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Study for obtaining the energy certificate in a hockey club building located in Terrassa

Final Report

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Their contributions and support have been invaluable, and I am truly grateful for their assistance in making this project a success.

HONOR DECLARATION

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SUMMARY

This document presents the results of a study conducted during the spring semester of the 2022-2023 academic year as the Final Degree Project in Industrial Technology Engineering at the School of Industrial, Aerospace, and Audiovisual Engineering in Terrassa, Universitat Politècnica de Catalunya.

The objective of the project is to evaluate the energy certification of Club Egara, located at Jacint Badiella No. 5 in Terrassa.

To achieve this, two energy certifications, a basic one and an exhaustive one, are carried out with the aim of identifying possible alternatives that can improve energy efficiency.

Finally, relevant conclusions have been drawn based on the study's results, as well as the actual energy consumption of the building.

INDEX

FIGURES INDEX

TABLE INDEX

1. PURPOSE

The main objective of this project is to carry out an energy certification of Club Egara, located in Terrassa, in order to improve the energy efficiency of the club.

Two energy certifications have been planned, a basic one and an exhaustive one, which will be conducted using the CE3X software, a specialized program for energy certifications.

After comparing the certifications with the actual energy consumption of the building, several alternatives will be analyzed that can contribute to improving the energy efficiency of the building.

2. SCOPE

First of all, an attempt will be made to contact the president and the manager of the club to gather all the necessary information, such as energy consumption data, plans, and projects of the club.

Next, a brief study of energy certification for buildings and various energy efficiency systems will be conducted to better understand how the energy efficiency of the club can be improved.

The next step will involve the energy certification of the club using the CE3X program, which will consist of two certifications: a basic certification and an exhaustive certification.

Once the certification is completed, an analysis of the club's energy consumption will be conducted and compared with the initial energy certifications. Different measures that can be taken to save energy and improve the energy certification will be evaluated.

3. REQUIREMENTS

The energy efficiency certificates of Club Egara will be carried out using the CE3X program.

The proposed improvement measures must be viable in terms of technical, economic, and environmental aspects.

To obtain the necessary information for the energy certification, the collected data from the club's documents and information provided by the club itself will be used. In case any data is missing, default values provided by the program will be used or estimations will be made.

It should be noted that the certification of the building is limited to the clubhouse building and activities building.

4. JUSTIFICATION

The current society is built upon unlimited consumption and unchecked growth, which confronts limited resources and increasingly irreversible environmental problems.

It is the responsibility of everyone to use resources moderately and be respectful towards the environment in order to mitigate the effects of pollution and climate change.

The construction sector is accountable for approximately 30% of the energy consumption in Spain, and the tertiary sector, which includes educational and sports facilities, accounts for 12.4% of the total consumption (1)

Many of these sports facilities have inefficient energy consumption due to their age and large dimensions. In this context, I have decided to focus this study on Club Egara in Terrassa, where I have played field hockey throughout my life.

This work is not only a theoretical study but also has a real-world application. Energy certification of the club and proposing efficient improvements can lead to significant economic savings, reduce energy consumption, and consequently decrease the building's environmental impact. This is a shared responsibility for everyone to ensure a sustainable future for the planet.

5. BACKGROUND

During the last years, there has been a global energy crisis, leading to negative impacts in various areas. Depletion of natural resources and climate change are two of the most important issues that need to be addressed to solve this global situation.

The demand for and consumption of energy have increased, generating widespread concern for the environment (2)

In 1972, the first conference was held to establish principles for the conservation and improvement of the environment, and recommendations were made to contribute to its protection. For the first time, climate change was recognized, and governments were warned to assess and consider activities that could contribute to it.

The Montreal Protocol, which took place in 1987, went further by regulating activities that contribute to the depletion of the ozone layer (3).

In the following years, climate change and the energy crisis became more visible in society, and events like the United Nations Framework Convention on Climate Change (UNFCCC) were organized. However, pollution continued to increase, leading to the Kyoto Protocol in 1997, which aimed to reduce CO_2 emissions by 5% for industrialized countries compared to 1990.

It is important to note that in 2015, one of the most significant United Nations Conferences on Climate Change took place in Paris, emphasizing the global temperature increase. More than 170 countries agreed to limit this increase to below 1.5°C, which required a significant reduction in the environmental impact of major cities.

During the same year, there was a significant investment in improving energy efficiency, made possible by specific regulations and policies.

Finally, in 2018, several objectives for 2030 were announced, including the reduction of greenhouse gas emissions and the improvement of energy efficiency by 30% or more (4).

6. LEGISLATION

Once the latest approved decree has been examined, the requirements in both the European legal framework and the Spanish legal framework will be considered, aiming to fulfill all the established purposes until 2023. Taking into account that this project involves the execution of an energy certification for a sports club, focus will be placed only on the necessary regulations for these types of certifications.

6.1. LEGAL EUROPEAN LEGISLATION

Directive 2002/91/EC is the first European regulation that establishes the need for energy efficiency certificates for buildings.

This directive was inspired by the Kyoto Protocol, which committed the EU to reduce CO_2 emissions by 8% by 2010 (5).

Focusing on energy efficiency certificates, the methodology of this directive establishes that:

-Building owners or tenants must have an energy efficiency certificate that is valid for a maximum of 10 years.

-Buildings occupied by public authorities or institutions providing public services and with a useful floor area exceeding 1000 m² must display a visible energy efficiency certificate that is less than 10 years old. This means that this regulation requires these public buildings to have a certificate displaying their energy efficiency level and that this information should be visible to citizens in an easily accessible location.

