





ESCUELA TÉCNICA SUPERIOR INGENIERÍA INDUSTRIAL VALENCIA

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<u>ABSTRACT</u>

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.

INDEX

DOCUMENTS CONTAINED IN THE BACHELOR THESIS

- History
- Budget
- Plans

HISTORY INDEX

- 1. Introduction (Page 4)
 - 1.1. Objective (Page 4)
 - 1.2. Regulatory Framework in Spain (Page 4)
 - 1.3. Energy Performance Certificate (Page 6)
 - 1.4. CE3X in-depth explanation (Page 8)
 - 1.5. CE3X: Practical case and brief study of the influence of inputs on outputs. (Page 13)
- 2. Study of the buildings (Page 19)
 - 2.1. Block of flats in Valencia (Page 19)
 - 2.2. Nursing Home in Moguer, Huelva (Page 24)
 - 2.2.1. Comment and comparison with calculations made manually (Page 29)
 - 2.2.2. Commentary and and comparison of the building in valencia and the nursing home in Moguer (*Page 30*)
 - 2.3. Block of flats in Barcelona (Page 32)
 - 2.4. Comparison of the three buildings (Page 36)
 - 2.4.1. Comparison of the inputs of the three buildings (Page 36)
 - 2.4.2. Comparison of the results of the three buildings (Page 37)
- 3. Improvements in the worst performing building (Page 39)
 - 3.1. Replacement of the electric radiators with heat pumps that are used for heating and cooling. *(Page 39)*
 - 3.1.1. Comparison of changes in results after changing the heating and cooling system in the barcelona building. *(Page 41)*
 - *3.2.* Installation of photovoltaic panels to cover part of the demand for electrical energy. **(Page 42)**
 - 3.2.1. Installation of the inverter (Page 48)
 - 3.2.2. Comparison of initial results, with heat pumps and with both measures. (Page 50)

2020

BUDGET INDEX

- 1. Economic analysis of the improvements (Page 50)
 - 1.1. Photovoltaic field in the roof (Page 50)
 - 1.2. Replacement of the electric radiators with heat pumps that are used for heating and cooling. (*Page 51*)

ANNEX INDEX

- 1. Energy certificate of the building in Valencia. (Page 55)
- 2. Energy certificate of the Nursing Home in Moguer (Page 57)
- 3. Energy certificate of the building in Barcelona (Page 59)
- 4. Energy certificate of the building in Barcelona with heat pumps (Page 61)
- 5. Energy certificate of the building in Barcelona with heat pumps and photovoltaic field (Page 63)
- 6. A200 ATERSA photovoltaic panels type plate (Page 65)
- 7. INGECON[®] SUN 1Play 5TL M photovoltaic inverter type plate (Page 66)
- 8. THERMOR ALFEA EXTENSA AI 5 heat pump type plate (Page 67)

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 / EC¹**: .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 / EU²: 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 <u>https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2003:001:0065:0071:EN:PDF</u>

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) 2018/844³: 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 <u>https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv%3AOJ.L</u>.2018.156.01.0075.01.ENG

⁴ https://en.wikipedia.org/wiki/Energy_Performance_Certificate_(United_Kingdom)

2020

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

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

- CE3X⁶ 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
 - o 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
- CERMA⁷ 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.

CE3X⁸ 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 <u>https://www.efinova.es/CE3X</u>

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.
- \circ 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:

īpo de	edificio		
	Residencial	Pequeño	Gran

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.

Localización e identificació	n del edificio				
Nombre del edificio					
Dirección					
Provincia/Ciudad autónoma	~	Localidad	\checkmark	Código Postal	
Referencia Catastral	+				

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

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

Datos del cliente				Figure 5: Third
Nombre o razón social				step to make an
Dirección				- ·
Provincia/Ciudad autónoma	~	Localidad	Código Postal	energy
Teléfono		E-mail		certificate of a
				building using
Datos del técnico certificador				the CE3X
Nombre y Apellidos			NIF	
Razón social			CIF	program.
Dirección				Source: CE3X
Provincia/Ciudad autónoma	~	Localidad	Código Postal	
Teléfono		E-mail		
Titulación habilitante según normativa vigente				

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 zone⁹ 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 (I / 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.

Datos generales										
Normativa vigente	~	?	Año construcción							
Tipo de edificio		~						HE-1	HE-4	
Provincia/Ciudad autónoma		~	Localidad		×	/	Zona <mark>cl</mark> imática	~		\sim
Definición edificio										
Superficie útil habitable		m2								
Altura libre de planta	2.7	m								
Número de plantas habitables										
Ventilación del inmueble	0.63	ren/h								
Demanda diaria de ACS		l/día								
Masa de las particiones internas	Media \checkmark									
🗌 Se ha ensayado la estanqueida	ad del edificio									
			Ima	gen edificio			P	lano situación		

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 60°C. 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:

⁹ <u>http://www.apici.es/wp-download/legislacion/CTE/CTE%20Parte%202%20DB%20HE-DA%201%20Zonas-</u> <u>climaticas-solar_v01.pdf</u>

¹⁰ https://www.terra.org/data/cteseccionhe4.pdf

Study, comparison and proposals to improve the energy efficiency of three independent buildings in Spain.

Table (1 Dom	anda de referencia a 60 º	C ⁽¹⁾	Table 4.1: Reference dem	and at 60ºC.
Criterio de demanda	Litros/día·unidad	unidad	Building type	Liters/day
Vivienda	28			person
		Por persona	Single family Home	28
Hospitales y clínicas	55	Por persona	Hospitals and clinics	55
Ambulatorio y centro de salud	41	Por persona	Ambulatory	41
Hotel *****	69	Por persona	5 star hotel	69
Hotel ****	55	Por persona	4 star hotel	55
Hotel ***	41	Por persona		
Hotel/hostal **	34	Por persona	3 star hotel	41
Camping	21	Por persona	2 star hotel	34
Hostal/pensión *	28	Por persona	1 star hotel	28
Residencia	41	Por persona	Camping	21
Centro penitenciario	28	Por persona	Nursing home	41
Albergue	24	Por persona	Penitentiary center	28
Vestuarios/Duchas colectivas	21	Por persona	Hostel	24
Escuela sin ducha	4	Por persona	Changing rooms / Showers	21
Escuela con ducha	21	Por persona	School without showers	4
Cuarteles	28	Por persona	School with showers	21
Fábricas y talleres	21	Por persona	Quarters	28
Oficinas	2	Por persona	Factories	21
Gimnasios	21	Por persona	Offices	2
Restaurantes	8	Por persona	Gyms	21
Cafeterías	1	Por persona	Restaurants	8
			Coffee shops	1

Table 1: Reference demand at 60°C 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	1	6	≥6			
Número de Personas	1,5	3	4	5	6	1	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.

Edificio Objeto	Envolvente térmica	a del edificio		\sim
	() Cublerta			
	Muro	O En contacto con el terreno		
	◯ Suelo	● De fachada ○ Medianería		Espacios habitables
	O Partición interior			
	O Hueco/Lucernario			
	O Puente térmico			and
	Muro de fachada			
	wuro de tachada			
	Nombre	Muro de fachada	Zona	Edificio Objeto 🗸
		Muro de fachada	Zona Características	Edificio Objeto 🗸 🗸
	Nombre	Muro de fachada m2		Edificio Objeto 🗸
	Nombre Dimensiones		Características	
	Nombre Dimensiones	Longitud m Altura m	Características Orientación	~

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.

🛱 Edificio Objeto	Instalaciones del edit	icio					
	Equipo de ACS		() Contribuc	iones energéticas	5		
	O Equipo de sólo calefacción						
	O Equipo de sólo refrigerado	śn					
	O Equipo de calefacción y re	frigeración					
	C Equipo mixto de calefacció	in y ACS					
	C Equipo mixto de calefacció	ón, refrigeración y ACS					
	Equipo de ACS						
	Nombre	Equipo ACS		Zona	Edificio Objeto		~
	Características	94		Demanda cu	bierta		
	Tipo de generador	Caldera Estándar	~	Superficie (n	ACS		
	Tipo de combustible	Gas Natural	~	Porcentaje (-		
	Rendimiento medio estacional						
	Rendimiento estacional	Estimado según Instalación	\sim	Rendimiento	o medio estacional	61.8	%
	Potencia nominal	24.0 kW					
	Carga media real ßcmb	0.2 ?	Aislamient	o de la caldera	Antigua con mal aisla	miento 🗸	
	Rendimiento de combustión	90.0 %					

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:

		CENER	CERRAMIENTOS	OPACOS							
See and Street and		CENER		L1 (m)	L2 (m)	Superficie (m2)	Modo delinición	Transmitancis térmi (Wilm2K)	e1	Otroe datoe	
DATOS GENERALES	Znges		Factoria ente Factoria conte Factoria nonte Factoria nonte Cubierra enterior Caterra sentror Caterra sentror	Tabique LH se	mento para socilio (40 m re sin ventila lo certámico-			1.60 1.20 1.7 Etypekor (m) C 0.02 0.02 0.04 0.25 0.02	Doble hoja onductividad (Wink) 1.3 1.3 0.445 0.908 0.25	oon calmara no alistamiento - - - - - - - - - - - - - - - - - - -	Pi (m2%/W) 0.02 0.02 0.05 0.18 0.28 0.08
Tipo de edificio Superficie habitable Altura libre de planta Número de plantas Número de viviendas Año de construcción	Blogue de viniendas (sividido en dos portales) 1293 44 m2 2.5 m 8 + 3. 16 1950 Media (fotgidos competas de entrevigado y		HUECOS	Azulejo cerám Martero de ce Harmigón en s	mento nasa 2000 -		4 (m) Hituecoe 1.3 5	Espesor (0.03 0.01 0.21 x planta Riplantas	ni) Superficie tot 49 92	And Association and Association	i (Wimik) Ientación Cesto
Masa de los forjados y particiones interfores L1 (m) L2 Plantas tipo 37.6 8	tabiquería de albañilería			Salones) (1) Domitorios) (1) nqueo 20 cm. V	entana poco	1.5 estanca con 10 %		4 4 1 1 Mico sin rotura de puente Mico sin rotura de puente			Oeste Este Este Este

