However, the results obtained by computer software are these:

	Heating	DHW	Cooling
kWh/m2 year	23,04	25,71	28,98

Table 11: **Non-renewable primary energy consumption. Source: CE3X.**

The first thing we are going to mention is that, regarding sanitary hot water, the results are quite acceptable. On the other hand, regarding air conditioning, we had calculated 35.99 kWh / m2 year, however, the computer software indicates a combined consumption of heating and cooling of almost double.

2.2.2. COMMENTARY AND COMPARISON OF THE BUILDING IN VALENCIA AND THE NURSING HOME IN MOGUER.

We will now show and comment on the results we have already obtained as well as briefly commenting on their differences.

- ENERGY RATING OF THE BUILDING IN EMISSIONS

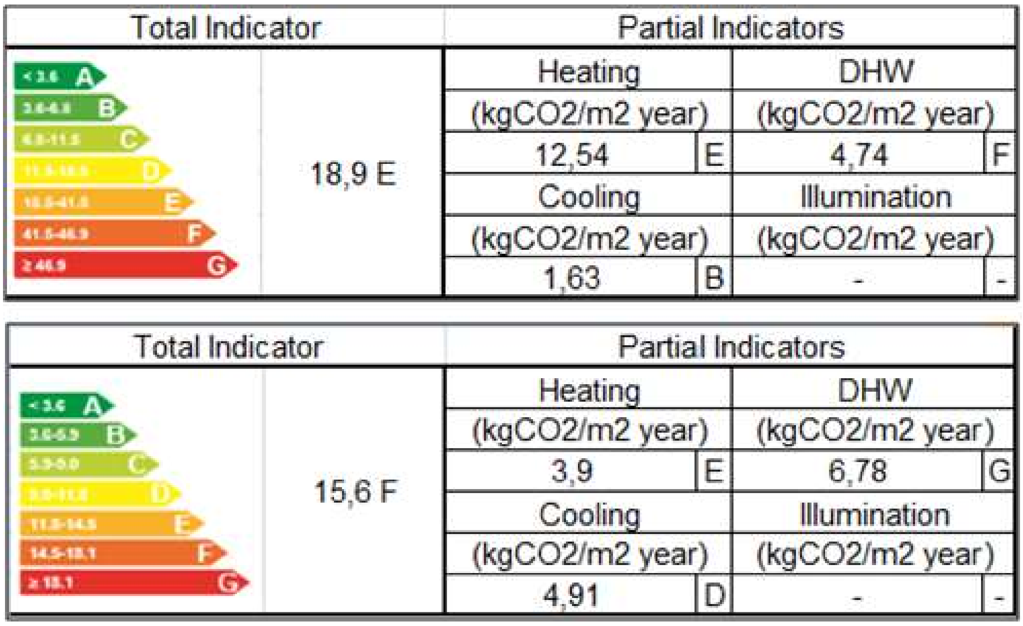


Figure 34: **Comparison of the energy rating of the buildings in emissions. Source: CE3X.**

We found that, without taking into account lighting, the tertiary building has lower CO2 / m2 emissions in general. The residential building has higher emissions in terms of heating (12.54 vs. 3.90 kgCO2 / m2 year). Regarding sanitary hot water and refrigeration, the emissions from the nursing home are higher than those from the housing block. In addition, it would be important to note that the emissions in relation to the housing block are mostly from natural gas, since both heating and domestic hot water use a natural gas boiler. In the case of the tertiary building, it does use a heat pump that works with electric energy and fan coils for heating and cooling.

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

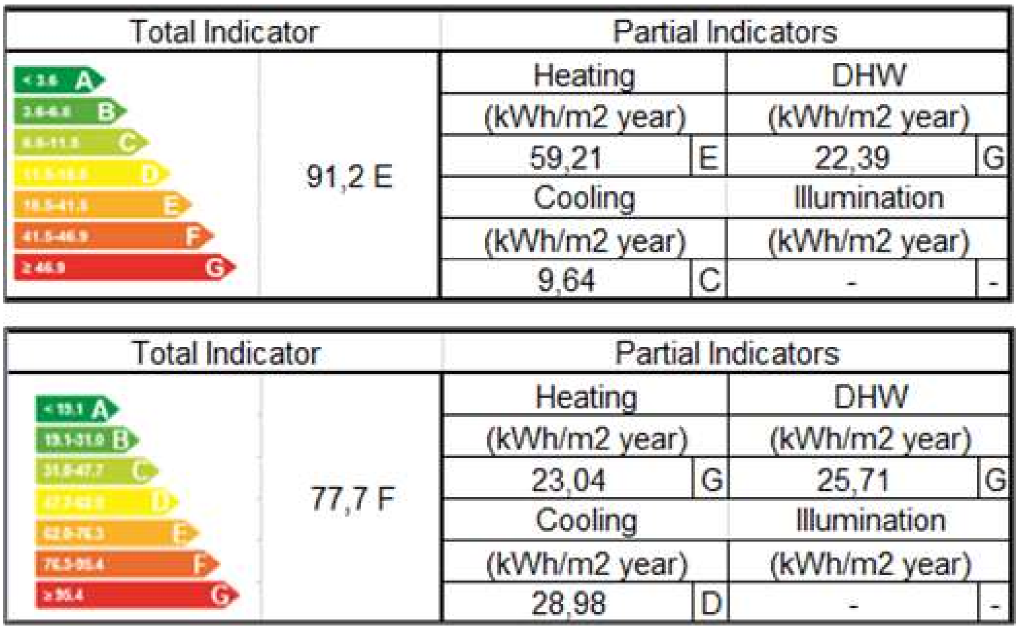


Figure 35: Comparison of the energy rating of the buildings in non-renewable primary energy consumption. Source: CE3X

In this aspect, and as expected since it is directly related to CO2 emissions, non-renewable primary energy consumption also comes out lower in the tertiary building. However, the tertiary bulding receive a worst general rating, even though in the tertiary building the ranges for each rating are different. As was the case with CO2 emissions, the consumption of the building in Valencia in terms of heating is much higher than in the tertiary building. However, in terms of DHW and refrigeration, energy consumption is higher in the tertiary building, although with a smaller difference.

- PARTIAL RATING OF THE ENERGY DEMAND FOR HEATING AND COOLING

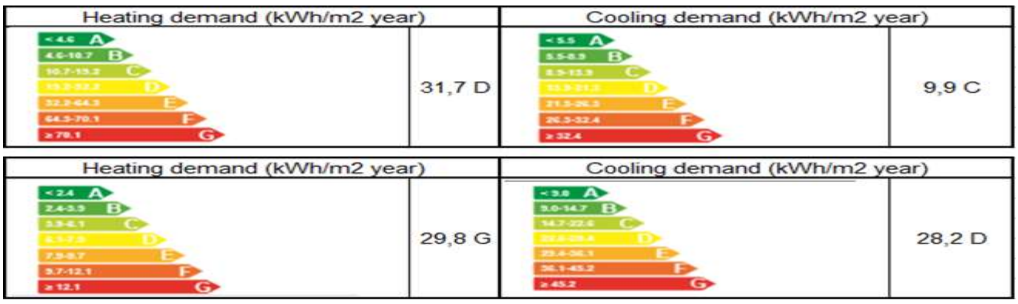


Figure 36: Comparison of the partial rating of the buildings in energy demand for heating and cooling. Source: CE3X.

As for the demand for heating and cooling. In the tertiary building the heating demand in kWh / m2 year is slightly higher than in the Valencia building. However, since the scale is different, it gets a much worse rating. Regarding refrigeration, the demand in the tertiary building would be almost triple the demand of the building in Valencia.

2.3. BLOCK OF FLATS IN BARCELONA

The last building we are going to work with is a block of flats built in 1885 in the heart of the city of Barcelona. This is located on Francisco Giner Street, 19. First of all, we access the Electronic Office of the Cadastre in Spain, since we have the cadastral reference of the building in question (9835205DF2893F). From this, we can access data on surfaces, plans, etc.

We know the following information about the building:

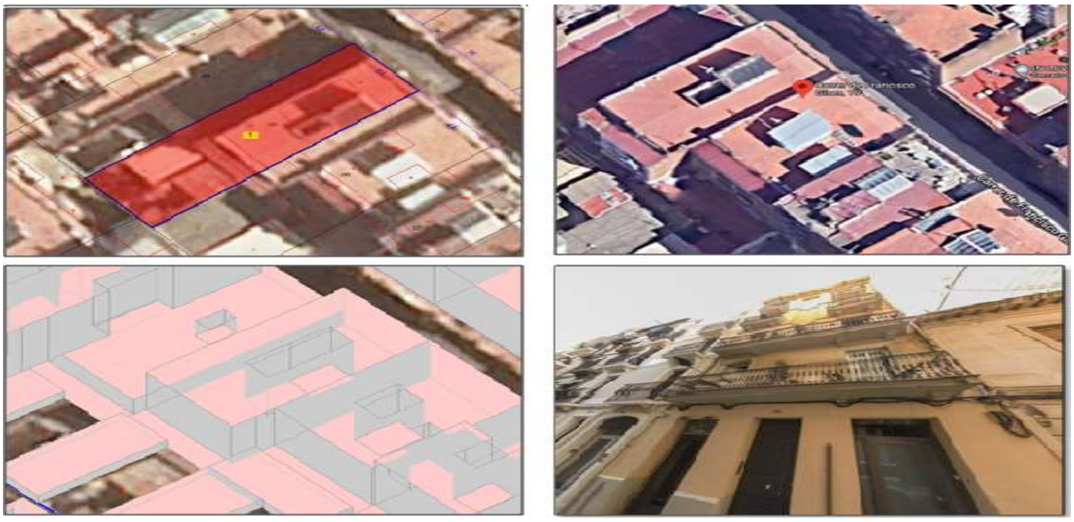


Figure 37: **Representation of the building to be worked on. Source: Cadastre and Google Maps.**

The building has a ground floor and 4 floors above. From this and the measurement tool of the cadastre itself we are going to extract the proportions of the building.

	Orientation	Width (m)	Height (m)	Area (m2)
Facade 1	Southwest	7,8	14,5	113,1
Facade 2	Northwest	14,8	14,5	214,6
Facade 3	Southeast	14,8	14,5	214,6
Facade 4	Northeast	7,8	14,5	113,1
Floor	-			101,1
Cover	-			101,1
Yard	-			13,6

Table 12: **Dimensions of the facades. Source: Cadastre and Google Maps.**

Furthermore, we know that homes are heated by electric radiators. We also know that there are no cooling facilities in the building and that a standard butane gas boiler with 24 kW power is used for domestic hot water. Is also important to mention that the southeast and northwest facades are in direct contact with the adjacent buildings andthat the building has 8 windows on the Northeast facade.

We enter the data of our building in the CE3X program:

- Identification of the building to be studied:

Figure 38: First step to make an energy certificate of a building using the CE3X program. Source: CE3X

- General data and data that allow the definition of the building:

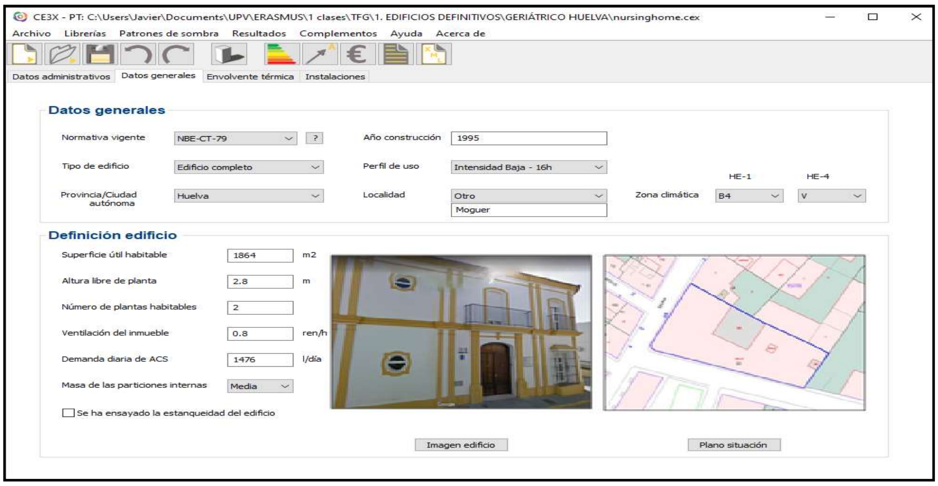


Figure 39: Second step to make an energy certificate of a building using the CE3X program. Source: CE3X

We enter the year of construction of the building, 1884. With this, the current regulations will appear automatically the year of construction of the building. In our case, it is the one before the NBE-CT-79. We also specify that it is a block of flats and with the province and the town. And we introduce the climate zone (C2-III).
Then we have to add certain building data. We introduce the useful living area (558 m2). We have also added the free height of the floor (2.7 m), the number of habitable floors (5), the ventilation of the building (0.63 renovations / hour) that we have assumed and the DHW demand, which we have calculated it according to what was previously explained.

$$28 \frac{liters}{person\ day} * 9 * houses * 3\ persons * 0{,}95 = 718{,}2\ l/day$$

Equation 3: Calculation of the domestic hot water demand. Source: CTE.