Directive 2002/91/EC was repealed by Directive 2010/31/EU (6), which aims to improve the energy efficiency of buildings in the European Union, taking into account different climatic conditions and local specificities.

Furthermore, this directive establishes minimum requirements and a common framework for calculating the energy efficiency of buildings.
Key points of this directive include:

-EU countries must establish fiscal and financial incentives for citizens, businesses, and organizations that promote energy efficiency and the use of renewable energy sources.

-Energy companies must provide transparent information to their customers about the origin and environmental impact of the energy they supply.

-Public authorities must lead by example and ensure that their buildings and facilities comply with energy efficiency standards.

-EU countries must promote cooperation and exchange of best practices to improve energy efficiency at a European scale.

-EU cities and regions must develop local action plans for energy efficiency and the use of renewable energy sources.

-Utility companies must offer their customers options to use renewable energy sources for their energy needs.

In 2012, Directive 2012/27/EU (was adopted, requiring EU member states to set targets to reduce energy consumption by 20% by 2020 (7). This included binding measures for end-users and energy suppliers. Additionally, EU countries were obligated to submit energy efficiency action plans every three years.

Following that, Directive 2018/844/EU amended the previous directives. This directive required EU countries to develop long-term renovation strategies to transform residential and non-residential buildings into highly energy-efficient and decarbonized building stocks by no later than 2050. This is to achieve a reduction of greenhouse gas emissions by 80-95% compared to 1990 levels by 2050.

6.2. LEGAL SPANISH LEGISLATION

In the past, energy laws in Spain were based on the NBE-CT-79 regulations, which are no longer in effect. These regulations, which were in use during the 1980s and much of the 1990s, were significant for the regulatory development of buildings and installations in the country, although at that time, energy priorities focused more on production than on energy savings. Subsequently, the LOE (Building Regulation Law) established minimum criteria for safety, functionality, and habitability in 2006, marking the first step towards the unification of regulations regarding building construction. In 2007, the Regulation of Thermal Installations in Buildings (RITE) was approved, introducing efficiency parameters in hot water and air conditioning installations that previously lacked normative support in Spanish legislation. Since then, this law has been the main regulation on energy efficiency.

The energy efficiency regulations in Spain have undergone significant changes, with a key milestone being Royal Decree 47/2007 on energy certification in buildings. This was the first decree on energy efficiency and laid the foundations for all subsequent laws. This decree was repealed by Royal Decree 235/2013, which transposed the European directive on energy efficiency. This law modified the regulations for energy efficiency certificates. In 2017, Royal Decree 564/2017 slightly amended this decree, but it was repealed by Law 390/2021 of June 1, 2021, which approves the basic procedure for energy certification of buildings (8).

The most relevant aspects of the new regulation are as follows:

-The energy certificate for project and completed buildings will not only apply to new buildings but also to all renovations that involve an expansion of more than 10% of the surface area, intervention in more than 25%, or modification of thermal installations.

-The previous modification will affect all buildings larger than 500 m² that are not residential.

-Energy certificates with a G rating will be valid for only 5 years, and it is mandatory for the technician to visit the property during the energy certification process.

7. ENERGETIC CERTIFICATION

7.1. THE ENERGETIC CERTIFICATE

The energy certificate is an official document that contains objective information about the energy characteristics of a building. This document is required for the sale or rental of a property and has a validity of 10 years(9). To obtain it, it is necessary for a competent technician with a degree in architecture, technical architecture, technical engineering, or higher engineering to calculate the energy consumption that a building requires during one year under normal operating and occupancy conditions.

An energy certificate is a document that must contain the following information(9),(10):

-Building address

-Type of procedure used to obtain the energy certificate (software program)

-Details of the energy characteristics of the building, including surface area, location, installations, technical envelope, among others.

-Label indicating the energy efficiency rating of the building

-Recommendations for improving energy efficiency, divided into major renovation improvements (technical installations) and minor renovation improvements.

-Details of the checks carried out by the competent technician who assessed the energy performance of the building.

-Environmental requirements for thermal installations.

In addition to this information, the energy certification report also includes four annexes with the following information(11):

-Annex I: Description of the thermal characteristics of the building.

-Annex II: Details of the energy rating of the building, including information on different energy demands and consumption.

-Annex III: Recommendations for improving the energy efficiency of the building.

-Annex IV: Description of the tests, checks, and inspections carried out during the energy certification process by the competent technician.

7.2. THE ENERGY LABEL

The energy label is one of its most visible and important components. It is a label that displays the energy rating of the building, represented by a letter from A (most efficient) to G (least efficient).

This label has become a key element in communicating energy information to end users as it allows for the comparison of energy efficiency between different buildings. An A label indicates that the building is highly efficient, while a G label indicates that the building has very low energy performance.

Additionally, the energy label may also include additional information such as the building's primary energy consumption, carbon dioxide emissions, or an estimate of the annual energy cost of the building.

Similar to certification, the label is valid for 10 years (12).

Figure 1.Example of energy label (30)

In the example provided, the energy label consists of three different sections(12).

-Building Information: This section includes the regulations that were in force during the construction of the building, the cadastral reference number, the building type, and its location.

-Energy Efficiency Scale: Here, the energy efficiency is displayed on a graded scale. Two factors are measured: energy consumption and CO_2 emissions.

-Registration and Validity: The bottom part of the label includes the registration number issued by the autonomous community and the expiration date of the certificate's validity.

7.3. ENERGY CERTIFICATION TOOLS

To carry out energy certification and register it officially, recognized documents must be used. These documents have been developed by the Ministry of Industry, Energy and Tourism in collaboration with the Ministry of Development, with the aim of simplifying the process.