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

Nar integratio en factuala			103 10	4 644				
For an experie								
Contanto de Nueso			100 III					
Cape de permare				ALC: NO.				
Decumentes de Tachada con fluijado			CC CC	1 100				
Encompto de Techedo van subterla-				-				
Disperitro de Techada con qualo en contacte con e								
trisentro de fachada con salece		10.000		-				
* 🗉 50 % de las viviendas tiene						nico. Caletacción sur	inistrada por et	dufas elèctric
* El 50 % de las viviendas tiene		por caldera m Tip	ixta para cal o de	efacción y A Demanda			Rendimiento	RAA BU MAAN
STALACIONES *El 50 % de las viviendas lieno *El 50 % de las viviendas com Termos eléctricos para ACS	bió su Instalación	por caldera m ador Tip comb	ixta para cai	efacción y A	C\$ de gas natural			Acumulado Si (1)
* El 50 % de las viviendas tiene * El 50 % de las viviendas com	bió su instalación Tipo de genera	por caldera m ador Tip comb e Electr	ixta para cal o de ostible	efacción y A Demanda cubierta	C\$ de gas natural Modo definición	AnligBedad	Rendimiento tiominal	Acumulado
* El 50 % de las vilviendas liene * El 50 % de las vilviendas com Termos eléctricos para ACS	bió su instalación Tipo de genera Efecto Jouk	por caldera m ador Tip comb e Electr	ixta para cal o de ostible icidad	efacción y A Demanda cubierta S0%	C\$ de gas natural Modo definición Estimado Estimado	Anligsedad Más de 10 años Más de 10 años	Rendimiento nominal 100% 100%	Acumulado Si (1)

Figure 10: Information about the CE3X example building. Source: CE3X

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			

In summary, we have the following information:

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:

Nombre del edificio	Bloque de Viviendas, Zaragoza					
Dirección	C/Don Quijote de la Mancha, 14-1	6				
Provincia/Ciudad autónoma	Zaragoza V	Localidad	Zaragoza	\sim	Código Postal	-

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

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

	Anterior	~ ?	Año construcción	1960				
Tipo de edificio	Bloque de Viviendas	s ~					HE-1	HE-4
Provincia/Ciudad autónoma	Zaragoza	~	Localidad	Zaragoza	~	Zona climática	D3 ···	IV
Definición edificio								
Superficie útil habitable	1293.4	4 m2 🦼		-		Cost in case	-	Not a state
0.01000-0000000000000000000000000000000	1255.1		ALL CONTRACTOR			The Part New York	N. W. LO. M.	- THE OWNER
Altura libre de planta	2.5	m [AL R	-		frame.		
	2.5	m		-		n	A*******	1
Altura libre de planta	2.5	m ren/n				0		A LAK
Altura libre de planta Número de plantas habita	2.5 ables 4	ren/h				0		A STATE
Altura libre de planta Número de plantas habita Ventilación del inmueble	2.5 ables 4 0.63 1612.8	ren/h				0		and the second se

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

• Thermal envelope:

🛱 Edificio Objeto	Envolvente térmica	del edificio			
E - Salones	() Cubierta				
E - Dormitorios	Muro	O En contacto con el terreno			
PT Pilar en Esquina-Fachada	() Suelo	De fachada Medianería		Espac	ables
PT Contorno de hueco-E - 5 PT Contorno de hueco-E - D	O Partición interior				2001 Million
Fachada Oeste	O Hueco/Lucernario				*****
0 - Galeria PT Pilar integrado en facha	O Puente térmico			3	
PT Pilar integrado en racia PT Pilar en Esquina-Fachadi PT Encuentro de fachada co	Muro de fachada				
	Nombre	Muro de fachada	Zona	Edificio Objeto	~
	Dimensiones		Características		
PT Pilar integrado en facha	Superficie	m2	Orientación		~
 PT Encuentro de fachada co Fachada Norte 		Longitud m Altura m	Patrón de sombras	Sin patrón	~
PT Pilar integrado en facha PT Encuentro de fachada co	Parámetros característicos o	lel cerramiento			
🖶 🔢 Suelo	Propiedades térmicas	Por defecto	 ✓ Trans 	mitancia térmica 2	38 <i>W/m2K</i>
PT Encuentro de fachada ou Grada Cubierta					
- PT Encuentro de fachada co					

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

• Building's air conditioning facilities:

Edificio Objeto 56lo ACS (60%) /Termoeléctri	Instalaciones del edit	ficio			
 Sólo ACS (60%) / Terrildelectri Sólo calefacción(60%)/estufa: 	Equipo de ACS		◯ Contribuc	iones energética	as
	O Equipo de sólo calefacción	1			
	O Equipo de sólo refrigeraci	ón			
	O Equipo de calefacción y re	efrigeración			
	O Equipo mixto de calefacci	ón y ACS			
	O Equipo mixto de calefaccio	ón, refrigeración y ACS			
	Equipo de ACS				
	Nombre	Equipo ACS		Zona	Edificio Objeto 🗸
	Características	51	10	Demanda d	ubierta ACS
	Tipo de generador	Caldera Estándar	~	Superficie	
	Tipo de combustible	Gas Natural	~	Porcentaje	
	Rendimiento medio estacional				
	Rendimiento estacional	Estimado según Instalación	~	Rendimien	to medio estacional 61.8 %
	Potencia nominal	24.0 kW			
	Carga media real ßcmb	0.2 ?	Aislamien	to de la caldera	Antigua con mal aislamiento $~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~$
	Rendimiento de combustión	90.0 %			
	Con Acumulación				
	Con Acumulación				

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 In	ndicator	Pa	artial In	dicators	
184 A		Heating		DHV	V
84.115 B		(kgCO2/m2)	(ear)	(kgCO2/m	2 year)
13.6-21.1 C	52 0 F	41,02	E	8,9	G
324463 E	53,0 E	Cooling		Illumina	ation
96.3-79.6 P	-	(kgCO2/m2)	/ear)	(kgCO2/m	2 year)
278.6 G		3,07	C	-	-
		3,07	kaC)2/m2 year	kgCO2/m2 ye
CO2 emissions	from electricity	consumption		30,48	39422,
	in other or o outloney		- C - C - C - C - C - C - C - C - C - C	00,10	00122,

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

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

Total Indic	ator	Par	tial Ind	licators	
<26.8 A		Heating	l.	DHW	
26.8-43.4 B		(kWh/m2 yea	ar)	(kWh/m2 ye	ar)
424573 6	286,2 E	220,33	E	47,79	G
103.5-212.5 E	280,2 E	Cooling		Illumination	1 .
212.9-240.5 F		(kWh/m2 yea	ar)	(kWh/m2 year)	
≥ 240.5 G		18,11	D	12	

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

O PARTIAL RATING OF THE ENERGY DEMAND FOR HEATING AND COOLING

Heating demand (kWh	/m2 year)	Cooling demand (k)	Vh/m2 year)
<77 A 7.7.47.9 B 17.9-32.4 C 18.4.643 D 54.2.00.6 E 199.8-108.8 F 2 108.8 G	11 <mark>3</mark> ,4 E	<2.1 A 2.1.3.9 B 2.3.44 C 100-612.8 E 128-45.7 F 2.45.7 G	18,5 D

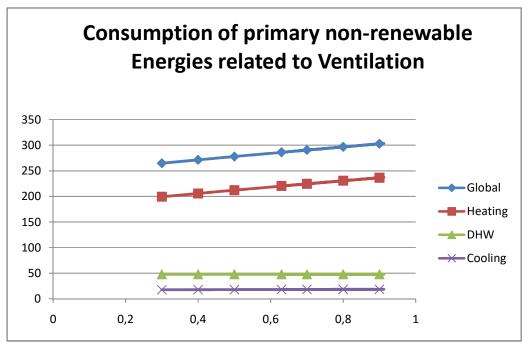
Figure 16: Partial rating of the energy demand for heating and cooling. Source: CE3X

2020

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:

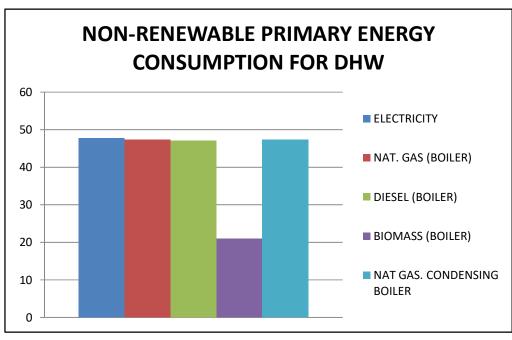
 As the ventilation factor increases (measured in renovations per hour), the consumption of nonrenewable primary energy used for both heating and cooling increases. The consumption of nonrenewable primary energy for domestic hot water is not influenced. CO2 emissions also increase accordingly, without 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.

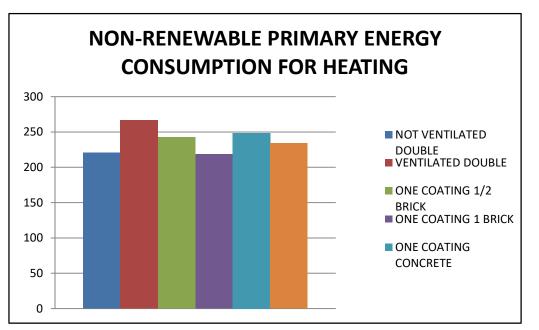
• Depending on the fuel or technology we use, the consumption of non-renewable primary energy also varies. In this case we have made the example with the DHW of the building.



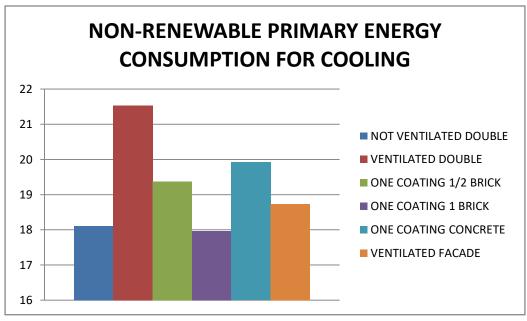
Graph 2: Non-renewable primary energy consumption for DHW depending on the equipment used. Source: Amutio, J.