- Thermal envelope:

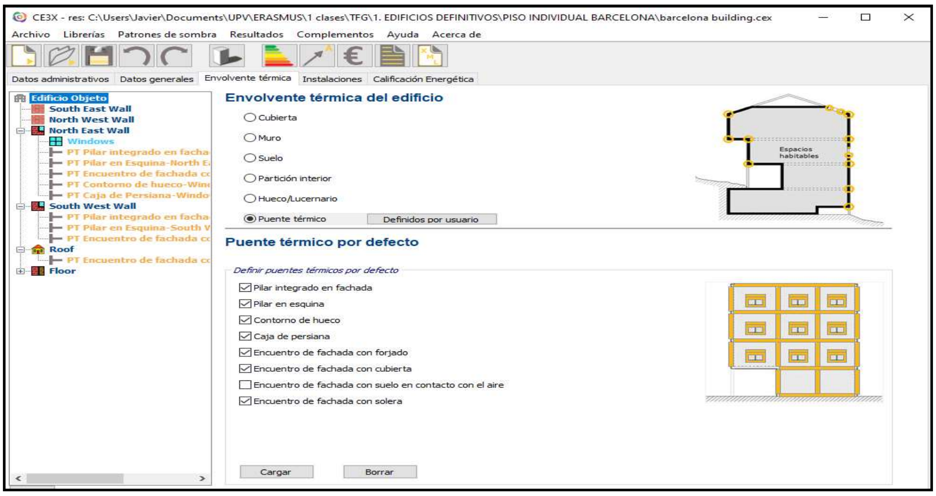


Figure 40: Third step to make an energy certificate of a building using the CE3X program. Source: CE3X

For the following section, regarding the thermal envelope, we have taken measurements with the cadastre and with the plans that we had. In addition, we have simplified the geometry of the building a little. The building has 8 windows on the north east facade (facing the avenue). The other two facades (south east and north west) are attached to two other buildings and have no windows.

From the data we have on the building, we know that the facade is made of brick. We have two options to select and we have assumed the one that offers us better results.

- Building's air conditioning facilities:

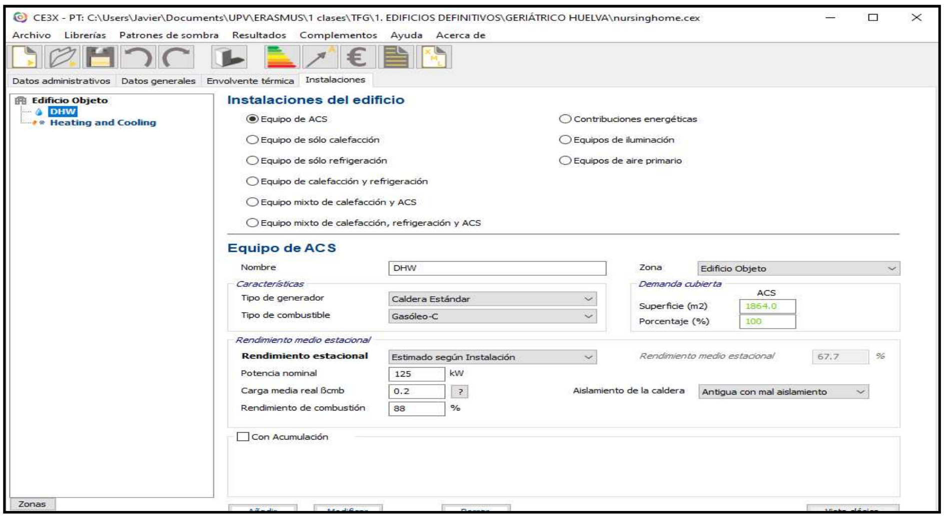


Figure 41: **Fourth step to make an energy certificate of a building using the CE3X program. Source: CE3X**

We have also added the building's air conditioning installations: A standard butane boiler used for domestic hot water and electric radiators for heating.

And the following results have been obtained:

- ENERGY RATING OF THE BUILDING IN EMISSIONS

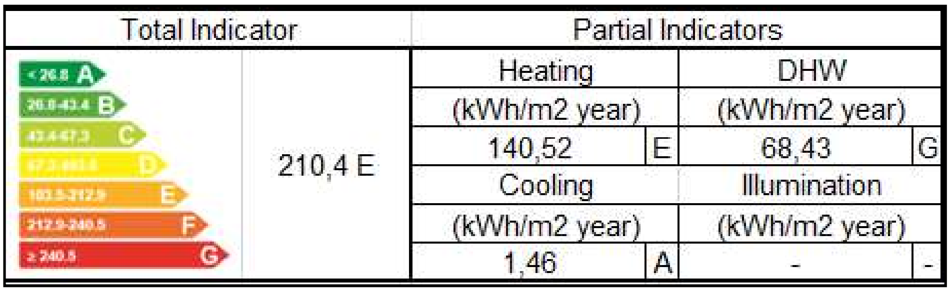
Total Indicator		Partial Indicators			
<6.1 A 6.1-9.9 B 9.9-15.3 C 15.3-23.5 D 23.5-49.0 E 49.0-57.3 F ≥57.3 G	38,5 E	Heating (kgCO2/m2 year)		DHW (kgCO2/m2 year)	
		23,8	E	14,71	G
		Cooling (kgCO2/m2 year)		Illumination (kgCO2/m2 year)	
		0,25	A	-	-

	kgCO2/m2 year	kgCO2/m2 year
CO2 emissions from electricity consumption	24,05	13419,56
CO2 emissions from other fuels	14,57	8075,86

Figure 42: **Energy rating of the building in emissions. Source: CE3X.**

We obtained an E rating for CO2 emissions. This is divided into emissions from heating, domestic hot water and cooling. Being that these separately obtain a rating of E, G and A respectively. In this way, domestic hot water emissions obtain the most negative rating and cooling emissions obtain the most positive rating.

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

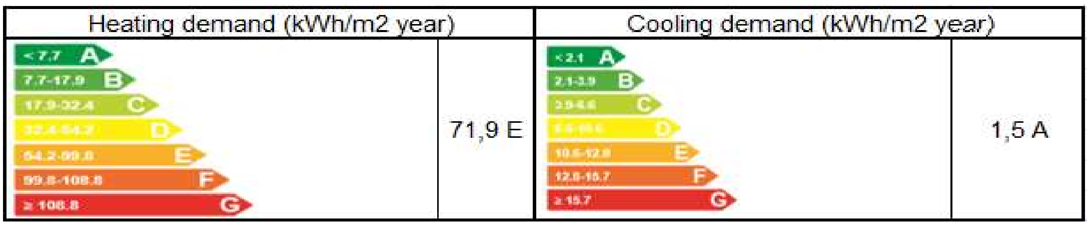


Total Indicator	Partial Indicators			
210,4 E	Heating (kWh/m2 year)		DHW (kWh/m2 year)	
	140,52	E	68,43	G
	Cooling (kWh/m2 year)		Illumination (kWh/m2 year)	
	1,46	A	-	-

Figure 43: **Energy rating of the building in non-renewable primary energy consumption. Source: CE3X.**

Regarding non-renewable primary energy consumption, we obtain an overall rating of E. Individually, we obtain an E, G and A for heating, domestic hot water and refrigeration respectively. The worst score is obtained in the consumption for domestic hot water and the best score is obtained in the consumption for cooling.

- PARTIAL RATING OF THE ENERGY DEMAND FOR HEATING AND COOLING



Heating demand (kWh/m2 year)	Cooling demand (kWh/m2 year)
71,9 E	1,5 A

Figure 44: **Partial rating of the energy demand for heating and cooling. Source: CE3X.**

2.4. COMPARISON OF THE THREE BUILDINGS

2.4.1. COMPARISON OF THE INPUTS OF THE THREE BUILDINGS

	Valencia Building	Nursing Home	Barcelona Building
Year of construction	1963	1995	1884
Climatic Zone	B3 - IV	B4 - V	C2 - III
Useful living area	2137	1864	558

Habitable Floors	9	2	5
Households	18	-	9
Beds (Nursing Home)	-	40	-
DHW demand (l/day)	1361	1476	718,2
Construction material	Double Leaf Brick	Brick	Brick
DHW equipment	Natural gas boiler	Diesel Oil Boiler	Butane Boiler
Heating equipment	Natural gas boiler	Heat pumps	Electric radiators
Cooling equipment	-	Heat pumps	-

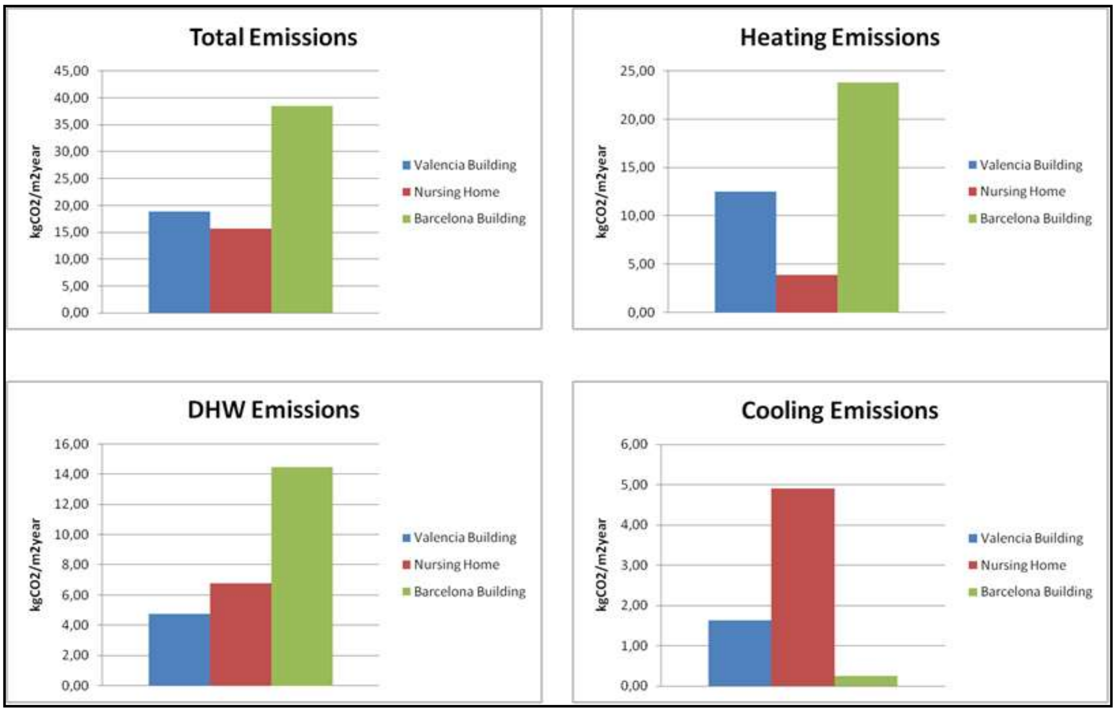
Table 13: **Comparison of the inputs of the three buildings. Source: Amutio, J.**

2.4.2. COMPARISON OF THE RESULTS OF THE THREE BUILDINGS

Firstly, even if they are buildings of different sizes, it must be said that we can compare these variables because the results obtained are given in values divided by square meter.

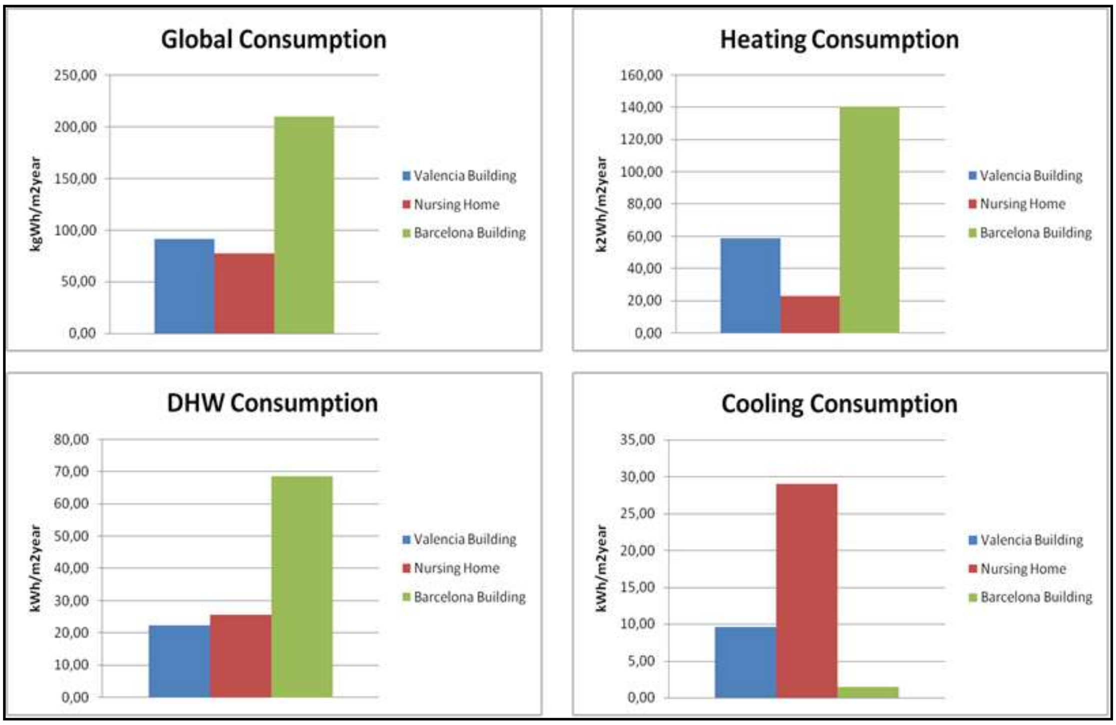
	Valencia Building				Nursing Home				Barcelona Building			
	Global	Heating	DHW	Cooling	Global	Heating	DHW	Cooling	Global	Heating	DHW	Cooling
kgCO2/m2 year	18,90	12,54	4,74	1,63	15,6	3,9	6,78	4,91	38,5	23,8	14,47	0,25
kWh/m2 year	91,20	59,21	22,39	9,64	77,70	23,04	25,71	28,98	210,4	140,52	68,43	1,46
Demand		31,7		9,9		36		28,1		71,9		1,5

Table 14: **Comparison of the results of the three buildings. Source: Amutio, J.**



Graph 5: **Comparison of the emissions: Total, heating, DHW and cooling. Source: Amutio, J.**

Regarding emissions in KgCO2 per square meter and year, it should be said that the building with the highest emissions corresponds to the oldest building (more specifically from the last century), located in Barcelona. This has a heating system with electric radiators and uses butane cylinders for domestic hot water. Then, we would have the building located in Valencia, from the 90s. Furthermore, the difference with the previous one is substantial. The Valencia building uses a standard Natural Gas boiler for both heating and DHW. Finally, the one with the least emissions per square meter per year is the tertiary building located in Moguer, although the difference with the building in Valencia is not particularly great. This used a diesel boiler for ACS and a heat pump for heating and cooling.