The software programs accepted by the Government are as follows (13):

-LDER-CALENER (HULC)

-CE3

-CERMA

-CYPETHERM HE plus

-SG SAVE

-CE3X complement

To carry out the energy certification of a building, there are several options available. It is possible to use different software programs or calculation tools that are recognized by the competent authorities.

The procedure for energy certification of buildings can be applied to different types of buildings and dwellings (14).

Below are the general steps to obtain the energy rating for each:

-Single-family residence: Information about the building is gathered, necessary calculations are performed, and the energy certification document is prepared.

-Multi-family residential buildings: Information about common elements and individual residence is collected, required calculations are performed, and the energy certification document is drafted.

-Individual residence within multi-family buildings: The same process of gathering information and calculations as in the previous case is carried out, but only for the individual residence.

-Tertiary buildings: Information about different spaces and equipment is collected, necessary calculations are performed, and the energy certification document is prepared.

This study is carried out using the following programs:

-LIDER-CALENER (HULC) is a public program that offers a more accurate tool for obtaining energy certification, but it is also more complex. This program is especially suitable for newly constructed buildings and is therefore the most commonly used in such cases.

-CYPETHERM He Plus, a privately initiated program.

-SG SAVE, a privately initiated program.

There are more simplified procedures for obtaining energy certification for existing buildings:

-CE3.

-CE3X is a user-friendly program, but its results may not be the most precise.

The CE3X Complement is an additional tool for obtaining energy certification for new buildings, whether they are newly constructed residential buildings or recently constructed small or medium-sized tertiary buildings. This complement provides additional information and helps in performing the necessary calculations to obtain an appropriate energy rating.

To carry out this energy certification project, the CE3X program will be used. In this case, it is a pre-existing building belonging to the tertiary sector, for which the corresponding energy certification will be conducted. So the necessary information will be gathered and the relevant calculations will be performed to obtain the appropriate energy rating for Club Egara.

8. METHODOLOGY

The following steps will detail the procedure to obtain the energy certification of our building using the CE3X program, including both simplified and exhaustive certification. The required data and how to input them into the program to obtain the actual energy consumption of our building will be described. Finally, the obtained results will be compared, and potential improvements to implement will be studied.

8.1. ENERGY CERTIFICATIONS WITH THE CE3X PROGRAM

To carry out the mentioned certifications, it is necessary to follow a series of steps using the CE3X program. The difference between the simplified certification and the exhaustive certification will be the data source. In the simplified certification, the CE3X program will use default data, while in the exhaustive certification, the data will be extracted from the provided documents, in this case, by Club Egara.

Below is an image extracted from the CE3X program manual describing the procedure to be followed. It is important to follow this diagram carefully to obtain an accurate and reliable certification.