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.

2020



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:

Records AV. PRIMADO REIG 125, VALENCIA	konbre del edificio	Residential Building	n Valencia, Spain					
	Wección	AV. PRIMADO REIG	AV. PRIMADO REIG 125, VALENCIA					

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

2020

2020

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:

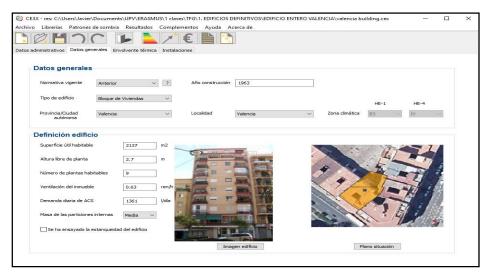


Figure 20: Second step to make an energy certificate of a building using the CE3X program. Source: CE3X

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-79¹¹. 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 <u>https://w3.ual.es/Depar/proyectosingenieria/descargas/Normas_Edificacion/NBE-CT-79.pdf</u>

2020

• Thermal envelope:

Envolvente térmica del edificio Inuiding For P1 Encentro de fachada o W - Vali Muranas G1 P F Encentro de fachada o P F Encentro de	s administrativos Datos generales E	nvolvente térmica Instalaciones					
Wentanas G3 Wentanas G4 Wentanas Wentanas G4 Wentanas G4 Wentanas G4 Wentanas G4	Building Floor PT Encuentro de fachada co		ı del edificio		<u> </u>		
Cublerta con aire Cublerta	Ventanas G1 Ventanas G2	_	De fachada			Espacios habitables	1
SE - Wall ■ PF finceuntro de fachada c ■ PF - Multinas GB ■ Ventanas GB ■ Ve	 Wentanas G4 PT Encuentro de fachada co NW - Wall 		2000 (2010) 2011 (112)				
INE - W wall Muro de fachada IV ventanas GB Nombre NE - Wall Cara Edition Objeto Ventanas G10 Sperfice 1000000000000000000000000000000000000	SE - Wall						the second
Currentanas G10 Ventanas G11 Ventanas V	NE - Wall	Muro de fachada					
Cubierta con aire Cubierta Cubierta con aire Cubi		Nombre	NE - Wall	Zona	Edificio Objeto		~
PT Excuentes de fachada co				Características			
Ahura 28.35 m Patrón de sombras Sin patrón Parámebras característicos del caramiento Propiedades térmicas Estimadas Tipo de fachada Deble hoja con cámara	PT Encuentro de fachada co	Superficie		Orientación	NE		~
Propiedades térmicas Estimadas Transmitancia térmicas 1.69 W/m2 Tipo de fachada Deble hoja con cámara <	Cubierta con aire			Patrón de sombras	Sin patrón		~
Tipo de fachada Doble hoja con cámara 🗸		Parámetros característicos o	del cerramiento				
		Propiedades térmicas	Estimadas 🗸	Trans	smitancia térmica	1.69	W/m2K
Cámara de aire No ventilada 🗸		Tipo de fachada	Doble hoja con cámara 🗸 🗸				
		Cámara de aire	No ventilada				
Tiene aislamiento térmico			1.5 -				
			.0				

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.

		. EDIFICIOS DEFINITIVOS\EDIFICIO ENTER	RO VALENCIA\valencia buildir	ng.cex	_20		\times
Archivo Librerías Patrones de somt	Resultados Complementos	Ayuda Acerca de					
Datos administrativos Datos generales	Envolvente térmica Instalaciones						
🛱 Edificio Objeto	Instalaciones del edif	icio					
 A Equipo ACS Sólo calefacción 	O Equipo de ACS	00	ontribuciones energéticas				
	Equipo de sólo calefacción						
	O Equipo de sólo refrigeració	in .					
	O Equipo de calefacción y re	frigeración					
	C Equipo mixto de calefacció	in y ACS					
	C Equipo mixto de calefacció	n, refrigeración y ACS					
	Equipo de sólo calefa	acción					-
	Nombre	Sólo calefacción	Zona Edifici	Objeto		~	1
	Características		Demanda cubierta				
	Tipo de generador	Efecto Joule	V Sumarficia (m2)	Calefacción			
	Tipo de combustible	Electricidad	Porcentaje (%)	Superficie (m2) 2137.0 Porcentaje (%) 100			
	Rendimiento medio estacional						
	Rendimiento estacional	Estimado según Instalación	~ Rendimiento medio	estacional	100.0	%	
	Rendimiento nominal	100.0 %					
Zonas							

• 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 Indi	cator	Pa	artial In	dicators		
<16 A		Heating		DHV	V	
1648 B		(kgCO2/m2)	/ear)	(kgCO2/m2 year)		
LA-11.5 C	10 0 E	12,54	E	4,74	F	
18.8-41.8 E	18,9 E	Cooling (kgCO2/m2 year)		Illumination ear) (kgCO2/m2 year)		
41.8-48.9 P						
246.9 G		1,63	В	-	-	
			kgC	O2/m2 year	kgCO2/r	n2 year
CO2 emissions fr	om electricity	consumption		1,63		3491,12
CO2 emissions fr	rom other fuel	s	17,28		3	6928,63

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 Ind	cator	Pa	Partial Indicators		
<36 A		Heating		DHW	
16-68 B		(kWh/m2 ye	ar)	(kWh/m2 year)	
58-t1.5 C	91,2 E	59,21	E	22,39	G
18.8-41.8	91,2 E	Cooling	- × ji	Illuminatio	n
41.5-46.9		(kWh/m2 year)		(kWh/m2 year)	
≥46.9 G		9,64	С	10 - 10 - 10 - 10 - 10 - 10 - 10 - 10 -	

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.

 Heating demand (kWh/m2 year)
 Cooling demand (kWh/m2 year)

 •4.4. A
 •4.4. A

O 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.

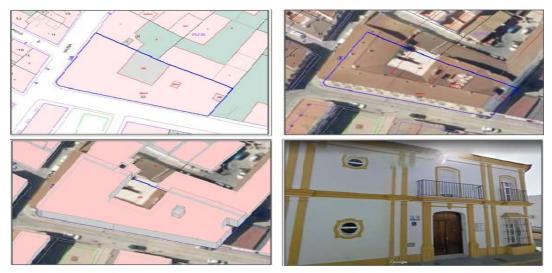


Figure 26: Representation of the building to be worked on. Source: Cadastre and Google Maps.

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-	76	28
	38		

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

2020

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 , it has 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:

Noribre del edificio	Nursing home in Mogue	er, Huelva					
Dirección	Calle Divina Pastora, 3	ł					
Provincia/Ciudad autónoma	Huelva	÷	Localidad	Otro	÷.	Código Postal	21800

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

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

administrativos Datos gene	erales Envolvente térmica In	* も 目 ご stalaciones	1				
Datos generales							
Normativa vigente	NBE-CT-79 ~	Año construcción	1995				
Tipo de edificio	Edificio completo	 Perfil de uso 	Intensidad Baja - 16h	~	HE-1	HE-4	
Provincia/Ciudad autónoma	Huelva	Localidad	Otro Moguer	 Zona climática 	B4 ~	-	~
Definición edificio	0		2				
Superficie útil habitable	1864 m2			17857 2		XX	
Altura libre de planta	2.8 m	(0)		Red L	1	Lifey	0
Número de plantas habi	tables 2		E E	EX1/	XX	26	A
Ventilación del inmueble	0.8 rer	A Contraction	and the second	K-1-1	1.7	N	
	1476 I/di		-	1.	~ 0	Y	
Demanda diaria de ACS	a-176 (/di			1		911	-
Demanda diaria de ACS	la base and a second			11 11 5			
Demanda diaria de ACS Masa de las particiones	internas Media 🗸			11 11 1 1			-

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-79¹². 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.

CE3X - PT: C:\Users\Javier\Document	ts\UPV\ERASMUS\1 clases\TF	G\1. EDIFICIOS DEFINITIVOS\GERIÁTRICO	HUELVA\nursinghome.c	ex	<u></u>		×
Archivo Librerías Patrones de sombra	Resultados Complement	tos Ayuda Acerca de					
	▶ 놀 🗡 €						
Datos administrativos Datos generales En	volvente térmica Instalaciones	1					
Roof	Cubierta	a del edificio		_	~		
South Windows	Muro	O En contacto con el terreno					
West Windows	O Suelo	● De fachada ○ Medianería			Espacios habitables		
East Wall	O Partición interior			Second Second			
	O Hueco/Lucernario						
	O Puente térmico			L		L.	
	Muro de fachada						
	Nombre	Muro de fachada	Zona	Edificio Objeto		\sim	
	Dimensiones		Características				
	Superficie	m2	Orientación			\sim	
		Longitud m Altura m	Patrón de sombras	Sin patrón		~	
	Parámetros característicos o			1			
	Propiedades térmicas			mitancia térmica	1.8	W/m2K	
	Propiedades termicas	Por detecto	11,0115	initaricia termica	1.0	vv/m2A	
Zonas					Make	Ad al sea	

• 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 <u>https://w3.ual.es/Depar/proyectosingenieria/descargas/Normas_Edificacion/NBE-CT-79.pdf</u>

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.