Graph 6: Comparison of the non-renewable primary energy consumption: Total, heating, DHW and cooling. Source: Amutio, J.

Regarding non-renewable primary energy consumption in kWh per year per square meter, the building with the highest consumption continues to be the oldest building in Barcelona. In this way, the rest of the positions are also maintained. The next one is the building in Valencia, and finally the tertiary building.

3. IMPROVEMENTS IN THE WORST PERFORMING BUILDING.

3.1. REPLACEMENT OF THE ELECTRIC RADIATORS WITH HEAT PUMPS THAT ARE USED FOR HEATING AND COOLING.

In this case the housing block with the worst results has been, as we have seen and commented, the housing block in Barcelona.

It currently uses electric radiators for heating. However, we are going to propose replacing this heating system with heat pumps.

These systems are not very well known by the users but nevertheless they were chosen by Greenpeace in 2011 as the best heating system in terms of energy efficiency. This feature is due to its operation: it is based on transporting heat instead of generating it. Air conditioning systems with heat pumps are the best option to obtain the highest level of efficiency in generating comfort in buildings. The simple combination of heating and cooling services makes it the least aggressive solution with the environment, with less energy expenditure and more versatile.

For this, the application allows us to choose between different heat pumps. These are: From before 1994, between 1994 and 2013 and after 2013. Also, we choose heat pumps with variable cooling flow (Air-Air).

We are going to choose the intermediate option.

The following results have been obtained:

- ENERGY RATING OF THE BUILDING IN EMISSIONS

Total Indicator		Partial Indicators			
<6.1 A 6.1-9.9 B 9.9-15.3 C 15.3-23.5 D 23.5-43.0 E 43.0-57.3 F ≥57.3 G	27,1 E	Heating (kgCO2/m2 year)		DHW (kgCO2/m2 year)	
		12,29	D	14,47	G
		Cooling (kgCO2/m2 year)		Illumination (kgCO2/m2 year)	
		0,34	A	-	-

	kgCO2/m2 year	kgCO2/m2 year
CO2 emissions from electricity consumption	12,64	7052,91
CO2 emissions from other fuels	14,47	8075,86

Figure 45: Energy rating of the building in emissions with heat pumps. Source: CE3X.

We obtained an E rating for CO2 emissions. This is divided into emissions from heating, domestic hot water and cooling. Being that these separately obtain a rating of D, G and A respectively. In this way, domestic hot water emissions obtain the most negative rating and cooling emissions obtain the most positive rating.

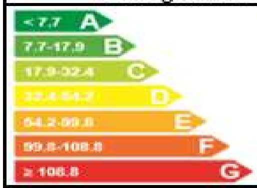
- ENERGY RATING OF THE BUILDING IN NON-RENEWABLE PRIMARY ENERGY CONSUMPTION

Total Indicator	Partial Indicators			
143,0 E	Heating (kWh/m2 year)		DHW (kWh/m2 year)	
	72,58	D	68,43	G
	Cooling (kWh/m2 year)		Illumination (kWh/m2 year)	
	2,04	A	-	-

Figure 46: Energy rating of the building in non-renewable primary energy consumption with heat pumps. Source: CE3X

Regarding non-renewable primary energy consumption, we obtain an overall rating of E. Individually, we obtain an E, G and B for heating, domestic hot water and refrigeration respectively. The worst score is obtained in the consumption for domestic hot water and the best score is obtained in the consumption for refrigeration.

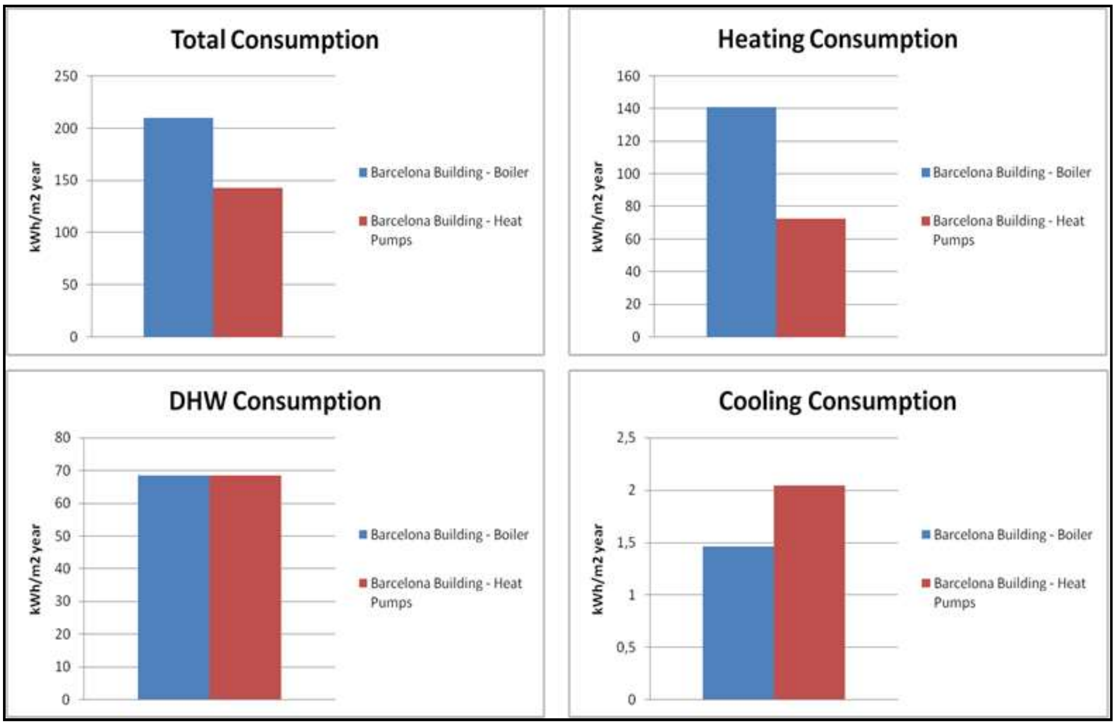
- PARTIAL RATING OF THE ENERGY DEMAND FOR HEATING AND COOLING



Heating demand (kWh/m2 year)	Cooling demand (kWh/m2 year)
71,9 E	1,5 A

Figure 47: Partial rating of the energy demand for heating and cooling. Source: CE3X.

3.1.1. COMPARISON OF CHANGES IN RESULTS AFTER CHANGING THE HEATING AND COOLING SYSTEM IN THE BARCELONA BUILDING.



Graph 7: **Comparison of results after changing the heating and cooling system. Source: Amutio, J.**

We have managed to reduce non-renewable primary energy consumption from 210.4 to 143.0 kWh / m2 year in a total way. This decrease is due to the decrease in consumption in heating, since for domestic hot water it remains the same and consumption in relation to refrigeration increases since before we did not really have refrigeration equipment.

3.2. INSTALLATION OF PHOTOVOLTAIC PANELS TO COVER PART OF THE DEMAND FOR ELECTRICAL ENERGY

We are going to study one of the improvements that we are going to propose for the building that consumes the most energy and has the most emissions, the building located in Barcelona.

For this, we are going to work with photovoltaic technology for self-consumption. With this, we are going to pretend that the building has a small energy contribution from electricity. With this, we will be able to reduce the qualifications since they contemplate non-renewable primary energy and we would also reduce CO2 emissions.

This option is especially interesting, since, although some in Spain there was a so-called "Sun Tax", it was repealed on October 5, 2018. The Sun Tax[13] was defined as a "backup toll" applied to energy generated through the use of photovoltaic panels. Therefore, the consumer should pay the corresponding taxes for the energy produced in his self-consumption installation. However, we no longer have to worry about it.

So the goal is to install photovoltaic panels on the roof of the building. We will begin to define the improvement. First of all, we are going to try to install the photovoltaic panels on the roof, since we have a free space that we could take advantage of. These spaces are:

Figure 48: **Spaces destined for the installation of photovoltaic fields. Source: Google Earth.**

Measuring with the Google Earth tool, the space of the first image is 4x8 m2. That is, 32 m2. The space of the second image is 2x8 m2. That is, 16 m2.

In addition, we also have to take into account that to take advantage of the space, the orientation of the panels would not be the most recommended (south), but rather that they would have to fit well with the orientation of the building. With this, let's find the azimuth angle of the panels.

[13] https://www.factorenergia.com/es/blog/autoconsumo/que-es-impuesto-al-sol/

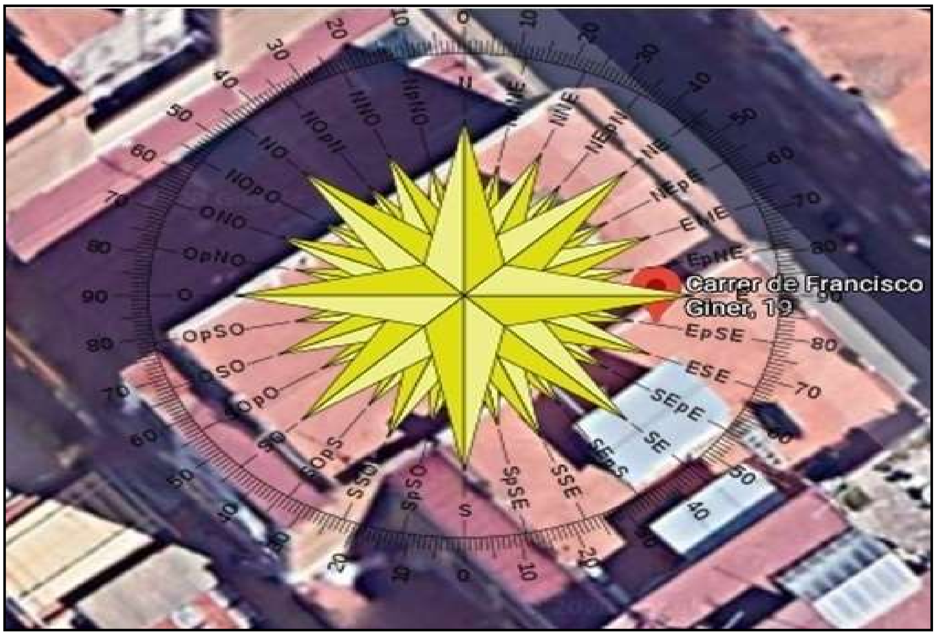


Figure 49: **Obtaining the azimuth angle according to the orientation of the building. Source: Amutio, J.**

The azimuth angle of the panels will be taken from 55º. Now, we would have to define the beta angle that the photovoltaic panels will have. For this, we are going to work with the acceptable losses in the photovoltaic panels.

Thus, for our azimuth angle, if we wanted to tolerate a maximum loss of 10%, the beta angle of inclination of the panels should be between 10º and 40º. In this way, we are going to choose a fixed 35º angle for the photovoltaic panels that we are going to place.

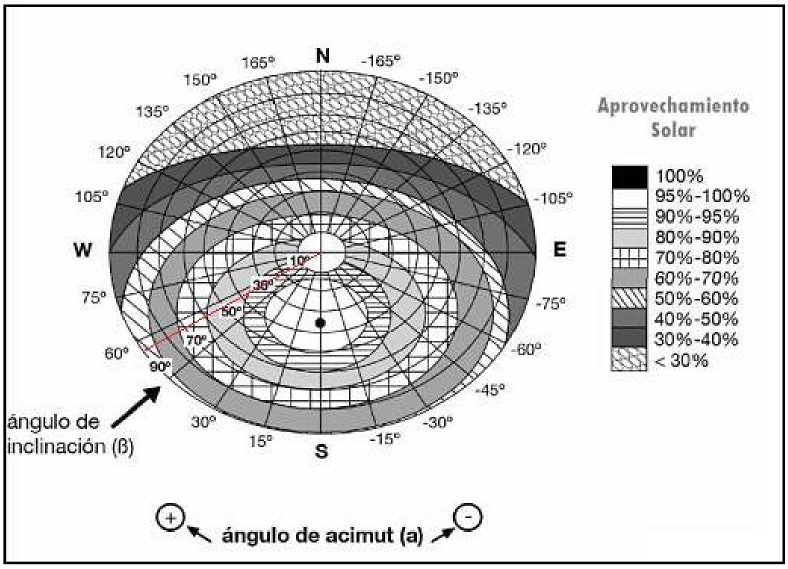


Figure 50: **Solar gain as a function of tilt angle and azimuth angle. Source: Google Images**

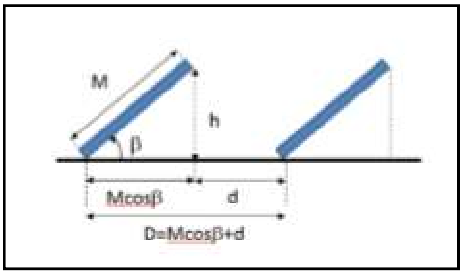
Now we are going to study how many panels fit us in the first space (32 m2) in series and in parallel.