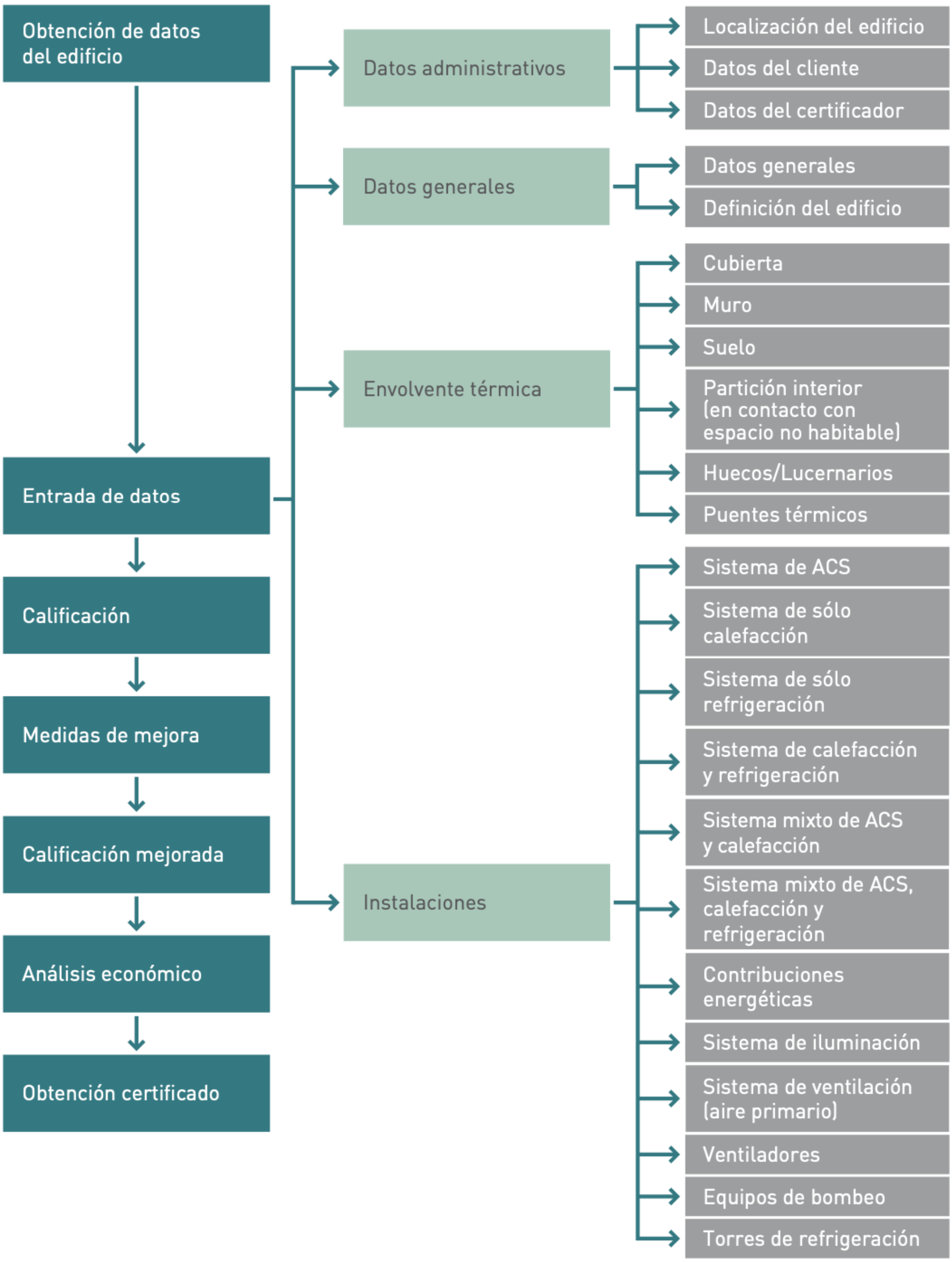


Figure 2. Structure of the certification procedure. CE3X (31)

8.1.1. DATA ACQUISITION OF THE BUILDING

As a first step in carrying out the certifications, we need to gather the necessary information.

During this phase, we have obtained all the required data of the building:

These data include:

-Club's blueprints

-Construction Report

-Visit to the facilities.

8.1.2. DATA ENTRY

To begin the data entry process in the program, the established procedure will be followed. In Figure 2, it can be observed that four different types of data need to be provided: administrative data, general data, thermal envelope, and installations (15).

Each of these data types will be detailed accurately to ensure their correct input into the program.

Firstly, before inserting the data, the program prompts us to select the type of building to which they belong. This can be clearly seen in the following figure:

Figure 3. Building typology selection.

8.1.3. ADMINISTRATIVE DATA

In this form, general information about the building is requested:

-Location and identification.

-Client data.

-Certifier data.

This information does not affect the final result.

8.1.4. GENERAL DATA OF THE BUILDING

To obtain the building's qualification, the general data is essential as it directly affects the final result.

The following are the general data that need to be considered for the building's qualification (15):

General Data:

- -Current regulations
- -Building type
- -Usage profile
- -Province/autonomous community and locality
- -Climate zone

Building Definition:

- -Usable floor area
- -Clear height of the floor
- -Number of occupied floors
- -Mass of partitions
- -Total daily hot water consumption (ACS)

These general data provide crucial information for assessing the energy performance and qualification of the building.

8.1.5. THERMAL ENVELOPE

The thermal envelope is composed of all the elements that separate the habitable spaces from the non-habitable spaces or the external environment, such as walls, doors, and others. In other words, the thermal envelope is the barrier that separates the interior habitable space from the external environment (15).