- ② CE3X PT: C:\Users\Javier\Documents\UPV\ERASMUS\1 clases\TFG\1. EDIFICIOS DEFINITIVOS\GERLATRICO HUELVA\nursinghome.cex ×) 🕅 つ 🤉 🕨 🖊 🗧 🗎 os Datos gene rmica Insta Edificio Objeto Instalaciones del edificio ◯ Contrib Equipo de ACS ng and Cooling nes energética: O Equipo de sólo calefa O Equipos de iluminación O Equipo de sólo refrigeración O Equipos de aire primario O Equipo de calefacción y refrigeración O Equipo mixto de calefacción y ACS O Equipo mixto de calefacción, refrigeración y ACS Equipo de ACS DHW Edificio Objeto ombre *Características* Tipo de generador Tipo de combustible Caldera Estándar Superficie (m2) Porcentaje (%) Gasóleo-C endimiento medio estac Rendimiento estacional 67.7 % Estimado según Insta ~ Potencia nomina kW ? % 0.2 Carga media real Bcmb nto de la caldera Antigua con mal aislamiento 🗸 idimiento de combustión Con Acumulación
- 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:

O ENERGY RATING OF THE BUILDING IN EMISSIONS

Total Indic	Total Indicator		artial In	dicators		
<3.6 A		Heating	DH		N	
1669 B		(kgCO2/m2)	(ear)	(kgCO2/m	12 year)	1
6.5-0.0 C	15,6 F	3,9	E	6,78	G	
11,8-14.5 E		Cooling (kgCO2/m2 year)		Illumination (kgCO2/m2 year)		1
14.5-11.1 E						
218.1		4,91	D		-	1
			kaC	02/m2 year	kaCO2/i	m2 vear
CO2 emissions fro	m electricity	consumption	go	8,81		6426,41
	CO2 emissions from electricity consumption CO2 emissions from other fuels			6,78		2640,64

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

Total Indic	Total Indicator			Partial Indicators				
<19.1 A		Heating	Heating					
18.1-01.0 B		(kWh/m2 year)		(kWh/m2 year)				
21.0-07.7 C	77,7 F	23,04	G	25,71	G			
12.6763 E	//,/ F	Cooling	- 10 L	Illuminatio	n			
75.3-854 F		(kWh/m2 year)		(kWh/m2 year)				
≥\$5.4 G		28,98	D	100 CERS	- 20			

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

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	n/m2 year)	Cooling demand (kW	/h/m2 year)
< 2.4 A 2.4.3.9 B 2.84.1 C 8.742.1 D 8.742.1 E 8.742.1 E 8.742.1 E	29,8 G	- 5.0 A 5.0-14.7 B 14.7-22.5 C 27.6-36.7 D 26.4-36.7 E 36.1-45.2 F 3.4.52 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 Energé	tica' - 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

Total Ind	licator	Pa	irtial In	dicators	
<16 A		Heating		DHW	
2848 B		(kgCO2/m2 y	ear)	(kgCO2/m2 y	(ear)
48-115 C	19.0 5	12,54	E	4,74	F
18.8-41.8 E	18,9 E	Cooling		Illuminatio	n
41.5-46.9		(kgCO2/m2 y	ear)	(kgCO2/m2 y	(ear)
246.9 G		1,63	В	-	-
Total Inc	licator	Pa	irtial In	dicators	
1111				EL BAL	

l otal Indic	ator	Pa	rtial in	dicators	
116 A		Heating		DHW	
2465 B		(kgCO2/m2 y	ear)	(kgCO2/m2 y	ear)
5.3-6.0	15,6 F	3,9	E	6,78	G
11.5-14.5 E	15,6 F	Cooling		Illuminatio	n
14.5-18.1 P		(kgCO2/m2 y	ear)	(kgCO2/m2 y	ear)
218.1 G		4,91	D		-

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.

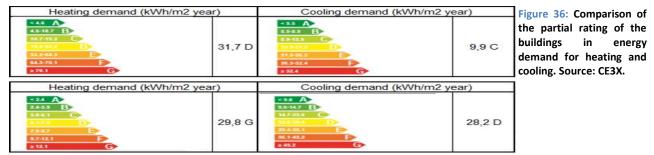
• ENERGY RATING OF THE BUILDING IN NON-RENEWABLE PRIMARY ENERGY CONSUMPTION

Total India	cator	Pa	rtial Ind	icators		
<35 A		Heating		DHW		
2648 B	(kWh/m2 year)		ar)	(kWh/m2 year)		
88-118 C	91,2 E	59,21	E	22,39	G	
18.8-41.8	01,2 L	Cooling			Illumination	
41.8-46.9 F		(kWh/m2 yea	ar)	(kWh/m2 ye	ar)	
246.9 G		9,64	C	- <u>-</u> -	-	
Total India	cator	Pa	rtial Ind	licators		
	cator	Pa Heating	rtial Ind	licators DHW		
Total India	cator	1			ar)	
<13.1 A		Heating		DHW	ar)	
< 19.1 A 19.1-31.9 B 31.8-47.7 C	77,7 F	Heating (kWh/m2 ye	ar)	DHW (kWh/m2 ye	G	
«15.1 A 13.1-31.0 B		Heating (kWh/m2 ye 23,04	ar) G	DHW (kWh/m2 ye 25,71	G n	

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 building 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.

O PARTIAL RATING OF THE ENERGY DEMAND FOR HEATING AND COOLING

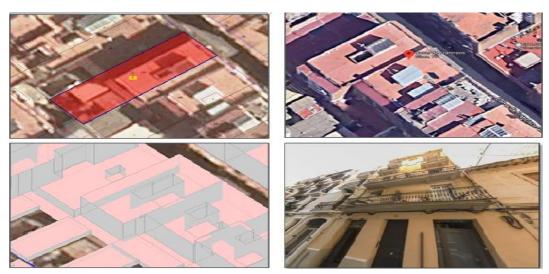


As for the demand for heating and cooling. In the tertiary building the heating demand in kWh / m2 year is slightly higher than in the Valencia building. However, since the scale is different, it gets a much worse rating. Regarding refrigeration, the demand in the tertiary building would be almost triple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

2020

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)	Table12:Dimensions of the
Facade 1	Southwest	7,8	14,5	113,1	facades. Source:
Facade 2	Northwest	14,8	14,5	214,6	Cadastre and Google Maps.
Facade 3	Southeast	14,8	14,5	214,6	Google Maps.
Facade 4	Northeast	7,8	14,5	113,1	
Floor	-			101,1	
Cover	-			101,1	
Yard	-			13,6	

2020

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:

Nombre del edificio	Residential Building in	Barcelona, Spain	1				
Dirección	Francisco Giner Street	Francisco Giner Street, 19					
Provincia/Cludad autónoma	Barcelona		Localdad	Haussland	<u> </u>	Cristen Postal	08012

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:

administrativos Datos ge	erales Envolvente térmic	a Instalaciones				
Datos generales						
Normativa vigente	NBE-CT-79	Año construct	ción 1995			
Tipo de edificio	Edificio completo	✓ Perfil de uso	Intensidad Baja - 16h	~	HE-1 HE-4	
Provincia/Ciudad autónoma	Huelva	~ Localidad	Otro Moguer	 Zona climática 	84 ~ V	~
Definición edific	0					
Superficie útil habitabl	1864	m2		178577	YA NO	\sim
Altura libre de planta	2.8	m (a)		KSY L	· / -/-/	A
	itables 2		I DI	Sil	<	1
Número de plantas ha		ren/h	and the local of the	K-1.1	1.	\sim
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Ventilación del inmueb					~ 8	1
		I/dia	*	1	- 9	(
Ventilación del inmueb	1476	I/dia		ITA		-

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:

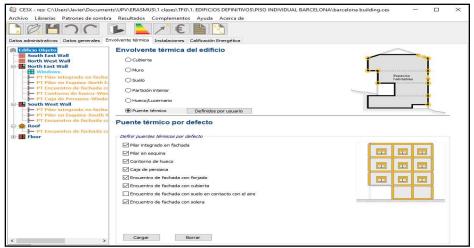


Figure 40: Third step to make an energy certificate of a building using the CE3X program. Source: CE3X

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.

2020

• Building's air conditioning facilities:

O CE3X - PT: C:\Users\Javier\Docume	nts\UPV\ERASMUS\1 clases\TFG\1	. EDIFICIOS DEFINITIVOS\GERIA	TRICO HUELVA	nursinghome.cex	100		×
Archivo Librerías Patrones de somb	ra Resultados Complementos	Ayuda Acerca de					
	⊾ _ ∕ €						
Datos administrativos Datos generales E							
Edificio Objeto	Instalaciones del edit	icio					
** Heating and Cooling	Equipo de ACS		Contribut	dones energéticas			
	O Equipo de sólo calefacción	r.	C Equipos d	de iluminación			
	O Equipo de sólo refrigeracio	án	O Equipos o	de aire primario			
	O Equipo de calefacción y re	frigeración					
	O Equipo mixto de calefaccio	1.411					
	Equipo mixto de calefaccio	on, refrigeración y ACS					-
	Equipo de ACS						
	Nombre	DHW		Zona Edificio Objeto		~	8
	Características			Demanda cubierta			
	Tipo de generador	Caldera Estándar	\sim	ACS Superficie (m2) 1864.0	Ť.		
	Tipo de combustible	Gasóleo-C	~	Porcentaje (%) 100	-		
	Rendimiento medio estacional						
	Rendimiento estacional	Estimado según Instalación	~	Rendimiento medio estacional	67.7	%	
	Potencia nominal	125 kW					
	Carga media real 6cmb	0.2 ?	Aislamien	to de la caldera Antigua con mal aisl	amiento	~	
	Rendimiento de combustión	88 %		1			
	Con Acumulación						
Zonas							

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 Indi	cator	Partial Indicators				
<61 A		Heating		DHW		
6105 B]	(kgCO2/m2 ye	ear)	(kgCO2/m2 y	ear)	
9.5-15.7 C	20 5 5	23,8	E	14,71	G	
215-01	38,5 E	Cooling		Illuminatio	n	
49.0-57.3 F	1	(kgCO2/m2 ye	ear)	(kgCO2/m2 y	ear)	
257.3 G		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 India	ator	Pa	rtial Inc	licators	
< 26.8 A		Heating		DHW	
26.8-43.4 B		(kWh/m2 yea	ar)	(kWh/m2 ye	ar)
42.4-67.3 C	210,4 E	140,52	E	68,43	G
103.5.212.9 E	210,4 E	Cooling	n in the	Illuminatio	n
212.9-240.5		(kWh/m2 yea	ar)	(kWh/m2 ye	ar)
2 240.5 G		1,46	A	an 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/r	m2 year)	Cooling demand (kV	Vh/m2 year)
<7.77.7-17.917.9-02.438.4.94.294.8-99.899.8-108.82-106.8	71,9 E	x2.1 A 2.1-3.0 B 3.9-4.4 C 10.5-12.0 E 12.8-16.7 F 2.15.7 C	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 (I/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	-

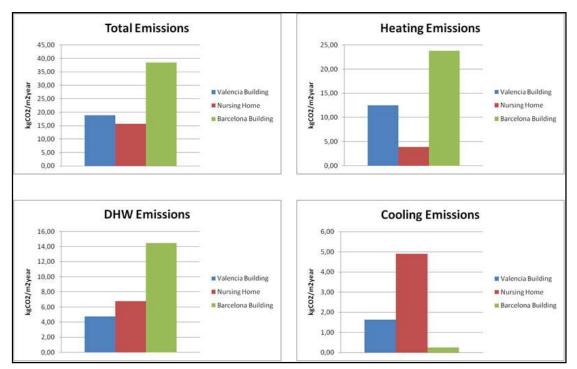
Table 13: Comparison of the inputs of the three buildings. Source: Amutio, J.