We are going to work with Atersa A200 panels. These are 1,618m wide and 0.814m long. Here we can see the type plate of the Atersa A200 panels.

Características físicas	
Dimensiones (mm ± 2mm)	1618x814x35
Peso (kg)	14,8
Área (m²)	1,63
Tipo de célula	Monocristalina 125x125mm (5 pulgadas)
Células en serie	72 (6x12)
Cristal delantero	Cristal templado ultra claro de 3,2mm
Marco	Aleación de aluminio pintado en poliéster
Caja de conexiones / Opcional	QUAD IP54 / QUAD IP65
Cables	Cable Solar 4mm² 1100mm
Conectores	MC4 o combinable MC4

Figure 51: **Name plate of ATERSA A200 panels. Source: 'Auditoría Energética' - UPV**

As we have two different spaces, we are going to place them horizontally in the bigger space, that is, the long side parallel to the ground and the short side perpendicular to the ground to avoid shading, to avoid shading. However, in the small space, as presumably we will not be able to put more than one row, the short side will be parallel to the ground to be able to place more panels. Furthermore, we know that the latitude of Barcelona is 41.38 ≈ 41º. From this we will obtain the value of k.



M = 0,814m

B = 35º

d = h*k (distance between panels)

k = 2,747

Latitud	29°	37°	39°	41°	43°	45°
k	1,600	2,246	2,475	2,747	3,078	3,487

Figure 52: **Diagram of the position of the panels and data necessary for the calculation. Source: 'Auditoría Energética' - UPV**

With all this information:

h = MsenB = 0,814*sen(35) = 0,4669

d = h*k = 0,4669*2,747 = 1,2826

Nseries$\leq \frac{8}{1{,}618} \leq 4{,}94$ -> 4 panels in series

Nparalel $\leq \frac{4}{0{,}6667+1{,}2826} \leq 2{,}71$ -> 2 rows of panels.

And in the other space, taking into account that the width is the same and that the length would become two meters, the panels that we are going to be able to put in series would remain (4) but the rows of panels that can be placed in parallel are probably 0 or 1. We check it:

Nseries$\leq \frac{8}{0{,}814} \leq 9{,}828$ -> 9 panels in series

Nparalel2 $\leq \frac{2}{0{,}6667+1{,}2826} \leq 1{,}026$ -> 1 row of panels.

In this way, in total we are going to work with 3 parallel rows of 4 panels two of them and the other with 9 panels. That makes a total of 17 panels.

Taking into account that the power of the panels is 200 W, in our small photovoltaic field we will have a total power of:

P = 17 panels * 200 W / panel = 3400 W = 3.4 kW

We assume an average of 1800 h of solar PV full load hours in Barcelona => annual PV generation = 3.4 kW * 1800 = 6120 kWh/year.

The energy consumption of the barcelona building with the heat pump is = 143,0 kWh/m² year * 558 m² = 79794 kWh/year

So, with this, the net consumption will be:

Net consumption = 79794 – 6120 = 73674 kWh/year

In this way, with both measures, the consumption will be:

Consumption 2 = 73674/558 = 132,02 kWh/year m²

So we have obtained a reduction of:

Reduction = 143,0-132,02 = 10,97 kWh/year m²

And, with both measures (the photovoltaic field and the heat pumps) we have a total reduction of:

Total reduction = 210,4 - 132,02 = 78,38 kWh/year m2

In this way, the contribution of the photovoltaic panels is going to be used only to complement the heating demand. The heating demand is currently 71.9 kWh / m2 year, which means 40120,2 kWh / year. In this way, since our photovoltaic panels could provide 6120 kWh / year, this means that we could cover 15,25% of the annual heating demand with photovoltaic panels.

Thus, we add the energy contribution of the photovoltaic field to the program:

- Building's air conditioning facilities:

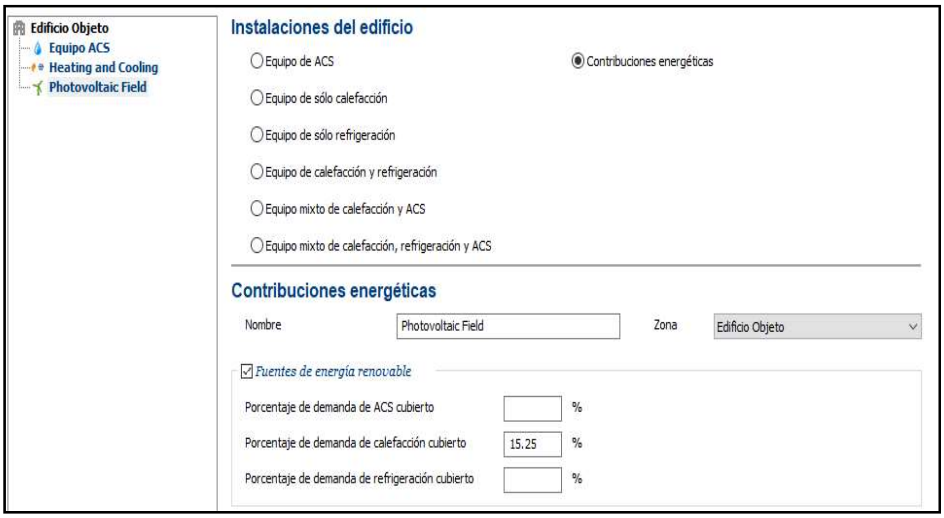


Figure 53: **Introduction of the photovoltaic field in the CE3X program. Source: CE3X.**

Now, we run the simulation again and if our previous calculations are correct, we should get the same results:

- ENERGY RATING OF THE BUILDING IN EMISSIONS

Total Indicator	Partial Indicators			
25,2 E	Heating (kgCO2/m2 year)		DHW (kgCO2/m2 year)	
	10,42	C	14,47	G
	Cooling (kgCO2/m2 year)		Illumination (kgCO2/m2 year)	
	0,34	A	-	-

	kgCO2/m2 year	kgCO2/m2 year
CO2 emissions from electricity consumption	10,76	6006,67
CO2 emissions from other fuels	14,47	8075,86

Figure 54: **Energy rating of the building in emissions with photovoltaic field. Source: CE3X.**

We obtained an E rating for CO2 emissions. This is divided into emissions from heating, domestic hot water and cooling. Being that these separately obtain a rating of C, G and A respectively. In this way, domestic hot water emissions obtain the most negative rating and cooling emissions obtain the most positive rating. **This means that we have managed to improve the individual rating of the heating (from D to C).**

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

Total Indicator	Partial Indicators			
	Heating (kWh/m2 year)		DHW (kWh/m2 year)	
132,0 E	61,51	D	68,43	G
	Cooling (kWh/m2 year)		Illumination (kWh/m2 year)	
	2,04	A	-	-

Figure 55: **Energy rating of the building in non-renewable primary energy consumption with photovoltaic field. Source: CE3X**

Regarding non-renewable primary energy consumption, we obtain an overall rating of E. Individually, we obtain an E, G and B for heating, domestic hot water and refrigeration respectively. The worst score is obtained in the consumption for domestic hot water and the best score is obtained in the consumption for refrigeration. **This means that we have managed to improve the individual rating of the heating (from E to D).**

- PARTIAL RATING OF THE ENERGY DEMAND FOR HEATING AND COOLING

Heating demand (kWh/m2 year)	Cooling demand (kWh/m2 year)
71,9 E	1,5 A

Figure 56: **Partial rating of the energy demand for heating and cooling. Source: CE3X.**

In this way, the manual calculations coincide with those obtained by the program, and although we have not managed to increase the total rating of non-renewable energy consumption, we have managed to lower the individual rating of non-renewable energy consumption for heating.

3.2.1. INSTALLATION OF THE INVERTER

However, photovoltaic cells convert sunlight into direct current (DC) electricity. In this way, we will need an inverter that converts DC into alternating current (AC) electricity to be usable in homes. Since the power that we can obtain on our roof is not excessively high, we will need a photovoltaic inverter of that order of magnitude. With this, the INGECON® SUN 1Play 5TL M model has been chosen. The data sheet for this will be attached in the annex.

Now we have to see if we can connect the photovoltaic panels to the inverter. For this, we will need data from the data sheet of the photovoltaic panels and the inverter. We are going to use the following formulas:

$$Fs = \frac{P_{DC-MAX}}{P_{GFV-MPP-STC}}$$

$$T_{MAX} = T_{Amb\_MAX} + G_{MAX}\left(\frac{NOTC - 20º}{0,8}\right)$$

$$V_{MOD}(T) = V_{MOD-25ºC} \cdot e^{(T-25º)\cdot\beta_{1/C}} \approx V_{MOD-25ºC} \cdot \left(1 + (T - 25º)\cdot\beta_{1/C}\right) \approx V_{MOD-25ºC} + (T - 25º)\cdot\beta_{V/C}$$

$$I_{MOD}(T) = I_{MOD-25ºC} \cdot e^{(T-25º)\cdot\alpha_{1/C}} \approx I_{MOD-25ºC} \cdot \left(1 + (T - 25º)\cdot\alpha_{1/C}\right) \approx I_{MOD-25ºC} + (T - 25º)\cdot\alpha_{A/C}$$

Equation 4: Equations to be used to know if the photovoltaic inverter can be used (or not). Source: UPV.

We calculate the maximum number of panels in series:

$$\beta_{\frac{V}{C}} = \beta_{1/C} * V_{oc} = 44{,}46 * -0{,}0032 = -0{,}142$$

$$V_{mod\_oc\_max} = V_{mod\_oc} + (T - 25) * \beta_{\frac{V}{C}} = 44{,}46 + (-5 - 25) * -0{,}142 = 48{,}728 \text{ V}$$

$$Ns_{max} \leq \frac{850}{48{,}728} \leq 17{,}44 \leq 17 \text{ panels}$$

We calculate the minimum number of panels in series:

$$T_{max} = T_{amb\_max} + G_{max}\left(\frac{NOTC - 20ºC}{0,8}\right) = 40 + 1\left(\frac{47ºC - 20ºC}{0,8}\right) = 73{,}75 \text{ ºC}$$

$$V_{mod\_mpp\_min} = V_{mod\_mpp} + (Tmax - 25) * \beta_{\frac{V}{C}} = 37{,}18 + (73{,}75 - 25) * -0{,}142 = 30{,}257\ \mathrm{V}$$

$$Ns_{min} \geq \frac{90}{30{,}257} \geq 2{,}97 \geq 3\ \text{panels}$$

We now calculate the maximum number of strings (parallel rows) we must have to use this photovoltaic inverter.

$$\alpha_{\frac{A}{C}} = \alpha_{1/C} * \mathrm{I_{mod\_SC\_STC}} = 0{,}0008 * 5{,}78 = 4{,}624$$

$$I_{mod\_SC\_max} = I_{mod\_SC\_STC} + (Tmax - 25) * \alpha_{\frac{A}{C}} = 5{,}78 + (73{,}75 - 25) * -0{,}0008 = 6{,}005\ \mathrm{A}$$

$$Np_{max} \leq \frac{22\ (*)}{6{,}005} \leq 3{,}66 \leq 3\ \text{panels}$$

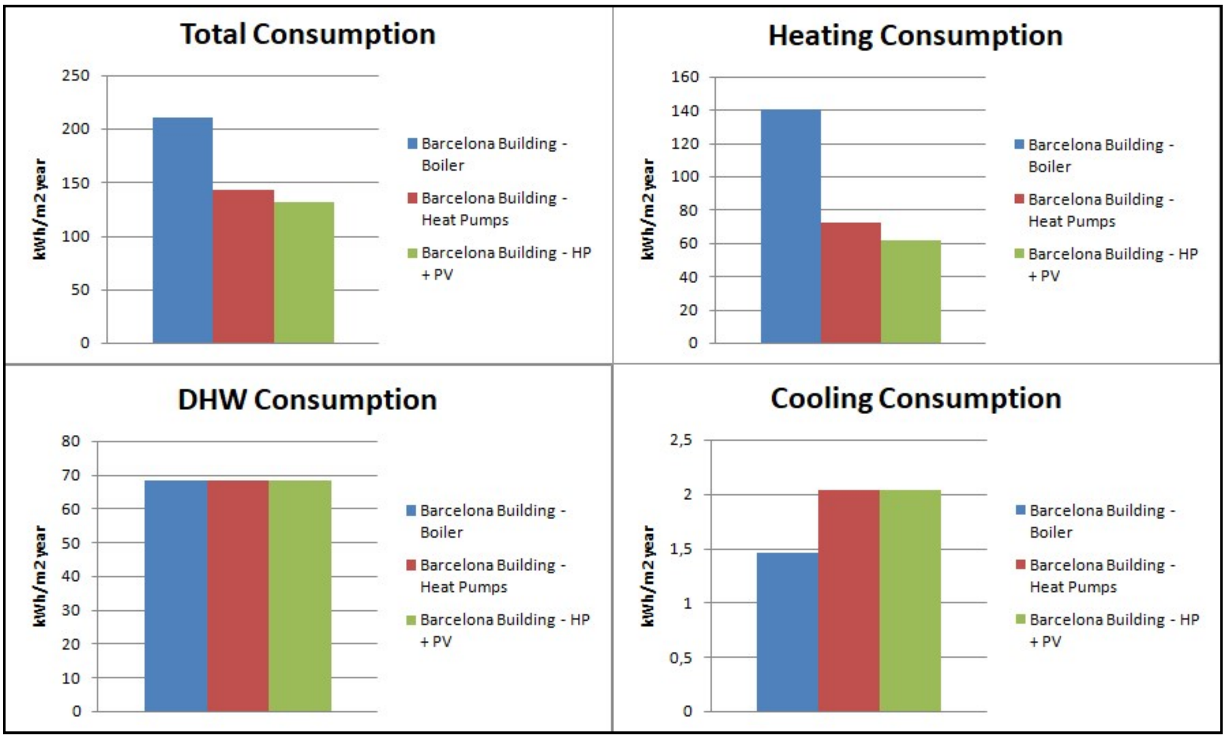
(*) The inverter has two inputs with a maximum of 11 A each.