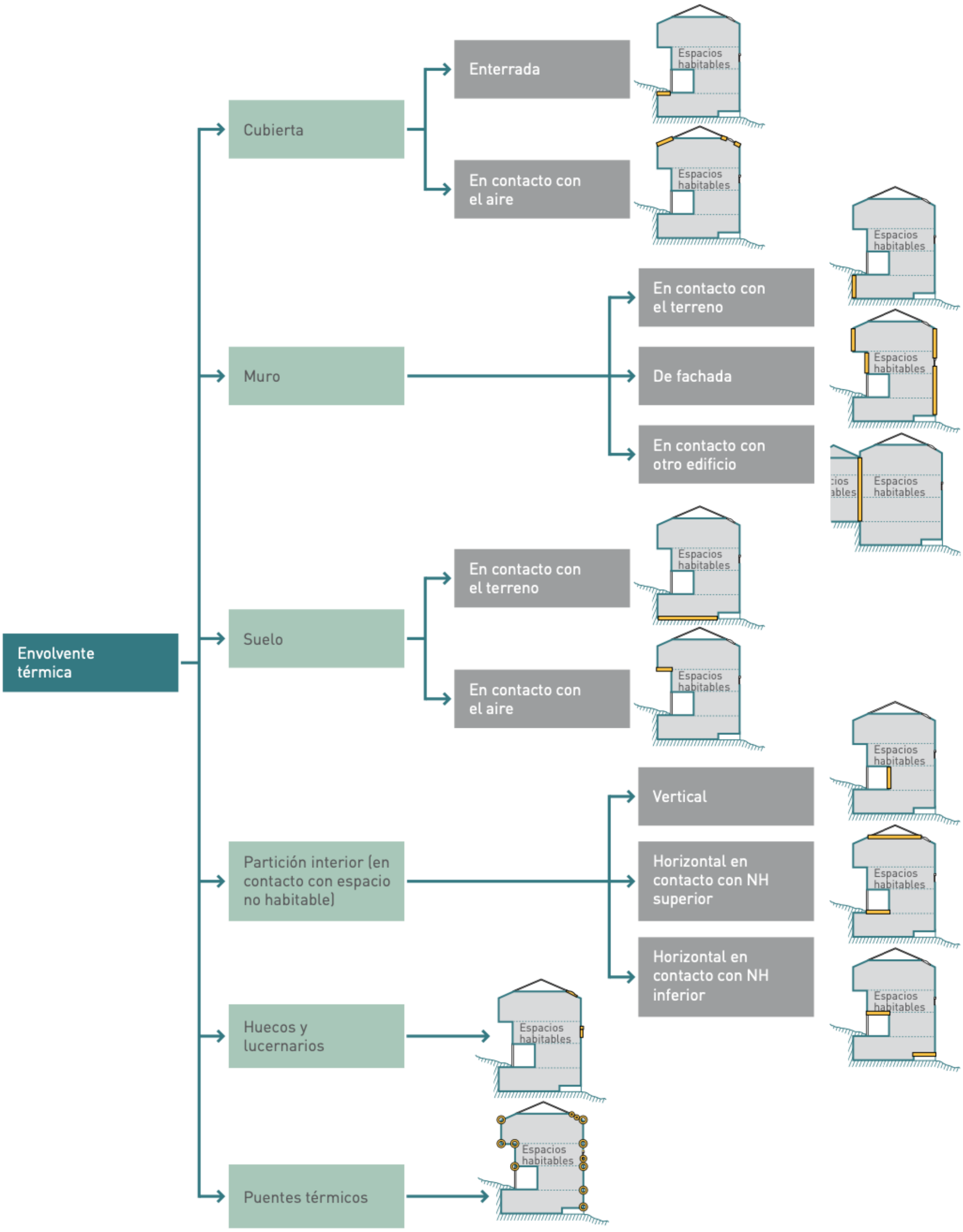


Figure 4. Organizational chart of thermal envelope components in the CE3X program (32)

As shown in the diagram, it is important to have various data of the building for the creation of the thermal envelope, which need to be entered for each surface. In case some data is not available, estimations or default values can be used.

8.1.6. INSTALLATION PANEL

In the CE3X program, there is the possibility to input different types of installations, as shown in the figure. If it is a large tertiary building, it will be necessary to consider all available installations and enter them correctly into the program. This includes HVAC systems, ventilation, lighting, hot water production, among others, to ensure an effective calculation of the building's energy consumption.

	CE³X Residencial	CE³X Pequeño terciario	CE³X Gran terciario
Equipo de ACS	x	x	x
Equipo de sólo calefacción	x	x	x
Equipo de sólo refrigeración	x	x	x
Equipo de calefacción y refrigeración	x	x	x
Equipo mixto de calefacción y ACS	x	x	x
Equipo mixto de calefacción, refrigeración y ACS	x	x	x
Contribuciones energéticas	x	x	x
Equipos de iluminación		x	x
Equipos de aire primario		x	x
Ventiladores			x
Equipos de bombeo			x
Torres de refrigeración			x

Figure 5. List of emerging technologies based on building typology (32)

For each installation, it is necessary to obtain various data for the certification process, such as the name of the installation, the zone where the building is located, the type of generator, the type of fuel, the efficiency, and the energy consumption, among others.

In case a surface to be certified does not have any system or the existing system does not cover 100% of the thermal needs of the space, the CE3X program assigns default equipment to meet the energy needs of that surface. This ensures that the energy certification of the building is as accurate as possible and reflects the actual needs of the space.

For each system defined in the CE3X program, it is necessary to input the seasonal efficiency. This data can be determined with a known value if precise information about the installed system is available or with an estimated value based on the type of installation.

8.1.7. OBTAINING THE RESULTS OF THE ENERGETIC CERTIFICATION

Once all the required data has been entered into the CE3X program, it is possible to perform a simulation to obtain the results of the energy certification of the building. These results include the qualification scale, the energy rating of the building, and data on energy demand and CO_2 emissions related to heating, cooling, domestic hot water, and lighting of the building (15).

8.2. CERTIFICATION AND COMPARISON WITH REAL CONSUMPTION DATA

After obtaining the results of the basic and exhaustive energy certifications, it is important to compare them with the actual data of the building to determine which certification aligns more closely with reality. To do this, it is necessary to obtain the actual data from Club Egara and request the invoices from the last two years via email.

This information will be useful for evaluating the effectiveness of the measures proposed by the CE3X program to improve the energy rating of the building and to identify possible discrepancies between the certification results and the reality of the building. In case there are significant differences between the estimated data and the actual data, it is important to analyze the possible causes of these differences and take the necessary measures to correct them.

8.3. ANALYSIS OF IMPROVEMENT PROPOSALS.

To conclude the certification, improvement proposals from CE3X will be analyzed. To choose the best one, they will be entered into the program and the economic, environmental, and energy viability will be considered. Finally, a budget will be prepared for the cost of the selected improvement proposal(s).

9. STUDY OF CLUB EGARA

Club Egara is a club located in Terrassa (Barcelona) at 5 Jacint Badiella Street, founded in 1935.

It is a social and sports club where its main sport is field hockey, being a clear reference both nationally and in Europe. Other sports practiced include tennis, paddle tennis, figure skating, indoor hockey, swimming, among others.

The club is bounded by Jacint Badiella Street and a small part by Can Carbonell Road, while the rest of the club is surrounded by fields, with no neighboring buildings.

Its total surface area is approximately 54,000 m².

Focusing on the energy certification, the club is divided into three buildings:

1. Social building. This building is divided into three floors, which will be specified later.

2. Activities building. This building is connected to the social building by a glass corridor. It is also divided into three floors, which will be explained later.

3. Old gymnasium building. This building is separate from the previous two and has only one floor. For the energy certification, we will not consider this building as it is very old, and we agreed with the tutor not to include it.

The total surface area of the two buildings we are focusing on is 5,961.33 m².

Figure 6. Satellite photograph showing the location of Club Egara.

9.1 RELATION OF SURFACES

As mentioned earlier, the Club is divided into two buildings, the social building and the activities building.

SOCIAL BUILDING.

This building is divided into three floors.

On the basement floor, we find several offices of the different technical directors of each sports section, the water treatment plant, and the lobby.