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.

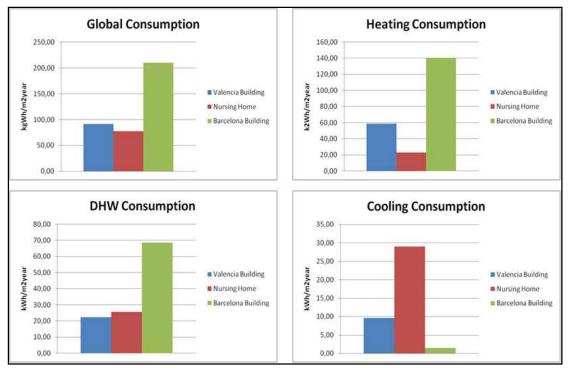
		Valencia Bu	ilding			Nursing	Home			Barcelona Bu	ilding	
	Global	Heating	DHW	Cooling	Global	Heating	DHW	Cooling	Global	Heating	DHW	Cooling
kgCO2/m2 year	18,90	12,54	4,74	1,63	15,6	3,9	6,78	4,91	38,5	23,8	14,47	0,25
kWh/m2 year	91,20	59,21	22,39	9,64	77,70	23,04	25,71	28,98	210,4	140,52	68,43	1,46
Demand		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 Indic	Total Indicator		artial In	dicators		
<61 A		Heating		DHV	V	
61-03 B		(kgCO2/m2)	/ear)	(kgCO2/m	2 year)	
95-15.2 C	27 1 E	12,29	D	14,47	G	
215-00 8	27,1 E	Cooling		Illumination		
49.0-57.3 F		(kgCO2/m2)	/ear)	(kgCO2/m	2 year)	
257.3 G		0,34	A	-	-	
			kgC0	02/m2 year	kgCO2/r	n2 yea
CO2 emissions fro	m electricity	consumption		12,64		7052,9
CO2 emissions fro	om other fuel	S	1)	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.

Total Indic	ator	Partial Indicators				
< 26.8 A		Heating		DHW		
20 8-43 4 B		(kWh/m2 ye	ar)	(kWh/m2 ye	ar)	
43.447.2 C	143,0 E	72,58	D	68,43	G	
103.5-212.5 E	143,0 E	Cooling	10. 10	Illumination	n	
212.9-240.5 F		(kWh/m2 ye	ar)	(kWh/m2 ye	ar)	
≥ 240.5 G		2,04	A	33 (22)	-	

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

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.

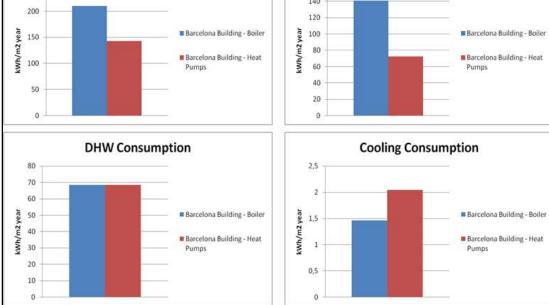
O PARTIAL RATING OF THE ENERGY DEMAND FOR HEATING AND COOLING

Heating demand (kWh	/m2 year)	Cooling demand (kW	/h/m2 year)
<7.7 A 7.7-47.9 B 17:9-02-4 C 38:4:54:2 D 64:2-09:5 E 99:8-108:8 F 2:108:8 G	71,9 E	x2.1 A 2.1-3.0 B 2.9-4.4 C 10.8-12.8 E 12.8-16.7 F x15.7 C	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 Tax¹³ 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 <u>https://www.factorenergia.com/es/blog/autoconsumo/que-es-impuesto-al-sol/</u>

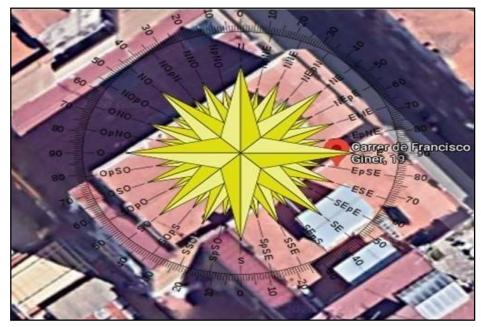


Figure 49: Obtaining the azimuth angle according to the orientation of the building. Source: Amutio, J.

The azimuth angle of the panels will be taken from 55^o. 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 10^o and 40^o. In this way, we are going to choose a fixed 35^o angle for the photovoltaic panels that we are going to place.

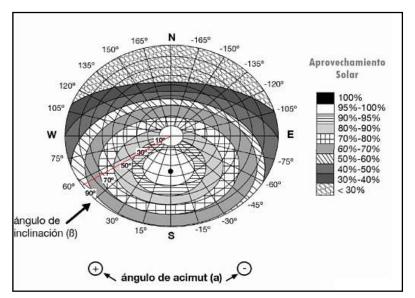


Figure 50: Solar gain as a function of tilt angle and azimuth angle. Source: Google Images

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.

Dimensiones (mm ± 2mm)	1618<814<35
Peer (kg)	14.8
Āres (m')	1,63
Tipo de olíula	Monocristalina 125x125mm (5 pulgadas)
Células en serie	72 (6x12)
Cristal delasters	Cristal templado ultra claro de 3,2mm
Marca	Alesción de aluminio pittado en poléster
Caja de convexiones / Oprivosal	QUAD IP54 / QUAD IP65
Cables	Cable Solar 4mm ² 1100mm
Conectores	MC4 s 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 $41.38 \approx 41^{\circ}$. From this we will obtain the value of k.

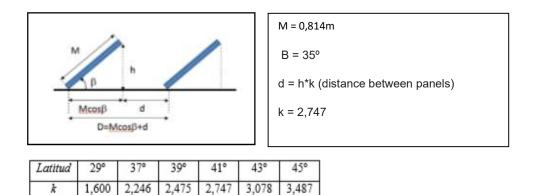


Figure 52: Diagram of the position of the panels and data necessary for the calculation. Source: 'Auditoría Energética' - UPV

With all this information:

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

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

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

Nparalel
$$\leq \frac{4}{0,6667+1,2826} \leq 2,71 \rightarrow 2$$
 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 $\leq \frac{8}{0,814} \leq 9,828 \rightarrow 9$ panels in series

Nparalel2 $\leq \frac{2}{0,6667+1,2826} \leq 1,026 \rightarrow 1$ 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 * $558 \text{ m}^2 = 79794 \text{ kWh/year}$

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:

🛱 Edificio Objeto	Instalaciones de	el edificio					
— 4 Equipo ACS — 4 Heating and Cooling	O Equipo de ACS			 Contri 	ouciones energét	icas	
└── ✓ Photovoltaic Field	O Equipo de sólo ca	lefacción					
	O Equipo de sólo re	frigeración					
	O Equipo de calefac	ción y refrigeración					
	O Equipo mixto de c	alefacción y ACS					
	O Equipo mixto de c	alefacción, refrigeración y ACS	5				
	Contribuciones	energéticas					
	Nombre	Photovoltaic Field			Zona	Edificio Objeto	×
	- 🗹 Fuentes de energi	ia renovable					
	Porcentaje de deman	da <mark>d</mark> e ACS cubierto		%			
	Porcentaje de deman	da de calefacción cubierto	15.25	%			
	Porcentaje de deman	da de refrigeración cubierto		%			

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 In	dicator	Pa	rtial In	dicators		
ALL A		Heating		DHW		
	1	(kgCO2/m2 y	(kgCO2/m2 year) (kgCO			
	25.2.5	10,42	C	14,47	G	
32.446.1 E	25,2 E	Cooling		Illuminatio	n	
66.3.73.5 E		(kgCO2/m2 ye	ear)	(kgCO2/m2 y	ear)	
2786 G	-1	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 Indi	cator	Pa	rtial Ind	licators	
< 26.8 A		Heating		DHW	
26.8-43.4 B		(kWh/m2 ye	ar)	(kWh/m2 ye	ar)
42.447.3 C	132,0 E	61,51	D	68,43	G
103.5-712.9 E	132,0 E	Cooling	- * j)	Illuminatio	n
212.9-240.5 F		(kWh/m2 ye	ar)	(kWh/m2 ye	ar)
2 240.5 G		2,04	A	24 - Ula Au	-

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. 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 yea	ır)	Cooling demand (kWh/m2 ye	ear)
<7.7 A 7.7-17.8 B 17.9-52.4 C 12.4-54.2 D 54.2-90.8 E 99.8-108.8 F ≥ 108.8 G	71,9 E	<pre><2.1 A 2.1-3.9 B 2.9-45 C 19.5-12.8 E 12.8-15.7 F 2.15.7 F 3.15.7 G</pre>	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:

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

$$T_{MAX} = T_{Amb_MAX} + G_{MAX} \left(\frac{NOTC - 20^{\circ}}{0.8}\right)$$

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

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

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:

$$\beta_{\overline{C}}^{V} = \beta_{1/C} * V_{oc} = 44,46 * -0,0032 = -0,142$$
$$V_{mod_oc_max} = V_{mod_oc} + (T - 25) * \beta_{\overline{C}} = 44,46 + (-5 - 25) * -0,142 = 48,728 V$$
$$Ns_{max} \le \frac{850}{48,728} \le 17,44 \le 17 \text{ panels}$$