This way, knowing that we have three rows in parallel: 2 rows in parallel have 4 panels each. The other row has 9 panels. In this way, we comply with the limit of parallel rows and each row complies with the limit of panels in series so we can connect the inverter by selecting the panels in the row.

Row	Ns	Np	Ns_max	Ns_min	Np_max	
1	4	3	17	3	3	✓
2	4					✓
3	9					✓

Table 15: **Selected values and upper and lower limits. Source: Amutio, J.**

3.2.2. COMPARISON OF INITIAL RESULTS, WITH HEAT PUMPS AND WITH BOTH MEASURES.



Graph 8: Comparison of initial results, with heat pumps and with both measures

As we can see, the measure with the most impact on the initial assessment is the replacement of the use of electric radiators by heat pumps. On the other hand, the implementation of the photovoltaic field on the roof has a much smaller influence on the final result.

In the following, we will carry out the economic analysis of both measures, because although heat pumps actually have a much greater impact, they also require a higher investment.

BUDGET

1. ECONOMIC ANALYSIS OF IMPROVEMENTS

1.1. PHOTOVOLTAIC FIELD IN THE ROOF

The photovoltaic modules of the selected model have been found at a price of € 314.60. Which means that the total of 17 models would cost € 5348,2. On the other hand, the photovoltaic inverter is priced at € 1216,29. This makes a total of € 6564,49. We will also understand a total of € 1500 additional for installation and wiring. This would make a total of € 8064,5.

Figure 57: Prices of the chosen products. Source: Internet catalogues.

Item	Units	Cost/Unit	Total cost
ATERSA A200	17	314,60	5348,20
INVERTER	1	1216,29	1216,29
INST. & WIRING	-	1500	1500
TOTAL			8064,49

Table 16: Cost of the installation of the photovoltaic field. Source: Amutio, J.

As we are obtaining the heating from the heat pumps that work with electrical energy, with this measure what we are saving is the consumption of the electrical kWh. Therefore, to calculate the savings, we need to obtain an annual average price of the electric kWh in Spain, so we have used the monthly average data of the electric kWh in Spain in the wholesale market, collected in the following table:

Evolution of the kWh price 2019 (PVPC)	
Month	**Energy Term (€/kWh)**
January	0,1289
February	0,1194
March	0,1138
April	0,1153
May	0,1109
June	0,1084
July	0,1125
August	0,1057
September	0,1018
October	0,1085
November	0,1047
December	0,0956
Annual average	0,1105

Table 17: **Evolution of the kWh price 2019. Source: PVPC.**[14]

In this way, taking into account that we are saving 6120 kWh / year, this means a saving of € 676,26 / year. With this, we calculate the return period.

Return period = $\frac{Investment}{Saving} = \frac{8064,5}{676,26} = 11,925\ year$

Equation 5: **Return period.**

1.2. REPLACEMENT OF THE ELECTRIC RADIATORS WITH HEAT PUMPS THAT ARE USED FOR HEATING AND COOLING.

Heat pumps are becoming more and more popular as an air-conditioning system because, as we have said, it is a very efficient system. The main question is often: "How much does it cost to install a ground source heat pump?.

Well, the first thing to note is that this will obviously depend on the type of home, size of home and heat pump chosen.

In our case, we find that the homes in the building to be improved in Barcelona are of a reduced size (56 m2). Thus, we must know that in apartments are recommended aerothermal heat pumps for air conditioning by heat pump and even more if the home is in the Mediterranean area, as is the case.

[14] https://www.esios.ree.es/es/pvpc

In addition, we can say that the substitution of the electric radiators by the Aerothermia makes special sense in the selected building because these electric radiators can be used in the own installation, which would reduce the cost of the installation, as we will see next.

Now, we are going to proceed with the economic study of the installation of Aerothermia in the house. In addition, we must say that although the price of installation of these systems is usually chosen, its amortization period is usually reduced.

Therefore, for the installation of the equipment of Aerotermia in the house we will need:

1. Aerothermal heat pump: There are two types:

 - Monobloc: Includes the entire refrigeration circuit in a unit that is located outside.

 -Bibloc: Includes one outdoor unit and one indoor unit.

2. DHW Accumulator: Necessary if we were to use it for DHW as well. This is not the case.

3. Inertia tank.

4. Drive groups.

In this way, we have a building with 558 useful m2 to heat. At the same time, we know that the annual demand for heating is 71.9 kWh/m2 and the annual demand for cooling is 1.5 kWh/m2.

Thus, we need:

$$558\,m2 * 71{,}9\frac{kWh}{m2} = 40120{,}2\,kWh$$

Equation 6: Annual demand for heating

$$558\,m2 * 1{,}5\frac{kWh}{m2} = 837\,kWh$$

Equation 7: Annual demand for cooling

We are therefore assuming an annual use of 2000 hours of aerothermal heating and cooling systems. Also, we are going to focus on heating consumption as we will of course comply with cooling consumption.

We need, therefore, for the whole building:

$$\frac{40120{,}2\ kWh}{2000\ h} = 20{,}06\ kW$$

Equation 8: **Power needed.**

Bearing in mind that we have to heat 9 houses and that each one is going to have an aerothermal heat pump, we need each heat pump to have an output of around 2.22 kW.

However, a higher power model has been chosen, the Thermor Alfea Extensa Ai 5 heat pump.

Figure 58:

Therefore, the estimated cost of the aerothermal equipment and its installation is shown in the following table:

EQUIPMENT	UNITS	COST/UNIT	TOTAL COST
HEAT PUMP	9	2744,99	24704,91
INERTIA TANK	9	374,99	3374,91
INSTALLATION	-	3000	3000
TOTAL			31079,82

Table 18:

In this way, we see that the initial inertia that would have to be made in the building is high, being that divided by 9 houses would mean an outlay of 3453.31 euros per house.

This system in old buildings has an average return period of 8 - 9 years.

In conclusion, it seems an interesting solution that would above all improve the emissions and consumption of our building.

ANNEX

1. ENERGY CERTIFICATE OF THE BUILDING IN VALENCIA.

CERTIFICADO DE EFICIENCIA ENERGÉTICA DE EDIFICIOS

IDENTIFICACIÓN DEL EDIFICIO O DE LA PARTE QUE SE CERTIFICA:

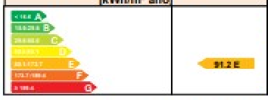
Nombre del edificio	Residential Building in Valencia, Spain		
Dirección	AV. PRIMADO REIG 125, VALENCIA		
Municipio	Valencia	Código Postal	46020
Provincia	Valencia	Comunidad Autónoma	Comunidad Valenciana
Zona climática	B3	Año construcción	1963
Normativa vigente (construcción / rehabilitación)	Anterior a la NBE-CT-79		
Referencia/s catastral/es	6840312YJ2764B		

Tipo de edificio o parte del edificio que se certifica:	
○ Edificio de nueva construcción	• Edificio Existente
• Vivienda ○ Unifamiliar • Bloque • Bloque completo ○ Vivienda individual	○ Terciario ○ Edificio completo ○ Local

DATOS DEL TÉCNICO CERTIFICADOR:

Nombre y Apellidos	Javier Amutio Just	NIF(NIE)	21795167E
Razón social	Bachelor Thesis	NIF	-
Domicilio	-		
Municipio	Valencia	Código Postal	46022
Provincia	Valencia	Comunidad Autónoma	Comunidad Valenciana
e-mail:	javieramutio98@gmail.com	Teléfono	-
Titulación habilitante según normativa vigente	-		
Procedimiento reconocido de calificación energética utilizado y versión:	CEXv2.3		

CALIFICACIÓN ENERGÉTICA OBTENIDA:

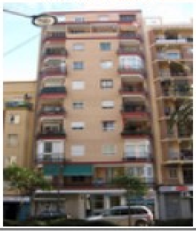
CONSUMO DE ENERGÍA PRIMARIA NO RENOVABLE [kWh/m² año]	EMISIONES DE DIÓXIDO DE CARBONO [kgCO2/ m² año]
	

El técnico abajo firmante declara responsablemente que ha realizado la certificación energética del edificio o de la parte que se certifica de acuerdo con el procedimiento establecido por la normativa vigente y que son ciertos los datos que figuran en el presente documento, y sus anexos:

Fecha: 12/04/2020

1. SUPERFICIE, IMAGEN Y SITUACIÓN

Superficie habitable [m²]	2137.0

Imagen del edificio	Plano de situación
	

2. ENVOLVENTE TÉRMICA

Cerramientos opacos

Nombre	Tipo	Superficie [m²]	Transmitancia [W/m²·K]	Modo de obtención
Building Floor	Suelo	210.0	2.50	Por defecto
SW - Wall	Fachada	363.4	1.69	Estimadas
NE - Wall	Fachada	325.8	1.69	Estimadas
Cubierta con aire	Cubierta	219.6	2.27	Estimadas
South East Wall	Fachada	449.06	0.00	
North West Wall	Fachada	449.06	0.00	

Huecos y lucernarios

Nombre	Tipo	Superficie [m²]	Transmitancia [W/m²·K]	Factor solar	Modo de obtención. Transmitancia	Modo de obtención. Factor solar
Ventanas G1	Hueco	3	3.78	0.64	Estimado	Estimado
Ventanas G2	Hueco	1.5	3.78	0.64	Estimado	Estimado
Ventanas G3	Hueco	25.0	3.78	0.64	Estimado	Estimado
Ventanas G4	Hueco	4.0	3.78	0.64	Estimado	Estimado
Ventanas G8	Hueco	37.5	3.78	0.64	Estimado	Estimado
Ventanas G9	Hueco	18.0	3.78	0.64	Estimado	Estimado
Ventanas G10	Hueco	14.0	3.78	0.64	Estimado	Estimado
Ventanas G11	Hueco	1.6	3.78	0.64	Estimado	Estimado

3. INSTALACIONES TÉRMICAS

Generadores de calefacción

Nombre	Tipo	Potencia nominal [kW]	Rendimiento Estacional [%]	Tipo de Energía	Modo de obtención
Calefacción y ACS	Caldera Estándar	24.0	63.8	Gas Natural	Estimado
TOTALES	Calefacción				

Generadores de refrigeración

Nombre	Tipo	Potencia nominal [kW]	Rendimiento Estacional [%]	Tipo de Energía	Modo de obtención
TOTALES	Refrigeración				

Instalaciones de Agua Caliente Sanitaria

Demanda diaria de ACS a 60° (litros/día)	1361.0

Nombre	Tipo	Potencia nominal [kW]	Rendimiento Estacional [%]	Tipo de Energía	Modo de obtención
Calefacción y ACS	Caldera Estándar	24.0	63.8	Gas Natural	Estimado
TOTALES	ACS				

ANEXO II
CALIFICACIÓN ENERGÉTICA DEL EDIFICIO

Zona climática	B3	Uso	Residencial

1. CALIFICACIÓN ENERGÉTICA DEL EDIFICIO EN EMISIONES

INDICADOR GLOBAL

18.3 E

Emisiones globales [kgCO2/m² año]

INDICADORES PARCIALES

CALEFACCIÓN		ACS	
Emisiones calefacción [kgCO2/m² año] 12.54	E	Emisiones ACS [kgCO2/m² año] 4.74	F
REFRIGERACIÓN		**ILUMINACIÓN**	
Emisiones refrigeración [kgCO2/m² año] 1.63	B	Emisiones iluminación [kgCO2/m² año] -	-

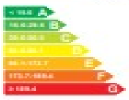
La calificación global del edificio se expresa en términos de dióxido de carbono liberado a la atmósfera como consecuencia del consumo energético del mismo.

	kgCO2/m² año	kgCO2/año
Emisiones CO2 por consumo eléctrico	1.63	3491.12
Emisiones CO2 por otros combustibles	17.28	36928.73

2. CALIFICACIÓN ENERGÉTICA DEL EDIFICIO EN CONSUMO DE ENERGÍA PRIMARIA NO RENOVABLE

Por energía primaria no renovable se entiende la energía consumida por el edificio procedente de fuentes no renovables que no ha sufrido ningún proceso de conversión o transformación.