In this table provided by the club, we can see in more detail the surface area of this "basement" floor:

ZONA	SUPERFICIE ÚTIL (m^2)
Depuradora	30,57
Almacén	16,79
Lavadero	6,00
Calderas	17,80
Habitación Plancha	15,95
Aseo	3,86
Vestuario mujeres cocina	3,20
Archivo	9,50
Trastero	7,25
Comedor trabajadores	13,40
Vestuario mujeres limpieza	5,00
Despensa	21,00
Vestuario camareros	9,83
Aseo vestuario camareros	2,47
Ducha camareros	1,70
Cámara	12,35
Cuadro de mandos	14,80
Bajo escalera	4,10
Circulaciones	48,85
Secretaria Técnicas Tenis	23,60
Director Deportivo hockey senior	9,65
Director Escuela Hockey	9,80
Secretaria Hockey	45,00
Redacción El Drac	16,40
Sala	4,10
Vestíbulo	118,00
Escalera	32,45
Bajo escalera	17,72
TOTAL SUPERFICIE ÚTIL	521,14
TOTAL SUPERFICIE CONSTRUIDA PS	604,68

Table 1. Surface of the basement floor of Social Building

Next, we have the ground floor. On this floor, we find the living room, the restaurant, the bar, and the kitchen.

ZONA	SUPERFICIE ÚTIL (m^2)
Sala de estar	240,00
Bar	114,00
Restaurante	130,50
Cocina	61,04
Alacena	6,90
Cámara frigorífica	4,85
Zona fuera de uso	310,74
Aseos	23,04
Circulaciones	96,84
Bajo escalera	2,12
Escaleras	36,27
TOTAL SUPERFICIE ÚTIL	1026,30
TOTAL SUPERFICIE CONSTRUIDA PB	1104,00

Table 2. Surface of the ground floor of Social Building

Lastly, we have the first floor. It is a multipurpose room where various activities can take place.

PLANTA PRIMERA	
ZONA	SUPERFICIE ÚTIL (m^2)
Sala Social	188,20
Huecos Escalera	25,39
TOTAL SUPERFICIE ÚTIL	213,29
TOTAL SUPERFICIE CONSTRUIDA P1	249,60

Table 3. Surface of the first floor of Social Building

In summary, the social headquarters building is structured as follows:

RESUMEN		
ZONA	SUPERFICIE ÚTIL (m^2)	SUPERFICIE CONSTRUIDA (m^2)
Planta Sótano	521,14	604,68
Planta Baja	1026,30	1104,00
Planta Primera	243,29	249,60
TOTAL	1790,73	1958,28

Table 4. Total surface of Social Building

Here are the floor plans provided by Club Egara for this building.

- Basement floor plan and Ground floor plan:

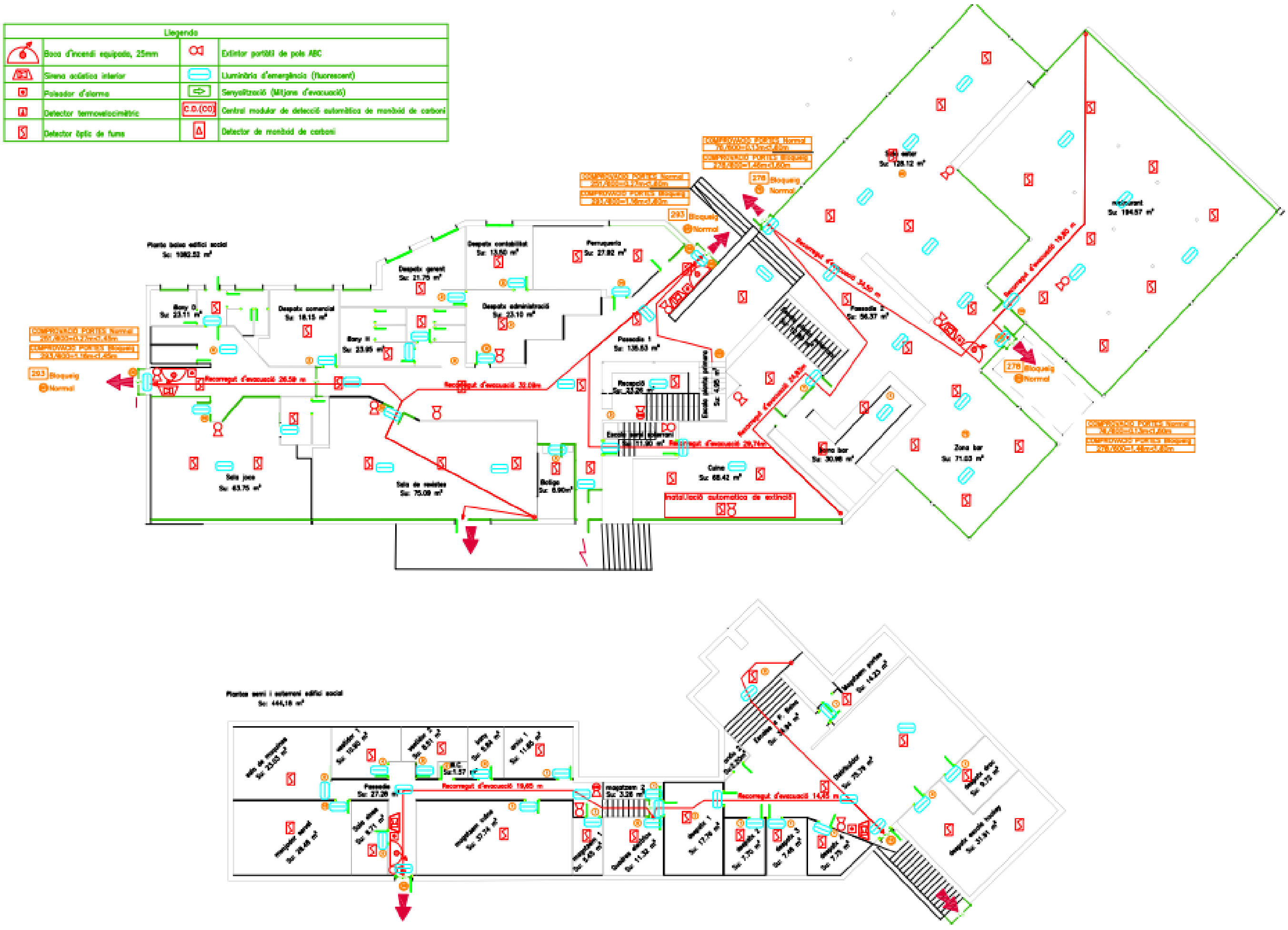


Figure 7. Basement floor plan and Ground floor plan Social Building

<u>-First-floor plan:</u>

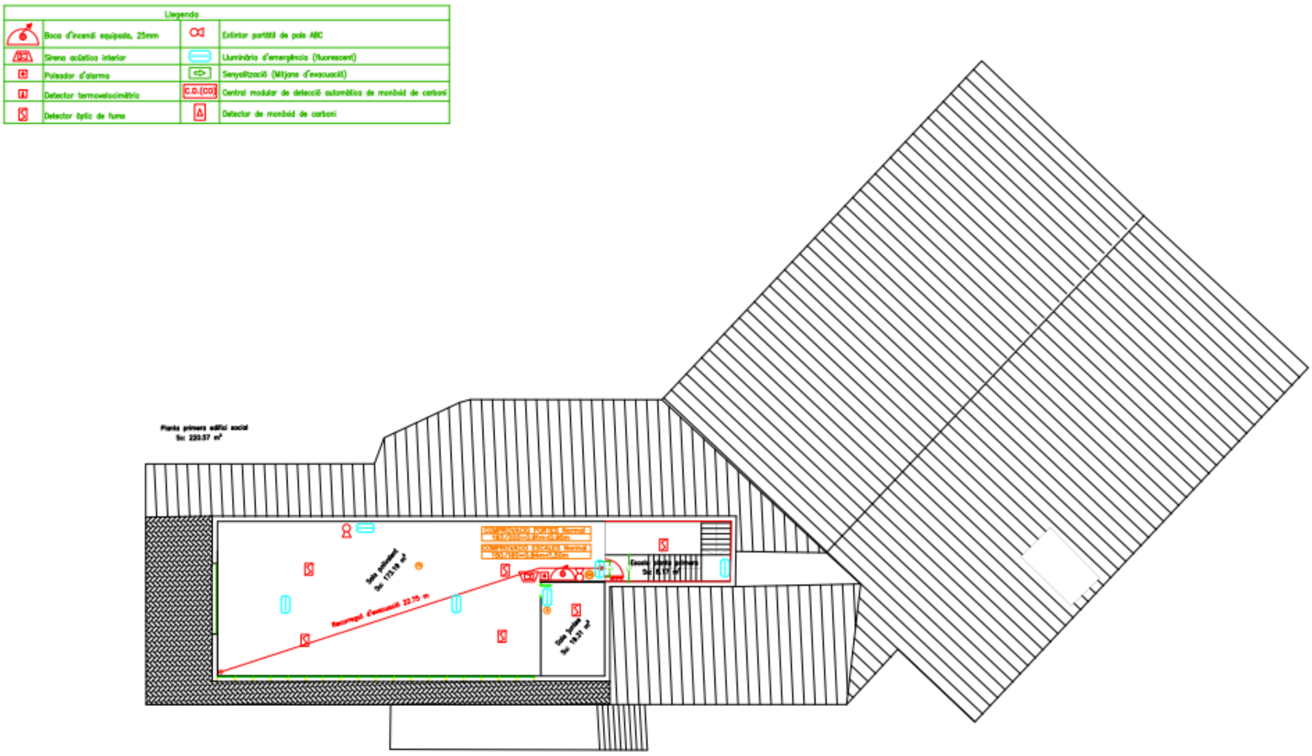


Figure 8. First-floor plan Social Building

ACTIVITIES BUILDING

It occupies the space between the landscaped area of the outdoor pool and the west side of the plot.

In it, we find the indoor sports court and spaces where various activities take place, including group classes, fitness rooms, and member changing rooms, the indoor pool, and the gym.

The indoor sports court is located on the west side, creating its own volume in proportion to its size. Due to height requirements of 7 meters, the court is situated in the basement, 4 meters below the current ground level. Adjacent to the court on its east side, the basement is completed with a room dedicated to centralizing the Club's facilities.

On the ground floor of this building, we find the aerobic rooms and the member changing rooms for both males and females.

On the first floor, we find the indoor pool, the REDI physiotherapy room (formerly a hair salon, hence the information provided by the club says "hairdresser"), and the gym.

We also have tables provided by the club where we can see a summary of the surface areas of the different floors.

PLANTA SEMISÓTANO	
ZONA	SUPERFICIE ÚTIL (m^2)
Pista polideportiva	973,73
Almacén 1	47,43
Almacén 2	65,90
Banquillos	21,00
Almacén productos piscina	18,46
Grupo electrógeno	19,78
Sala CGD	19,78
ET	16,94
Sala Calderas	55,06
Sala de Bombas	54,00
Sala Depuración Piscina	63,07
Grupo de presión protección contra incendios	38,92
Galería de instalaciones	54,20
Patio de instalaciones	9,69
Pasos	42,52
Escalera 1	24,23
Escalera 2	30,55
Escalera 3	19,42
Escalera 4	6,50
TOTAL SUPERFICIE ÚTIL	1581,18
TOTAL SUPERFICIE CONSTRUIDA PSS	1618,42

Table 5. Surface of the basement floor of Activities Building.