We calculate the minimum number of panels in series:

$$T_{max} = T_{amb_max} + G_{max} \left(\frac{NOTC - 20^{\circ}C}{0.8} \right) = 40 + 1 \left(\frac{47^{\circ}C - 20^{\circ}C}{0.8} \right) = 73,75 \, ^{\circ}C$$

 $V_{mod_mpp_min} = V_{mod_mpp} + (Tmax - 25) * \beta_{\frac{V}{C}} = 37,18 + (73,75 - 25) * -0,142 = 30,257 \text{ V}$

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

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

$$\alpha_{\underline{A}} = \alpha_{1/C} * I_{\text{mod}_SC_STC} = 0,0008 * 5,78 = 4,624$$

 $I_{mod_SC_max} = I_{mod_SC_STC} + (Tmax - 25) * \alpha_{\underline{A}} = 5,78 + (73,75 - 25) * -0,0008 = 6,005 \text{ A}$

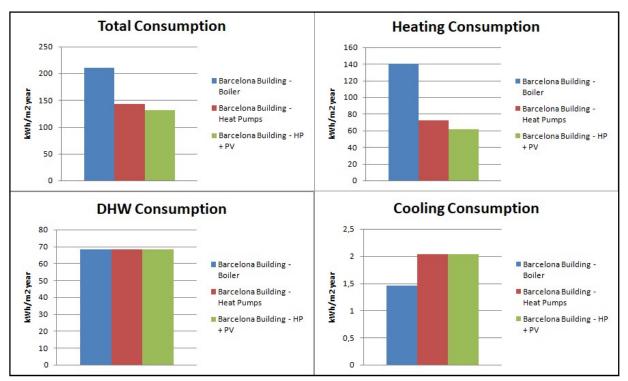
$$Np_{max} \le \frac{22 (*)}{6,005} \le 3,66 \le 3$$
 panels

(*) 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	 Image: A second s
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 \notin 314.60. Which means that the total of 17 models would cost \notin 5348,2. On the other hand, the photovoltaic inverter is priced at \notin 1216,29. This makes a total of \notin 6564,49. We will also understand a total of \notin 1500 additional for installation and wiring. This would make a total of \notin 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 kV	Vh price 2019 (PVPC)
Month	Energy Term (€/kWh)
January	0,1289
February	0,1194
March	0,1138
April	0,1153
Мау	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 \notin 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.

53

¹⁴ <u>https://www.esios.ree.es/es/pvpc</u>

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:			

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

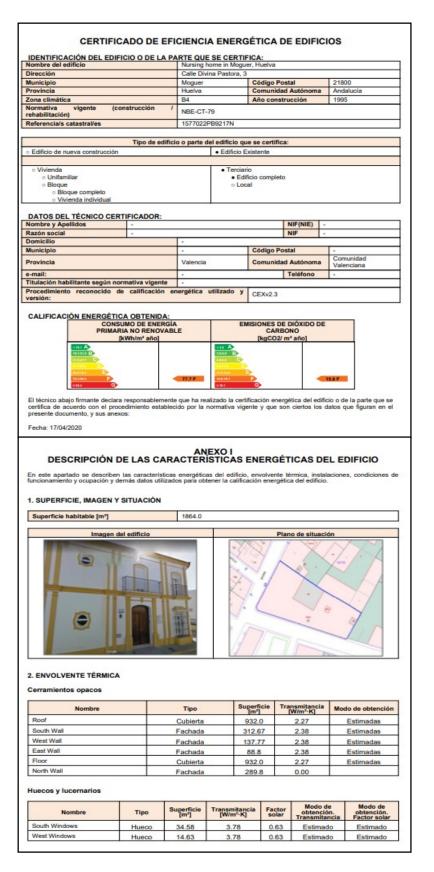
CERTIFICADO DE EFICIENCIA ENERGÉTICA DE EDIFICIOS IDENTIFICACIÓN DEL EDIFICIO O DE LA PARTE QUE SE CERTIFICA: AV. PRIMADO REIG 125, VALENCIA Dirección Municipio Código Postal 46020 Comu Valend 1963 Valencia Val Com nidad Auto Provincia ncia **B**3 Año cor Zona climática vigente (construcción mativa shilitación) Anterior a la NBE-CT-79 Referencia/s catastral/es 6840312YJ2764B Tipo de edificio o parte del edificio que se certifica: Edificio Existente Edificio de nueva construcción Vivienda Unifamiliar Bloque Bloque completo Vivienda individual Terciario Edificio completo Local DATOS DEL TÉCNICO CERTIFICADOR: Nombre y Apellidos Javier Amu NIF(NIE) 21795167E Bachelor The Razón social Domicilio Código Postal Municipio Valencia 46022 Comunidad Valenciana Provincia Valencia Comunidad Autónoma e-mail: Titulación habilitante según normativa vigente Procedimiento reconocido de calificación e javieramutio98@gmail.com Teléfono ergética utilizado y CEXv2.3 versión: CALIFICACIÓN ENERGÉTICA OBTENIDA: CONSUMO DE ENERGIA EMISIONES DE DIÓXIDO DE PRIMARIA NO RENOVABLE CARBONO [kWh/m² año] [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 Superficie [m²] Transmitancia [W/m²-K] Nombre Tipo Modo de obtención Building Floor Suelo 210.0 2.50 Por defecto SW - Wall Fachada 363.4 1.69 Estimadas NE - Wall 325.8 1.69 Estimadas Fachada Cubierta con aire Cubierta 219.6 2.27 Estimadas South East Wall 449.06 Fachada 0.00 North West Wall Fachada 449.06 0.00 Huecos y lucernarios Factor solar Modo de obtención. Transmitancia Modo de obtención. Factor solar Superficie [m²] Transmitancia [W/m²-K] Nombre Tipo Ventanas G1 Hueco 3 3.78 0.64 Estimado Estimado Ventanas G2 1.5 0.64 Estimado Hueco 3.78 Estimado Ventanas G3 Hueco 25.0 3.78 0.64 Estimado Estimado Ventanas G4 3.78 Estimado Hueco 4.0 0.64 Estimado Estimado Ventanas G8 Hueco 37.5 3.78 0.64 Estimado Ventanas G9 Hueco 18.0 3.78 0.64 Estimado Estimado Ventanas G10 Hueco 14.0 0.64 3.78 Estimado Estimado 0.64 Estimado Estimado Ventanas G11 Hueco 1.6 3.78

1. ENERGY CERTIFICATE OF THE BUILDING IN VALENCIA.

B. INSTALACIONES TE	RMICAS								
Generadores de calefa	cción								
Nombre	Tip	po	Pote	ancia al [kW]	Rendimiento Estacional (%		Tipo de Energia	Modo de obtenció	n
Calefacción y ACS	Caldera I	Estándar	2	4.0	63.8	0	Gas Natural	Estimade	5
TOTALES	Calefa	acción							
Generadores de refrig	eración								
Nombre	Tip	po	Pote	ancia al [kW]	Rendimiento Estacional [%	1	Tipo de Energia	Modo de obtenció	n
TOTALES	Refrige	ración							
nstalaciones de Agua					_				
Demanda diaria de	ACS a 60° (litr	os/dia)	13	61.0					
Nombre	Tip	oo	Pote	al [kW]	Rendimiento Estacional [%		Tipo de Energia	Modo de obtenció	
Calefacción y ACS	Caldera		2	1.0	63.8	0	Gas Natural	Estimade	0
TOTALES	AC	S						12	
1. CALIFICACIÓN ENE	RGÉTICA D		EN EM			ORE	S PARCIALE		_
*34 A				c	ALEFACCIÓN			ACS	
		18.3	E	Matt	nisiones pracojón 22m ² añoj 12.54	E	1.0	es ACS m ² añoj	,
allanta Po					FRIGERACIÓN			INACIÓN	
Emisiones g	lobales pigCC	02/m² añoj		Mac	nisiones peración 52m ² añoj 1.63	в	Emis RgC 02	iones lación mª añoj	
La calificación global del e consumo energético del m	dificio se expr	esua en leirmin	ce de dió	cido de ca	rbono liberado a	la at	másfera como		is d
	2945.—2			2/m² año	kgC02/año				
Emisiones CO2 p Emisiones CO2 p	or consumo e	Véctrico	1	63	3491.12 36928.73	+			
2. CALIFICACIÓN ENE Por energia primeria no re	RGÉTICA D								
ha sufrido ningún proceso	de conversión	o transformac	sión.				S PARCIALE		_
1 10 A				c	ALEFACCIÓN			ACS	
MARIE		-	1.28	DOM:	ia primaria eracción him ⁻ añoj 59.21	E	performance in the second seco	primaria nº añoj 39	G
DIRA D					FRIGERACIÓN			INACIÓN	
Consumo globai de	ARRIP BIOT	aria no renov	vable	Energ	la primaria geración 8m² añoj 9.64	с	Energia	primaria lacidroj matioj	
3. CALIFICACIÓN PAR La demanda energitica e confort del edificio.									ana d
	A DE CALEFA	CCION		_		DEF	REFRIGERAC	ION	
		- 3	1.7 D	• E.E. E.B.E.E. E.B.E.E.E. E.B.E.E.E. DE.B.E.E.E. DE.B.E.E.E. DE.B.E.E.E. DE.B.E.E.E. DE.B.E.E.E. DE.B.E.E.E.E.E.E.E.E.E.E.E.E.E.E.E.E.E.E				- 990	
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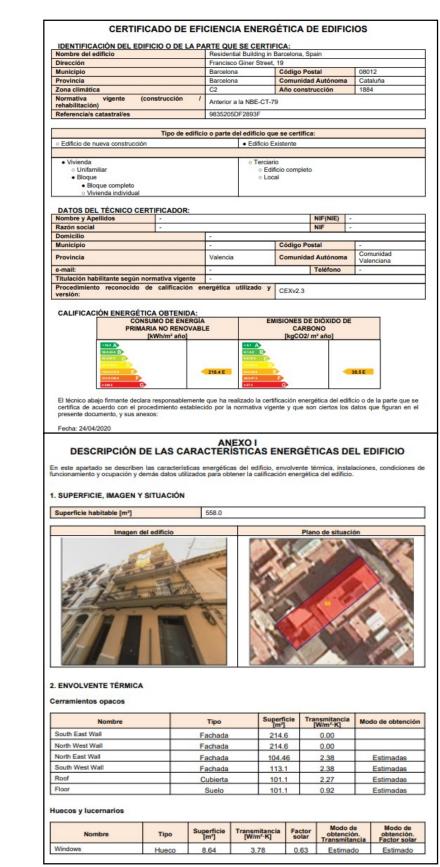
^{nt} 2020