INDICADOR GLOBAL



91.2 E

Consumo global de energía primaria no renovable [kWh/m² año]

INDICADORES PARCIALES

CALEFACCIÓN		ACS	
Energía primaria calefacción [kWh/m² año] 59.21	E	Energía primaria ACS [kWh/m² año] 22.39	G
REFRIGERACIÓN		**ILUMINACIÓN**	
Energía primaria refrigeración [kWh/m² año] 9.64	C	Energía primaria iluminación [kWh/m² año] -	-

3. CALIFICACIÓN PARCIAL DE LA DEMANDA ENERGÉTICA DE CALEFACCIÓN Y REFRIGERACIÓN

La demanda energética de calefacción y refrigeración es la energía necesaria para mantener las condiciones internas de confort del edificio.

DEMANDA DE CALEFACCIÓN

31.7 D

Demanda de calefacción [kWh/m² año]

DEMANDA DE REFRIGERACIÓN

9.9 C

Demanda de refrigeración [kWh/m² año]

El indicador global es resultado de la suma de los indicadores parciales más el valor del indicador para consumos auxiliares, si los hubiera (sólo ed. terciarios, ventilación, bombeo, etc. ...). La energía eléctrica autoconsumida se descuenta únicamente del indicador global, no así de los valores parciales.

2. ENERGY CERTIFICATE OF THE NURSING HOME IN MOGUER

CERTIFICADO DE EFICIENCIA ENERGÉTICA DE EDIFICIOS

IDENTIFICACIÓN DEL EDIFICIO O DE LA PARTE QUE SE CERTIFICA:

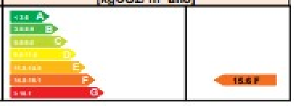
Nombre del edificio	Nursing home in Moguer, Huelva		
Dirección	Calle Divina Pastora, 3		
Municipio	Moguer	**Código Postal**	21800
Provincia	Huelva	**Comunidad Autónoma**	Andalucía
Zona climática	B4	**Año construcción**	1995
Normativa vigente (construcción / rehabilitación)	NBE-CT-79		
Referencia/s catastral/es	1577022PB9217N		

Tipo de edificio o parte del edificio que se certifica:	
○ Edificio de nueva construcción	● Edificio Existente
○ Vivienda ○ Unifamiliar ○ Bloque ○ Bloque completo ○ Vivienda individual	● Terciario ● Edificio completo ○ Local

DATOS DEL TÉCNICO CERTIFICADOR:

Nombre y Apellidos	-	**NIF(NIE)**	-
Razón social	-	**NIF**	-
Domicilio	-		
Municipio	-	**Código Postal**	-
Provincia	Valencia	**Comunidad Autónoma**	Comunidad Valenciana
e-mail:	-	**Teléfono**	-
Titulación habilitante según normativa vigente	-		
Procedimiento reconocido de calificación energética utilizado y versión:	CEXv2.3		

CALIFICACIÓN ENERGÉTICA OBTENIDA:

CONSUMO DE ENERGÍA PRIMARIA NO RENOVABLE [kWh/m² año]	EMISIONES DE DIÓXIDO DE CARBONO [kgCO2/ m² año]
	

El técnico abajo firmante declara responsablemente que ha realizado la certificación energética del edificio o de la parte que se certifica de acuerdo con el procedimiento establecido por la normativa vigente y que son ciertos los datos que figuran en el presente documento, y sus anexos:

Fecha: 17/04/2020

ANEXO I
DESCRIPCIÓN DE LAS CARACTERÍSTICAS ENERGÉTICAS DEL EDIFICIO

En este apartado se describen las características energéticas del edificio, envolvente térmica, instalaciones, condiciones de funcionamiento y ocupación y demás datos utilizados para obtener la calificación energética del edificio.

1. SUPERFICIE, IMAGEN Y SITUACIÓN

Superficie habitable [m²]	1864.0

Imagen del edificio	Plano de situación
	

2. ENVOLVENTE TÉRMICA

Cerramientos opacos

Nombre	Tipo	Superficie [m²]	Transmitancia [W/m²·K]	Modo de obtención
Roof	Cubierta	932.0	2.27	Estimadas
South Wall	Fachada	312.67	2.38	Estimadas
West Wall	Fachada	137.77	2.38	Estimadas
East Wall	Fachada	88.8	2.38	Estimadas
Floor	Cubierta	932.0	2.27	Estimadas
North Wall	Fachada	289.8	0.00	

Huecos y lucernarios

Nombre	Tipo	Superficie [m²]	Transmitancia [W/m²·K]	Factor solar	Modo de obtención. Transmitancia	Modo de obtención. Factor solar
South Windows	Hueco	34.58	3.78	0.63	Estimado	Estimado
West Windows	Hueco	14.63	3.78	0.63	Estimado	Estimado

3. INSTALACIONES TÉRMICAS

Generadores de calefacción

Nombre	Tipo	Potencia nominal [kW]	Rendimiento Estacional [%]	Tipo de Energía	Modo de obtención
Heating and Cooling	Bomba de Calor - Caudal Ref. Variable		253.1	Electricidad	Estimado
TOTALES	Calefacción				

Generadores de refrigeración

Nombre	Tipo	Potencia nominal [kW]	Rendimiento Estacional [%]	Tipo de Energía	Modo de obtención
Heating and Cooling	Bomba de Calor - Caudal Ref. Variable		190.2	Electricidad	Estimado
TOTALES	Refrigeración				

Instalaciones de Agua Caliente Sanitaria

Demanda diaria de ACS a 60° (litros/día)	1476.0

Nombre	Tipo	Potencia nominal [kW]	Rendimiento Estacional [%]	Tipo de Energía	Modo de obtención
DHW	Caldera Estándar	125	67.7	Gasóleo-C	Estimado
TOTALES	ACS				

5. CONDICIONES DE FUNCIONAMIENTO Y OCUPACIÓN (sólo edificios terciarios)

Espacio	Superficie [m²]	Perfil de uso
Edificio	1864.0	Intensidad Baja - 16h

ANEXO II
CALIFICACIÓN ENERGÉTICA DEL EDIFICIO

Zona climática	B4	**Uso**	Intensidad Baja - 16h

1. CALIFICACIÓN ENERGÉTICA DEL EDIFICIO EN EMISIONES

INDICADOR GLOBAL

Emisiones globales [kgCO2/m² año]

INDICADORES PARCIALES

CALEFACCIÓN		ACS	
Emisiones calefacción [kgCO2/m² año]	E	*Emisiones ACS [kgCO2/m² año]*	G
3.90		6.78	
REFRIGERACIÓN		**ILUMINACIÓN**	
Emisiones refrigeración [kgCO2/m² año]	D	*Emisiones iluminación [kgCO2/m² año]*	-
4.91		0.00	

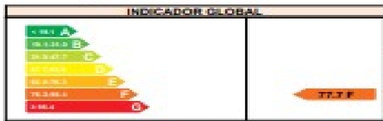
La calificación global del edificio se expresa en términos de dióxido de carbono liberado a la atmósfera como consecuencia del consumo energético del mismo.

	kgCO2/m² año	kgCO2/año
Emisiones CO2 por consumo eléctrico	8.81	16426.41
Emisiones CO2 por otros combustibles	6.78	12640.64

2. CALIFICACIÓN ENERGÉTICA DEL EDIFICIO EN CONSUMO DE ENERGÍA PRIMARIA NO RENOVABLE

Por energía primaria no renovable se entiende la energía consumida por el edificio procedente de fuentes no renovables que no ha sufrido ningún proceso de conversión o transformación.

INDICADOR GLOBAL



Consumo global de energía primaria no renovable [kWh/m² año]

INDICADORES PARCIALES

CALEFACCIÓN		ACS	
Energía primaria calefacción [kWh/m² año]	G	*Energía primaria ACS [kWh/m² año]*	G
23.04		25.71	
REFRIGERACIÓN		**ILUMINACIÓN**	
Energía primaria refrigeración [kWh/m² año]	D	*Energía primaria iluminación [kWh/m² año]*	-
28.98		0.00	

3. CALIFICACIÓN PARCIAL DE LA DEMANDA ENERGÉTICA DE CALEFACCIÓN Y REFRIGERACIÓN

La demanda energética de calefacción y refrigeración es la energía necesaria para mantener las condiciones internas de confort del edificio.

DEMANDA DE CALEFACCIÓN

Demanda de calefacción [kWh/m² año]

DEMANDA DE REFRIGERACIÓN

Demanda de refrigeración [kWh/m² año]

El indicador global es resultado de la suma de los indicadores parciales más el valor del indicador para consumos auxiliares, si los hubiera (sólo ed. terciarios, ventilación, bombeo, etc...). La energía eléctrica autoconsumida se descuenta únicamente del indicador global, no así de los valores parciales.

3. ENERGY CERTIFICATE OF THE BUILDING IN BARCELONA.

CERTIFICADO DE EFICIENCIA ENERGÉTICA DE EDIFICIOS

IDENTIFICACIÓN DEL EDIFICIO O DE LA PARTE QUE SE CERTIFICA:

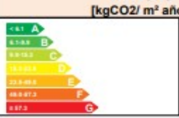
Nombre del edificio	Residential Building in Barcelona, Spain		
Dirección	Francisco Giner Street, 19		
Municipio	Barcelona	**Código Postal**	08012
Provincia	Barcelona	**Comunidad Autónoma**	Cataluña
Zona climática	C2	**Año construcción**	1884
Normativa vigente (construcción / rehabilitación)	Anterior a la NBE-CT-79		
Referencia/s catastral/es	9835205DF2893F		

Tipo de edificio o parte del edificio que se certifica:	
○ Edificio de nueva construcción	● Edificio Existente
● Vivienda ○ Unifamiliar ● Bloque ● Bloque completo ○ Vivienda individual	○ Terciario ○ Edificio completo ○ Local

DATOS DEL TÉCNICO CERTIFICADOR:

Nombre y Apellidos	-	**NIF(NIE)**	-
Razón social	-	**NIF**	-
Domicilio	-		
Municipio	-	**Código Postal**	-
Provincia	Valencia	**Comunidad Autónoma**	Comunidad Valenciana
e-mail:	-	**Teléfono**	-
Titulación habilitante según normativa vigente	-		
Procedimiento reconocido de calificación energética utilizado y versión:	CEXv2.3		

CALIFICACIÓN ENERGÉTICA OBTENIDA:

CONSUMO DE ENERGÍA PRIMARIA NO RENOVABLE [kWh/m² año]		EMISIONES DE DIÓXIDO DE CARBONO [kgCO2/ m² año]	
	210.4 E		38.5 E

El técnico abajo firmante declara responsablemente que ha realizado la certificación energética del edificio o de la parte que se certifica de acuerdo con el procedimiento establecido por la normativa vigente y que son ciertos los datos que figuran en el presente documento, y sus anexos:

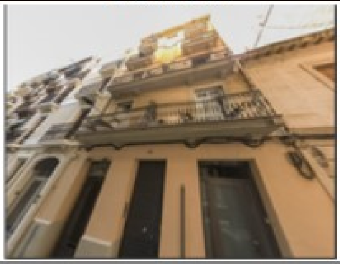
Fecha: 24/04/2020

ANEXO I
DESCRIPCIÓN DE LAS CARACTERÍSTICAS ENERGÉTICAS DEL EDIFICIO

En este apartado se describen las características energéticas del edificio, envolvente térmica, instalaciones, condiciones de funcionamiento y ocupación y demás datos utilizados para obtener la calificación energética del edificio.

1. SUPERFICIE, IMAGEN Y SITUACIÓN

Superficie habitable [m²]	558.0

Imagen del edificio	Plano de situación
	

2. ENVOLVENTE TÉRMICA

Cerramientos opacos

Nombre	Tipo	Superficie [m²]	Transmitancia [W/m²·K]	Modo de obtención
South East Wall	Fachada	214.6	0.00	
North West Wall	Fachada	214.6	0.00	
North East Wall	Fachada	104.46	2.38	Estimadas
South West Wall	Fachada	113.1	2.38	Estimadas
Roof	Cubierta	101.1	2.27	Estimadas
Floor	Suelo	101.1	0.92	Estimadas

Huecos y lucernarios

Nombre	Tipo	Superficie [m²]	Transmitancia [W/m²·K]	Factor solar	Modo de obtención. Transmitancia	Modo de obtención. Factor solar
Windows	Hueco	8.64	3.78	0.63	Estimado	Estimado

3. INSTALACIONES TÉRMICAS

Generadores de calefacción

Nombre	Tipo	Potencia nominal [kW]	Rendimiento Estacional [%]	Tipo de Energía	Modo de obtención
Sólo calefacción	Efecto Joule		100.0	Electricidad	Estimado
TOTALES	Calefacción				

Generadores de refrigeración

Nombre	Tipo	Potencia nominal [kW]	Rendimiento Estacional [%]	Tipo de Energía	Modo de obtención
TOTALES	Refrigeración				

Instalaciones de Agua Caliente Sanitaria

Demanda diaria de ACS a 60° (litros/día)	718.2

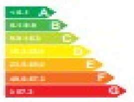
Nombre	Tipo	Potencia nominal [kW]	Rendimiento Estacional [%]	Tipo de Energía	Modo de obtención
Equipo ACS	Caldera Estándar	24.0	44.0	GLP	Estimado
TOTALES	ACS				

ANEXO II
CALIFICACIÓN ENERGÉTICA DEL EDIFICIO

Zona climática	C2	**Uso**	Residencial

1. CALIFICACIÓN ENERGÉTICA DEL EDIFICIO EN EMISIONES

INDICADOR GLOBAL



38.5 E

Emisiones globales [kgCO2/m² año]

INDICADORES PARCIALES

CALEFACCIÓN		ACS	
Emisiones calefacción [kgCO2/m² año]	E	Emisiones ACS [kgCO2/m² año]	G
23.80		14.47	
REFRIGERACIÓN		**ILUMINACIÓN**	
Emisiones refrigeración [kgCO2/m² año]	A	Emisiones iluminación [kgCO2/m² año]	-
0.25		-	

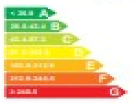
La calificación global del edificio se expresa en términos de dióxido de carbono liberado a la atmósfera como consecuencia del consumo energético del mismo.

	kgCO2/m² año	kgCO2/año
Emisiones CO2 por consumo eléctrico	24.05	13419.56
Emisiones CO2 por otros combustibles	14.47	8075.86

2. CALIFICACIÓN ENERGÉTICA DEL EDIFICIO EN CONSUMO DE ENERGÍA PRIMARIA NO RENOVABLE

Por energía primaria no renovable se entiende la energía consumida por el edificio procedente de fuentes no renovables que no ha sufrido ningún proceso de conversión o transformación.