2. ENERGY CERTIFICATE OF THE NURSING HOME IN MOGUER



3. INSTALACIONES TÉ	RMICAS								
Generadores de calefad	ción								
Nombre	Tipo)	Pot	encia nal [kW]	Rendimie	nto [%]	Tipo de Energia	Modo de obtención	
Heating and Cooling	Bomba de Caudal Ref.	Calor - Variable			253.1		Electricidad	Estimado	
TOTALES	Calefac	ción							
Generadores de refrige	ración								
Nombre	Tipe		Pot	encia tal [kW]	Rendimie	nto [%]	Tipo de Energia	Modo de obtención	
Heating and Cooling	Bomba de Caudal Ref.	Calor - Variable			190.2		Electricidad	Estimado	
TOTALES	Refriger								
nstalaciones de Agua	Callente Sani	taria			_				
Demanda diaria de A	CS a 60° (litro	s/dia)	14	176.0					
Nombre	Tipo	,	Pot	encia hal [kW]	Rendimie	nto [%]	Tipo de Energia	Modo de obtención	
DHW	Caldera Er	stándar		25	67.7		Gasóleo-C	Estimado	
TOTALES	ACS	3							
Espacio Edificio				ficie (m²) 64.0			Perfil de Intensidad B		
								10	
CALIFICACIÓN ENER INDICA	B4 GÉTICA DEL	EDIFICIO	EN EMI	_			Intensidad E	ŝ	
1444 B				Em	siones	1	ACS		
mana D		(RecO2im ano)		2m ² anol	E		m alloj G		
5 11 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1		15.6		REFRIGERACIÓN			ILUMINACIÓN		
Emisiones glob	ales pgCO2	m² añoj		En Reco	siones ieración 2/m² anoj 4.91	D	Emis Jume JegCO2	iones ación m° añoj -	
a calificación global del edi naumo energético del mis	ficio se express mo.	en términa	is de dióx	ido de car	bono liberado	-	tmósfera com	o consecuencia de	
Emisiones CO2 par	concerno eld	and the second		81	kgC02/wh				
Emisiones CO2 por				78	12640,64				
CALIFICACIÓN ENER	GÉTICA DEL	EDIFICIO	EN CO	SUMO D		A PRI	MARIA NO R	ENOVABLE	
or energia primaria no reno a sufrido ningún proceso de	vable se entier conversión o l	de la energ	ia consur ión.	nida por el	edificio proc	edente	de fuentes no	renovables que n	
SHI A	DOR GLOBAL	8		CA	INDIC		ES PARCIALE	ACS	
18.1.1.1.2 B	1			Energi	a primaria facción im ¹ añoj	6	Energia	erimaria n ² añoj G	
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RAND D RAND D NAMA D MARA D		-77		REP	RIGERACIÓ a primaria	N		primaria	
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Consumo global de gr	calefacción y	EMANDA I	ENERG	REF Energi SWA 2 2	RIGERACIÓ a primaria peración im" artoj 8.98 CALEFAC cesaria para	CIÓN	Y REFRIGE	Primaria lapido m ¹ arlog 00 RACIÓN ciones internas d	
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Consumo global de estinado en	IAL DE LA D calefacción y	EMANDA I refrigeració	ENERG	REF Energi 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2	RIGERACIÓ a primaria erreción mariaria sase CALEFAC cesseria para DEMANO		Energia Jumin (2005) C. Y REFRIGE Iner las condi	primaria strido strido so RACIÓN ciones internes di SON 29.2 D	
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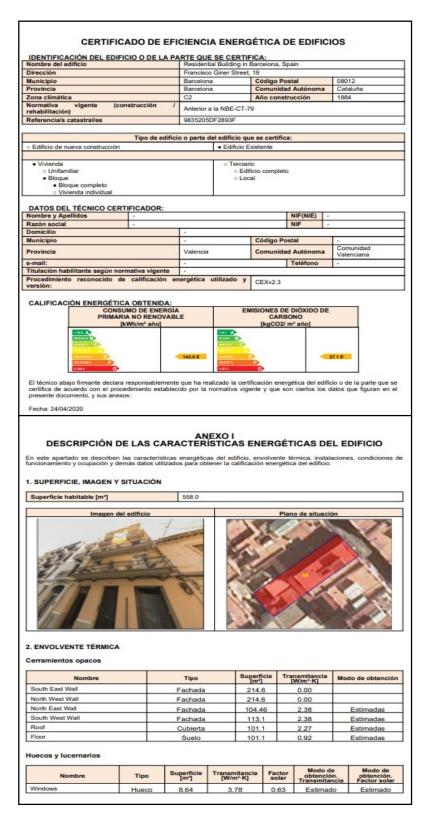


3. ENERGY CERTIFICATE OF THE BUILDING IN BARCELONA.

3. INSTALACIONES TÉRMICAS Generadores de calefacción Nombre Tipo Potencia nominal [kW] Rendimiento Estacional [%] Tipo de Energia Modo de obtención Sólo calefacción 100.0 Electricidad Estimado Efecto Joule TOTALES Calefacción Generadores de refrigeración Potencia nominal [kW] Rendimiento Estacional [%] Tipo de Energia Modo de obtención Nombre Tipo TOTALES Refrigeración Instalaciones de Agua Caliente Sanitaria Demanda diaria de ACS a 60° (litros/dia) 718.2 Potencia minal [kW] Rendimiento Estacional [%] Tipo de Energia Modo de obtención Nombre Tipo Equipo ACS 44.0 GLP Caldera Estándar 24.0 Estimado TOTALES ACS CALIFICACIÓN ENERGÉTICA DEL EDIFICIO Uso Zona climática C2 R 1. CALIFICACIÓN ENERGÉTICA DEL EDIFICIO EN EMISIONES INDICADOR GLOBA INDICADORES PARCIALES ACS CALEFACCIÓN Emisiones AGS (kgCO2m ano) G E 14.47 23.80 ILU Emisiones refigeração (xgCO2m² año) Emisiones iluminación MgC 02/m* añol A Emisiones globales (kgCO2/m² año) . eción global del edificio se energético del miarno. de di kgC02/m² año kgC02/año 2. CALIFICACIÓN ENERGÉTICA DEL EDIFICIO EN CONSUMO DE ENERGÍA PRIMARIA NO RENOVABLE energia primaria no renovable se entiende la energia cons sufrido ningún proceso de conversión o transformación. ida por el edificio p INDICADOR GLOBA ES CALEFACCIÓN ACS nergia primaria calefacción [kiWhimfaño] 140.52 ACS E ACS [kW/b/m² año] 68.43 G II UNINACIÓN REFERENCERACIÓN Frengia primaria refrigeración kwism añoj nergia primari iluminación (kwh/m año) Consumo global de energia primaria no renovable 3. CALIFICACIÓN PARCIAL DE LA DEMANDA ENERGÉTICA DE CALEFACCIÓN Y REFRIGERACIÓN manda energética de calefacción y refrigeración es la en rt del edificio. ergia necesaria pata mante ner las condicio DEMANDA DE CALEFACCION DEMANDA DE REFRIG 6 Demanda de calefacción [kWh/m³ año] Demanda de refrigeración (kWh/m² año)

or global es resultado de la suma de los indicadores parciales más el valor del indicador para consumos susiliares, si los tubiera (sólo ed. to , bonbeo, 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



. INSTALACIONES TE Generadores de calefa									
Nombre	т	ipo	Po	tencia inal [kW]	Rendimiento Estacional [%		Tipo de Energia	Modo	de
Heating and Cooling	Bomba Caudal R	de Calor - ef. Variable			193.6		Electricidad	Estim	
TOTALES		facción							
eneradores de refrig	eración								
Nombre	т	ipo	Po	tencia inal [kW]	Rendimie	Rendimiento Estacional [%]		Modo de obtención	
Heating and Cooling	Bomba (de Calor - ef. Variable			143.0		Electricidad	Estim	ado
TOTALES		eración							
stalaciones de Agua Demanda diaria de				718.2					
Newber		Inc	Pr	tencia	Rendimie	nto	Tipo de	Modo	de
Nombre Equipo ACS		ipo		inal [kW]	Estacional 44.0	[%]	Tipo de Energia	obten	ión
TOTALES		Estándar CS		24.0	44.0		GLP	Estim	ado
TO TALLO									
	ADOR GLOB	27.1	E	Emi	LEFACCIÓN siones (acción 2m ² artoj 2.29	D	A Figeressian States		G
a a a a a a a a a a a a a a a a a a a		REFRIGERACIÓN							
Emisiones gl			_	6	siones gración 2m ² añoj	*	Emision MgC 02m		-
a calificación global del e maumo energético del m	dificio se expressione	esa en término				_	másfera como o	onsecuent	cia del
Emisiones CO2 po	or consumo e	Véctrico	1	2/m² año 2.64	kgC02/año 7052.91				
Emisiones CO2 po				4.47	8075.86	-			
CALIFICACIÓN ENE or energia primeria no re a sufrido ningún proceso									
	ADOR GLOB		ón.				S PARCIALES		_
				CAL	EFACCIÓN			cs	
HARTS C				Energia Callet DKWb	a primaria acción imfañoj	ь	Energia pr ACS primbino	añol	
DEC MARKED		543	1.0 E	7.	2.58 RIGERACIÓN	1	68.43	ACIÓN	-
Consumo global de	energia prim	aria no renov	able	Energia	eración m ¹ añoj		Energia pr Numinaç AXWorm	imaria	
	whith allo			2	m*añoj .04	^	powersin'	aritoj	
CALIFICACIÓN PAR demanda energética d infort del edificio.	CIAL DE LA	DEMANDA I	ENERG	ÉTICA DE	CALEFACO	IÓN	Y REFRIGERA	CIÓN	an de
	DE CALEFA						EFRIGERACIO		
NATURE CONTRACTOR CONT			92	ALLER DERE DERE DERE DER DER DER DER DER DER DER				1.5.4	
Demandia de o Indicador global es resultado d			des más el				Macidin (AMALIN		nciarios.
I indicador global es resultado d entilación, bombeo, etc). La en	ergia el-lictrica auto	consumida se des	cuenta úni	camerte del int	icador global, no	aai de k	os valores parciales		