INDICADOR GLOBAL



218.4 E

Consumo global de energía primaria no renovable [kWh/m² año]

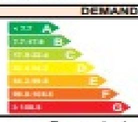
INDICADORES PARCIALES

CALEFACCIÓN		ACS	
Energía primaria calefacción [kWh/m² año]	E	Energía primaria ACS [kWh/m² año]	G
140.52		68.43	
REFRIGERACIÓN		**ILUMINACIÓN**	
Energía primaria refrigeración [kWh/m² año]	A	Energía primaria iluminación [kWh/m² año]	-
1.46		-	

3. CALIFICACIÓN PARCIAL DE LA DEMANDA ENERGÉTICA DE CALEFACCIÓN Y REFRIGERACIÓN

La demanda energética de calefacción y refrigeración es la energía necesaria para mantener las condiciones internas de confort del edificio.

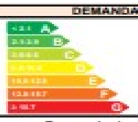
DEMANDA DE CALEFACCIÓN



71.9 E

Demanda de calefacción [kWh/m² año]

DEMANDA DE REFRIGERACIÓN



1.5 A

Demanda de refrigeración [kWh/m² año]

El indicador global es resultado de la suma de los indicadores parciales más el valor del indicador para consumos auxiliares, si los hubiera (sólo ed. terciarios, ventilación, bombeo, etc. ...). La energía eléctrica autoconsumida se descuenta únicamente del indicador global, no así de los valores parciales.

4. ENERGY CERTIFICATE OF THE BUILDING IN BARCELONA WITH HEAT PUMPS

CERTIFICADO DE EFICIENCIA ENERGÉTICA DE EDIFICIOS

IDENTIFICACIÓN DEL EDIFICIO O DE LA PARTE QUE SE CERTIFICA:

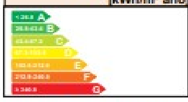
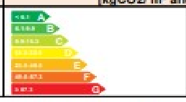
Nombre del edificio	Residential Building in Barcelona, Spain		
Dirección	Francisco Giner Street, 19		
Municipio	Barcelona	**Código Postal**	08012
Provincia	Barcelona	**Comunidad Autónoma**	Cataluña
Zona climática	C2	**Año construcción**	1884
Normativa vigente (construcción / rehabilitación)	Anterior a la NBE-CT-79		
Referencia/s catastral/es	9835205DF2893F		

Tipo de edificio o parte del edificio que se certifica:	
○ Edificio de nueva construcción	● Edificio Existente
● Vivienda ○ Unifamiliar ● Bloque ● Bloque completo ○ Vivienda individual	○ Terciario ○ Edificio completo ○ Local

DATOS DEL TÉCNICO CERTIFICADOR:

Nombre y Apellidos	-	**NIF(NIE)**	-
Razón social	-	**NIF**	-
Domicilio	-		
Municipio	-	**Código Postal**	-
Provincia	Valencia	**Comunidad Autónoma**	Comunidad Valenciana
e-mail:	-	**Teléfono**	-
Titulación habilitante según normativa vigente	-		
Procedimiento reconocido de calificación energética utilizado y versión:	CEXv2.3		

CALIFICACIÓN ENERGÉTICA OBTENIDA:

CONSUMO DE ENERGÍA PRIMARIA NO RENOVABLE [kWh/m² año]	EMISIONES DE DIÓXIDO DE CARBONO [kgCO2/ m² año]
 143.0 E	 27.1 E

El técnico abajo firmante declara responsablemente que ha realizado la certificación energética del edificio o de la parte que se certifica de acuerdo con el procedimiento establecido por la normativa vigente y que son ciertos los datos que figuran en el presente documento, y sus anexos:

Fecha: 24/04/2020

ANEXO I
DESCRIPCIÓN DE LAS CARACTERÍSTICAS ENERGÉTICAS DEL EDIFICIO

En este apartado se describen las características energéticas del edificio, envolvente térmica, instalaciones, condiciones de funcionamiento y ocupación y demás datos utilizados para obtener la calificación energética del edificio.

1. SUPERFICIE, IMAGEN Y SITUACIÓN

Superficie habitable [m²]	558.0

Imagen del edificio	Plano de situación
	

2. ENVOLVENTE TÉRMICA

Cerramientos opacos

Nombre	Tipo	Superficie [m²]	Transmitancia [W/m²·K]	Modo de obtención
South East Wall	Fachada	214.6	0.00	
North West Wall	Fachada	214.6	0.00	
North East Wall	Fachada	104.46	2.38	Estimadas
South West Wall	Fachada	113.1	2.38	Estimadas
Roof	Cubierta	101.1	2.27	Estimadas
Floor	Suelo	101.1	0.92	Estimadas

Huecos y lucernarios

Nombre	Tipo	Superficie [m²]	Transmitancia [W/m²·K]	Factor solar	Modo de obtención. Transmitancia	Modo de obtención. Factor solar
Windows	Hueco	8.64	3.78	0.63	Estimado	Estimado

3. INSTALACIONES TÉRMICAS

Generadores de calefacción

Nombre	Tipo	Potencia nominal [kW]	Rendimiento Estacional [%]	Tipo de Energía	Modo de obtención
Heating and Cooling	Bomba de Calor - Caudal Ref. Variable		193.6	Electricidad	Estimado
TOTALES	Calefacción				

Generadores de refrigeración

Nombre	Tipo	Potencia nominal [kW]	Rendimiento Estacional [%]	Tipo de Energía	Modo de obtención
Heating and Cooling	Bomba de Calor - Caudal Ref. Variable		143.0	Electricidad	Estimado
TOTALES	Refrigeración				

Instalaciones de Agua Caliente Sanitaria

Demanda diaria de ACS a 60° (litros/día)	718.2

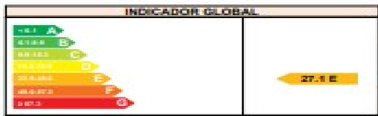
Nombre	Tipo	Potencia nominal [kW]	Rendimiento Estacional [%]	Tipo de Energía	Modo de obtención
Equipo ACS	Caldera Estándar	24.0	44.0	GLP	Estimado
TOTALES	ACS				

ANEXO II
CALIFICACIÓN ENERGÉTICA DEL EDIFICIO

Zona climática	C2	Uso	Residencial

1. CALIFICACIÓN ENERGÉTICA DEL EDIFICIO EN EMISIONES

INDICADOR GLOBAL



Emisiones globales [kgCO2/m² año]

INDICADORES PARCIALES

CALEFACCIÓN		ACS	
Emisiones calefacción [kgCO2/m² año] 12.29	D	Emisiones ACS [kgCO2/m² año] 14.47	G
REFRIGERACIÓN		**ILUMINACIÓN**	
Emisiones refrigeración [kgCO2/m² año] 0.34	A	Emisiones iluminación [kgCO2/m² año] -	-

La calificación global del edificio se expresa en términos de dióxido de carbono liberado a la atmósfera como consecuencia del consumo energético del mismo.

	kgCO2/m² año	kgCO2/año
Emisiones CO2 por consumo eléctrico	12.64	7052.91
Emisiones CO2 por otros combustibles	14.47	8075.86

2. CALIFICACIÓN ENERGÉTICA DEL EDIFICIO EN CONSUMO DE ENERGÍA PRIMARIA NO RENOVABLE

Por energía primaria no renovable se entiende la energía consumida por el edificio procedente de fuentes no renovables que no ha sufrido ningún proceso de conversión o transformación.

INDICADOR GLOBAL

Consumo global de energía primaria no renovable [kWh/m² año]

INDICADORES PARCIALES

CALEFACCIÓN		ACS	
Energía primaria calefacción [kWh/m² año] 72.58	D	Energía primaria ACS [kWh/m² año] 68.43	G
REFRIGERACIÓN		**ILUMINACIÓN**	
Energía primaria refrigeración [kWh/m² año] 2.04	A	Energía primaria iluminación [kWh/m² año] -	-

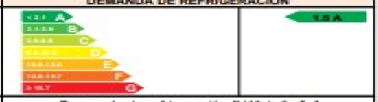
3. CALIFICACIÓN PARCIAL DE LA DEMANDA ENERGÉTICA DE CALEFACCIÓN Y REFRIGERACIÓN

La demanda energética de calefacción y refrigeración es la energía necesaria para mantener las condiciones internas de confort del edificio.

DEMANDA DE CALEFACCIÓN

Demanda de calefacción [kWh/m² año]

DEMANDA DE REFRIGERACIÓN



Demanda de refrigeración [kWh/m² año]

El indicador global es resultado de la suma de los indicadores parciales más el valor del indicador para consumos auxiliares, si los hubiera (sólo ed. terciarios, ventilación, bombeo, etc...). La energía eléctrica autoconsumida se descuenta únicamente del indicador global, no así de los valores parciales.

5. ENERGY CERTIFICATE OF THE BUILDING IN BARCELONA WITH HEAT PUMPS AND PHOTOVOLTAIC FIELD

CERTIFICADO DE EFICIENCIA ENERGÉTICA DE EDIFICIOS

IDENTIFICACIÓN DEL EDIFICIO O DE LA PARTE QUE SE CERTIFICA:

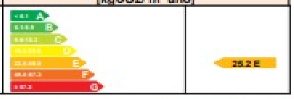
Nombre del edificio	Residential Building in Barcelona, Spain		
Dirección	Francisco Giner Street, 19		
Municipio	Barcelona	**Código Postal**	08012
Provincia	Barcelona	**Comunidad Autónoma**	Cataluña
Zona climática	C2	**Año construcción**	1884
Normativa vigente (construcción / rehabilitación)	Anterior a la NBE-CT-79		
Referencia/s catastral/es	9835205DF2893F		

Tipo de edificio o parte del edificio que se certifica:	
○ Edificio de nueva construcción	• Edificio Existente
• Vivienda ○ Unifamiliar • Bloque • Bloque completo ○ Vivienda individual	○ Terciario ○ Edificio completo ○ Local

DATOS DEL TÉCNICO CERTIFICADOR:

Nombre y Apellidos	-	**NIF(NIE)**	-
Razón social	-	**NIF**	-
Domicilio	-		
Municipio	-	**Código Postal**	-
Provincia	Valencia	**Comunidad Autónoma**	Comunidad Valenciana
e-mail:	-	**Teléfono**	-
Titulación habilitante según normativa vigente	-		
Procedimiento reconocido de calificación energética utilizado y versión:	CEXv2.3		

CALIFICACIÓN ENERGÉTICA OBTENIDA:

CONSUMO DE ENERGÍA PRIMARIA NO RENOVABLE [kWh/m² año]	EMISIONES DE DIÓXIDO DE CARBONO [kgCO2/ m² año]
	

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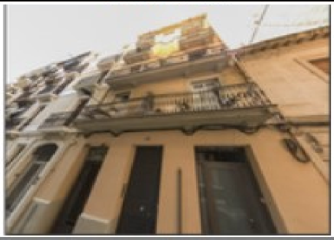	

2. ENVOLVENTE TÉRMICA

Cerramientos opacos

Nombre	Tipo	Superficie [m²]	Transmitancia [W/m²·K]	Modo de obtención
South East Wall	Fachada	214.6	0.00	
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North East Wall	Fachada	104.46	2.38	Estimadas
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Huecos y lucernarios

Nombre	Tipo	Superficie [m²]	Transmitancia [W/m²·K]	Factor solar	Modo de obtención. Transmitancia	Modo de obtención. Factor solar
Windows	Hueco	8.64	3.78	0.63	Estimado	Estimado

3. INSTALACIONES TÉRMICAS

Generadores de calefacción

Nombre	Tipo	Potencia nominal [kW]	Rendimiento Estacional [%]	Tipo de Energía	Modo de obtención
Heating and Cooling	Bomba de Calor - Caudal Ref. Variable		193.6	Electricidad	Estimado
TOTALES	Calefacción				