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

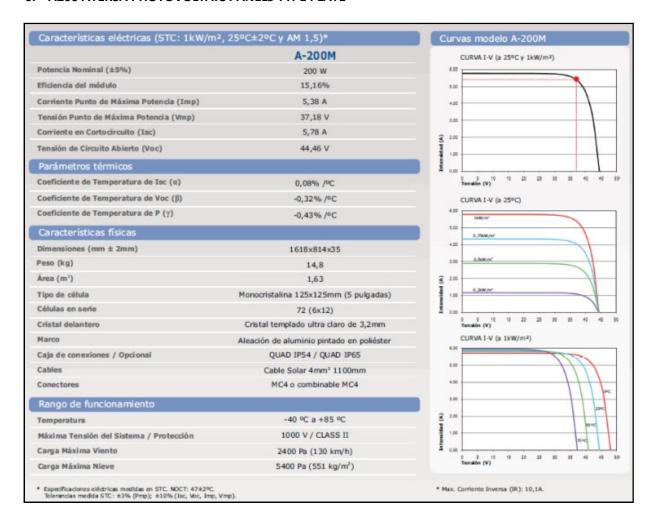
IDENTIFICACIÓN DEL ED	IFICIO O DE	LA PARTE QU	E SE CE	RTIFICA				
Nombre del edificio Dirección		Residen	tial Buildin	g in Barc	elona, S	pain		
Municipio		Barcelo	na	Cé	idigo Po		08012	
Provincia Zona climática		Barcelo C2	na			d Autónoma trucción	Catalu 1884	iña
Normativa vigente (construcción		a la NBE-	_				
rehabilitación) Referencia/s catastral/es			5DF2893F					
Edificio de nueva construcció		edificio o parte		cio Existe		a:		
Editicio de hueva construccio	n		• Edmi	CIO EXISTE	ense			
Vivienda Unifamiliar				Edificio				
Bloque				Local	compiet	D		
 Bloque completo Vivienda individual 								
DATOS DEL TÉCNICO CE Nombre y Apellidos	RTIFICADO	R:				NIF(NIE)	63	
Razón social					3	NIF		
Domicilio Municipio		-		Cé	idigo Po	vetal		
Provincia		Valencia		_		d Autónoma	Comu	
-rovincia		v arence	2			Teléfono	Valen	ciana
litulación habilitante según r						, electronico		
Procedimiento reconocido	de calificac	ión energética	utilizado	Y CE	Xv2.3			
CALIFICACIÓN ENERGÉT	ICA OBTEN	IDA:		EMISI	NESO	E DIÓXIDO DE		1
	ARIA NO REN	OVABLE			CAR	ONO		
1388 A	[kWh/m ² and	2	-		kgCO2	m² año]		1
BARRINE B			6168 E					1
mana D		132.0 E	-	0			25.2 E	
20.8363 P		132.0 E	68.8 67.3		100		19.7 6	
1.001		-	100					
El técnico abajo firmante decla certifica de acuerdo con el pr	ara responsabl	emente que ha re						
		stablecido por la	normativa	vigente	v que s	rgética del edifi on ciertos los	cio o de datos qu	e ficuran en e
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3. INSTALACIONES TÉRMICAS Generadores de calefacción Modo de obtención Potencia nominal [kW] Rendimiento Estacional [%] Tipo de Energia Nombre Tipo Heating and Cooling Bomba de Calor -Caudal Ref. Variab 193.6 Electricidad Estimado Calefacción TOTALES Generadores de refrigeración Potencia nominal [kW] Rendimiento Estacional [%] Tipo de Energia Modo de obtención Nombre Tipo Bomba de Calor -Caudal Ref. Variab 143.0 Heating and Cooling Electricidad Estimado TOTALES Refrigeración Instalaciones de Agua Caliente Sanitaria Demanda diaria de ACS a 60° (litros/dia) 718.2 Modo de obtención Nombre Tipo Potencia ominal [kW] Rendimiento Estacional [%] Tipo de Energia Equipo ACS Caldera Estándar 44.0 GLP 24.0 Estimado TOTALES ACS 6. ENERGIAS RENOVABLES Térmica Consumo de Energía Final, cubierto en función del servicio asociado [%] Demanda de ACS cubierta [%] Nombre Calefacción Refrigeración ACS Photovoltaic Field 15.25 TOTAL 15.25 CALIFICACIÓN ENERGÉTICA DEL EDIFICIO Zona climáti U R 1. CALIFICACIÓN ENERGÉTICA DEL EDIFICIO EN EMISIONES ES PARCIALES INDICADOR GLOBAL INDICADO CALEFACCIÓN ACS Emisiones calsfacción legc 02m añoj Emisiones ACS G c 14.47 REFRIGERACIÓN ILUMINACIÓN Emisiones remperación NgCO2m⁻ anoj Emisiones Juminación RegC 02/m² año) Emisiones globales (kgCO2/m² año) A La calificación global del edificio se expresa en terr os de dióx do de carb and an inte kgC02/m² año kgCO2/año Emisiones CO2 par consumo eléctrico Emisiones CO2 par atros combustibles 10.76 6006.67 14.47 8075.8 2. CALIFICACIÓN ENERGÉTICA DEL EDIFICIO EN CONSUMO DE ENERGÍA PRIMARIA NO RENOVABLE r energia primaria no renovable se entiende la energia o sufrido ningún proceso de conversión o transformación. nida por el edificio pr le de fu no renovables qui INDICADOR GLOBA INDICADO 10.00 CALEFACCIÓN ACS nergia primari caleracción JkWh/m*añoi Energia grimaria ACS (kWh/m² año) E ía D G 68.43 61.5 ILUMINACIÓN REFRIGERACIÓN Energía primaria refrigeración ktyrism² anoj Cons mo global de energia grimaria no renovable -Ruminación Referención CALIFICACIÓN PARCIAL DE LA DEMANDA ENERGÉTICA DE CALEFACCIÓN Y REFRIGERACIÓN 3 ática de calefacción y refrio ración es la erv ingle nece ria reara er las conde DEMANDA DE CALEFACCIÓN DEMANDA DE REF

Demanda de refrigeración [kWh/m² año]

Demanda de calefacción (kWh/m² año)

6. A200 ATERSA PHOTOVOLTAIC PANELS TYPE PLATE



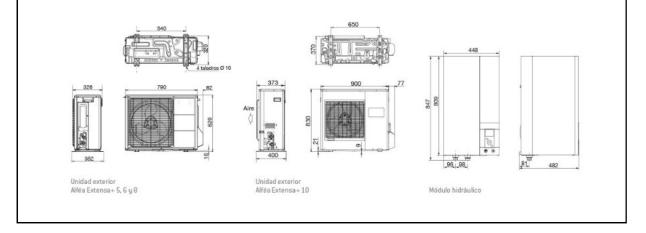
7. INGECON[®] SUN 1Play 5TL M PHOTOVOLTAIC INVERTER TYPE PLATE

1	5TL M	6TL M			
Valores de Entrada (DC)					
Rango pot, campo FV recomendado ¹¹	5.7-6.5 WWp	6,3-7 kWp			
Rango de tensión MPP1 ^o		125 - 750 V			
Rango de tensión MPP2 ¹³¹⁸		90 - 750 V			
Tensión máxima ^{ce}		850 V			
Corriente máxima (Ereats 1 / Ereats 2)		11/11A			
Nº entradas (Desas 1) Desas 2/10		1/1			
MPPT		2			
Valores de Salida (AC)					
Polencia nominal	5 kW	6 KW			
Máx. temperatura para potencia nominal ^{re}	55 °C	45 %			
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 ²³	TT / TN / 208 V de	Ita corner ground / 240 V delta corner ground			
Factor de Potencia		1			
Factor de Potencia ajustable	SI. Smaker5 kVA	SI. Smikeri kitik			
THD		d%			
Rendimiento					
Eficiencia máxima	98%	98%			
Euroeficiencia	97.6%	97,6%			
Datos Generales					
Sistema de refrigeración		Convección natural			
		<10 W			
Consumo en stand-by ^{es} Consumo noctumo		0W			
Temperatura de funcionamiento		-25% #+65%			
Humedad relativa (sin condemuación) Grado de protección	0 - 100%				
		IP65 CE			
Marcado		000-6-4, EN 63000-3-11, EN 63000-3-12, EN 62109-1, EN 62309-2, IEC62303,			
Normativa EMC y de seguridad	EN	50178, FCC Part 15, AS3000			
Normativa de conexión a red	IEC 61727, UNE 206007-1, ABNT NBR 16149, ABN	VDE-AR-M 4105-2011-08, GS8/2, G83/2 ¹⁰ , PO.12.3, AS4777.2, AS4777.3, IEC 62116, T NBR 16150, South African Grid code, Chilean Grid Code, Romanian Grid Code, Thalland MEA & PEA requirements, DEIIRA (Dubai) Grid Code, Jordan Grid Code			
salida quedată condicionada por la con ¹⁰ Para bajar a 90 V la otra entrada tie caso. Considerar el aumento de terreidor conectores dobles para conectar dos c potencia de salida se reducirá un 1,85	alación y de la obicación geográfica: ^{III} La potencia de figuración de tensión y consente elegida en cada entrada ne que entar al menor al 25 V ^{III} No superar en mingún de los paneles "loc a bajes tempentunes "Disponition ables por cada entrada. ^{III} Por cada "C de incremento, la V. III con con de duda, por lavor comunitar el manual de fetovoltaico. ^{III} Sólo pana invencens hanta 36 A de salida.	Rendimiento INGECON® SUN 5TL M visc. = 680 V			
Dimensiones y peso (mm)		TLM/6TLM			

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 t" / 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



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