Generadores de refrigeración

Nombre	Tipo	Potencia nominal [kW]	Rendimiento Estacional [%]	Tipo de Energía	Modo de obtención
Heating and Cooling	Bomba de Calor - Caudal Ref. Variable		143.0	Electricidad	Estimado
TOTALES	Refrigeración				

Instalaciones de Agua Caliente Sanitaria

Demanda diaria de ACS a 60° (litros/día)	718.2

Nombre	Tipo	Potencia nominal [kW]	Rendimiento Estacional [%]	Tipo de Energía	Modo de obtención
Equipo ACS	Caldera Estándar	24.0	44.0	GLP	Estimado
TOTALES	ACS				

6. ENERGÍAS RENOVABLES

Térmica

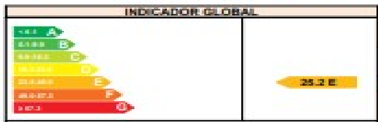
Nombre	Consumo de Energía Final, cubierto en función del servicio asociado [%]			Demanda de ACS cubierta [%]
	Calefacción	Refrigeración	ACS	
Photovoltaic Field	15.25	-	-	-
TOTAL	15.25	-	-	-

ANEXO II
CALIFICACIÓN ENERGÉTICA DEL EDIFICIO

Zona climática	C2	**Uso**	Residencial

1. CALIFICACIÓN ENERGÉTICA DEL EDIFICIO EN EMISIONES

INDICADOR GLOBAL



Emisiones globales [kgCO2/m² año]

INDICADORES PARCIALES

CALEFACCIÓN		ACS	
Emisiones calefacción [kgCO2/m² año] 10.42	C	*Emisiones ACS [kgCO2/m² año]* 14.47	G
REFRIGERACIÓN		**ILUMINACIÓN**	
Emisiones refrigeración [kgCO2/m² año] 0.34	A	*Emisiones iluminación [kgCO2/m² año]* -	-

La calificación global del edificio se expresa en términos de dióxido de carbono liberado a la atmósfera como consecuencia del consumo energético del mismo.

	kgCO2/m² año	kgCO2/año
Emisiones CO2 por consumo eléctrico	10.76	6006.67
Emisiones CO2 por otros combustibles	14.47	8075.86

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INDICADOR GLOBAL

Consumo global de energía primaria no renovable [kWh/m² año]

INDICADORES PARCIALES

CALEFACCIÓN		ACS	
Energía primaria calefacción [kWh/m² año] 61.51	D	*Energía primaria ACS [kWh/m² año]* 68.43	G
REFRIGERACIÓN		**ILUMINACIÓN**	
Energía primaria refrigeración [kWh/m² año] 2.04	A	*Energía primaria iluminación [kWh/m² año]* -	-

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La demanda energética de calefacción y refrigeración es la energía necesaria para mantener las condiciones internas de confort del edificio.

DEMANDA DE CALEFACCIÓN

Demanda de calefacción [kWh/m² año]

DEMANDA DE REFRIGERACIÓN

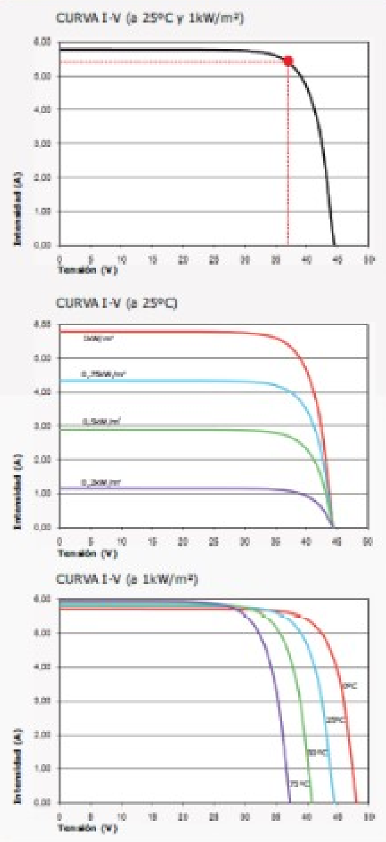
Demanda de refrigeración [kWh/m² año]

6. A200 ATERSA PHOTOVOLTAIC PANELS TYPE PLATE

Características eléctricas (STC: 1kW/m², 25ºC±2ºC y AM 1,5)*	A-200M
Potencia Nominal (±5%)	200 W
Eficiencia del módulo	15,16%
Corriente Punto de Máxima Potencia (Imp)	5,38 A
Tensión Punto de Máxima Potencia (Vmp)	37,18 V
Corriente en Cortocircuito (Isc)	5,78 A
Tensión de Circuito Abierto (Voc)	44,46 V
Parámetros térmicos	
Coeficiente de Temperatura de Isc (α)	0,08% /ºC
Coeficiente de Temperatura de Voc (β)	-0,32% /ºC
Coeficiente de Temperatura de P (γ)	-0,43% /ºC
Características físicas	
Dimensiones (mm ± 2mm)	1618x814x35
Peso (kg)	14,8
Área (m²)	1,63
Tipo de célula	Monocristalina 125x125mm (5 pulgadas)
Células en serie	72 (6x12)
Cristal delantero	Cristal templado ultra claro de 3,2mm
Marco	Aleación de aluminio pintado en poliéster
Caja de conexiones / Opcional	QUAD IP54 / QUAD IP65
Cables	Cable Solar 4mm² 1100mm
Conectores	MC4 o combinable MC4
Rango de funcionamiento	
Temperatura	-40 ºC a +85 ºC
Máxima Tensión del Sistema / Protección	1000 V / CLASS II
Carga Máxima Viento	2400 Pa (130 km/h)
Carga Máxima Nieve	5400 Pa (551 kg/m²)

* Especificaciones eléctricas medidas en STC. NOCT: 47±2ºC.
Tolerancias medida STC: ±3% (Pmp); ±10% (Isc, Voc, Imp, Vmp).

Curvas modelo A-200M



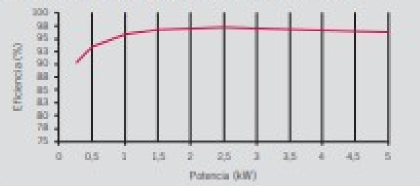
* Max. Corriente Inversa (IR): 10,1A.

7. INGECON® SUN 1Play 5TL M PHOTOVOLTAIC INVERTER TYPE PLATE

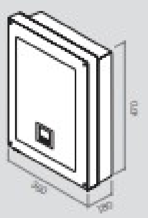
	5TL M	6TL M
Valores de Entrada (DC)		
Rango pot. campo FV recomendado[1]	5,7 - 6,5 kWp	6,3 - 7 kWp
Rango de tensión MPP1[2]	125 - 750 V	
Rango de tensión MPP2[2][3]	90 - 750 V	
Tensión máxima[4]	850 V	
Corriente máxima (Entrada 1 / Entrada 2)	11 / 11 A	
Nº entradas (Entrada 1 / Entrada 2)[5]	1 / 1	
MPPT	2	
Valores de Salida (AC)		
Potencia nominal	5 kW	6 kW
Máx. temperatura para potencia nominal[6]	55 ºC	45 ºC
Corriente máxima	26,2 A	26,2 A
Tensión nominal	230 V	
Rango de tensión	122 - 265 V	
Frecuencia nominal	50 / 60 Hz	
Tipo de red[7]	TT / TN / 208 V delta corner ground / 240 V delta corner ground	
Factor de Potencia	1	
Factor de Potencia ajustable	Sí. Smáx=5 kVA	Sí. Smáx=6 kVA
THD	<3%	
Rendimiento		
Eficiencia máxima	98%	98%
Euroeficiencia	97,6%	97,6%
Datos Generales		
Sistema de refrigeración	Convección natural	
Consumo en stand-by[8]	<10 W	
Consumo nocturno	0 W	
Temperatura de funcionamiento	-25 ºC a +65 ºC	
Humedad relativa (sin condensación)	0 - 100%	
Grado de protección	IP65	
Marcado	CE	
Normativa EMC y de seguridad	EN 61000-6-1, EN 61000-6-2, EN 61000-6-3, EN 61000-6-4, EN 61000-3-11, EN 61000-3-12, EN 62109-1, EN 62109-2, IEC62103, EN 50178, FCC Part 15, AS3100	
Normativa de conexión a red	RD1699/2011, DIN V VDE V 0126-1-1, EN 50438, CEI 0-21, VDE-AR-N 4105:2011-08, G59/2, G83/2[9], P.O.12.3, AS4777.2, AS4777.3, IEC 62116, IEC 61727, UNE 206007-1, ABNT NBR 16149, ABNT NBR 16150, South African Grid code, Chilean Grid Code, Romanian Grid Code, Ecuadorian Grid Code, Peruvian Grid code, IEEE 929, Thailand MEA & PEA requirements, DEWA (Dubai) Grid Code, Jordan Grid Code	

Notas: [1] Dependiendo del tipo de instalación y de la ubicación geográfica [2] La potencia de salida quedará condicionada por la configuración de tensión y corriente elegida en cada entrada [3] Para bajar a 90 V la otra entrada tiene que estar al menos a 125 V [4] No superar en ningún caso. Considerar el aumento de tensión de los paneles 'Voc' a bajas temperaturas [5] Disponibles conectores dobles para conectar dos cables por cada entrada [6] Por cada ºC de incremento, la potencia de salida se reducirá un 1,8% [7] En caso de duda, por favor consultar el manual de instalación [8] Consumo desde el campo fotovoltaico [9] Sólo para inversores hasta 16 A de salida.

Rendimiento INGECON® SUN 5TL M Vdc = 680 V



Dimensiones y peso (mm)



5TL M / 6TL M
21 kg.

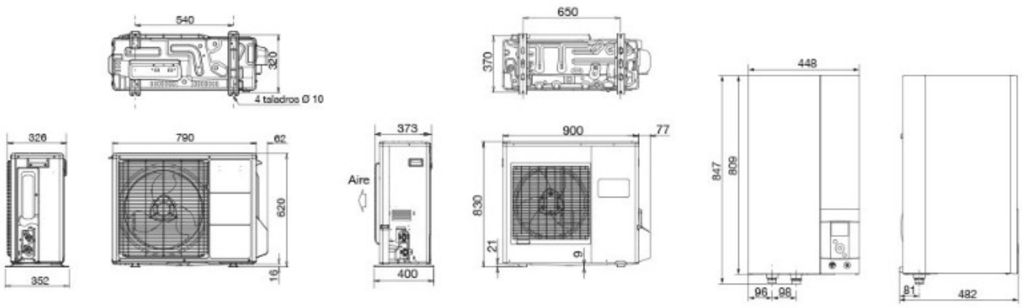
8. THERMOR ALFEA EXTENSA AI 5 HEAT PUMP TYPE PLATE

Características

Model: Alféa Extensa Ai 5

Código	-	524775
Clase Eficiencia Estacional Calefacción Baja Temperatura	-	A++
Clase Eficiencia Estacional Calefacción	-	A+
(+7°C / +35°C)		
Potencia calorífica - Suelo radiante	kW	4,5
Potencia consumida - Suelo radiante	kW	1,0
COP - Suelo radiante	-	4,5
(+7°C / +45°C)		
Potencia calorífica - Radiadores baja tª / Fancoils	kW	4,5
Potencia consumida - Radiadores baja tª / Fancoils	kW	1,3
COP - Radiadores baja tª	-	3,4
(+35°C/+18°C)		
Potencia frigorífica - Suelo refrescante	kW	5,5
Potencia consumida - Suelo refrescante	kW	1,8
EER - Suelo refrescante	-	3
(+35°C/+7°C)		
Potencia frigorífica - Fancoils	kW	3,2
Potencia consumida - Fancoils	kW	1,6
EER - Fancoils	-	1,9

Dibujo técnico



Unidad exterior Alféa Extensa+ 5, 6 y 8

Unidad exterior Alféa Extensa+ 10

Módulo hidráulico

REFERENCES

1. Directive 2002/91/EC: https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2003:001:0065:0071:EN:PDF
2. Directive 2010/31/EU: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32010L0031
3. Directive (EU) 2018/844: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv%3AOJ.L_.2018.156.01.0075.01.ENG
4. Energy Performance Certificate: https://en.wikipedia.org/wiki/Energy_Performance_Certificate_(United_Kingdom)
5. HULC (Lider-Calener) software: https://www.codigotecnico.org/index.php/menu-recursos/menu-aplicaciones/282-herramienta-unificada-lider-calener.html
6. CE3X software: https://www.efinova.es/CE3X
7. CERMA software: https://www.five.es/tienda-ive/cerma/
8. CE3 software: https://www.certificadosenergeticos.com/como-realizar-certificado-energetico-ce3
9. Climatic zones in Spain: http://www.apici.es/wp-download/legislacion/CTE/CTE%20Parte%202%20DB%20HE-DA%201%20Zonas-climaticas-solar_v01.pdf
10. Demand of domestic hot water: https://www.terra.org/data/cteseccionhe4.pdf
11. NBE-CT-79: https://w3.ual.es/Depar/proyectosingenieria/descargas/Normas_Edificacion/NBE-CT-79.pdf
12. NBE-CT-79: https://w3.ual.es/Depar/proyectosingenieria/descargas/Normas_Edificacion/NBE-CT-79.pdf
13. Sun Tax: https://www.factorenergia.com/es/blog/autoconsumo/que-es-impuesto-al-sol/
14. PVPC (Prices of Energy): https://www.esios.ree.es/es/pvpc