PLANTA BAJA	
ZONA	SUPERFICIE ÚTIL (m^2)
Graderío	216,50
Escalera 2	30,60
Aeróbic 1	89,72
Aeróbic 2	90,34
Aeróbic 3	159,22
Vestuario femenino	147,80
Vestuario masculino	172,36
Botiquín	6,66
Vestuario externos	19,12
Vestuario árbitro	17,30
Entrada	7,58
Oficinas	43,56
Tienda	16,46
Recepción	15,38
Oficinas	17,54
Vestíbulo	57,51
Pasillos	49,75
TOTAL SUPERFICIE ÚTIL	1157,40
TOTAL SUPERFICIE CONSTRUIDA PB	1284,63

Table 6. Surface of ground floor of Activities Building.

PLANTA PRIMERA	
ZONA	SUPERFICIE ÚTIL (m^2)
Sala de espera	18,27
Peluquería	14,21
Spa	92,41
Área piscina	489,15
Almacén piscina	8,99
Baños de vapor	19,52
Jacuzzi	17,55
Relax	28,23
Fitnes	367,07
TOTAL SUPERFICIE ÚTIL	1055,40
TOTAL SUPERFICIE CONSTRUIDA P1	1055,40

Table 7. Surface of first floor of Activities Building.

Summarizing:

RESUMEN		
ZONA	SUPERFICIE ÚTIL (m^2)	SUPERFICIE CONSTRUIDA (m^2)
Planta Sótano	1581,18	1618,42
Planta Baja	1157,40	1284,63
Planta Entresuelo	39,01	44,60
Planta Primera	1055,40	1055,40
TOTAL	3832,99	4003,05

Table 8. Total surface of Activities Building.

<u>-Basement floor plan</u>

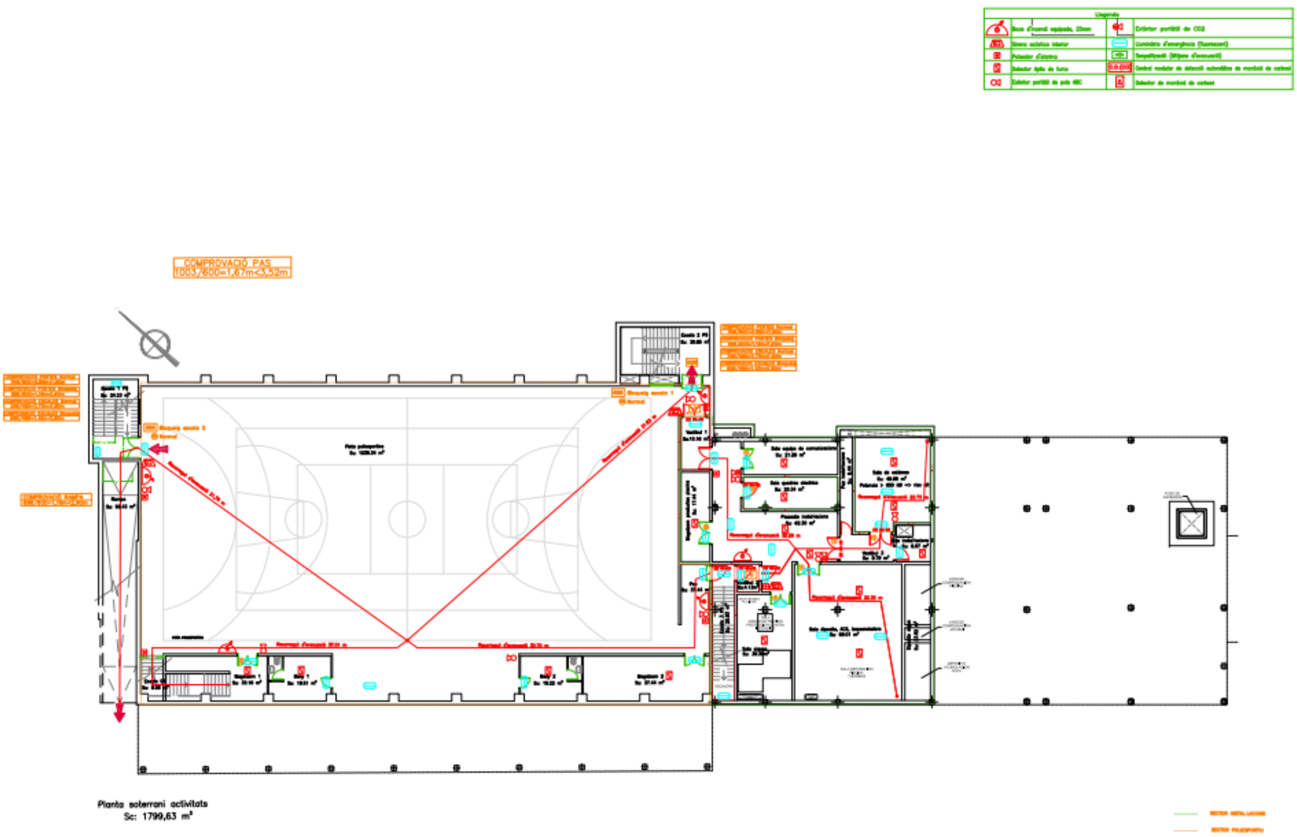


Figure 9. Basement floor plan Activities Building

-Ground floor plan

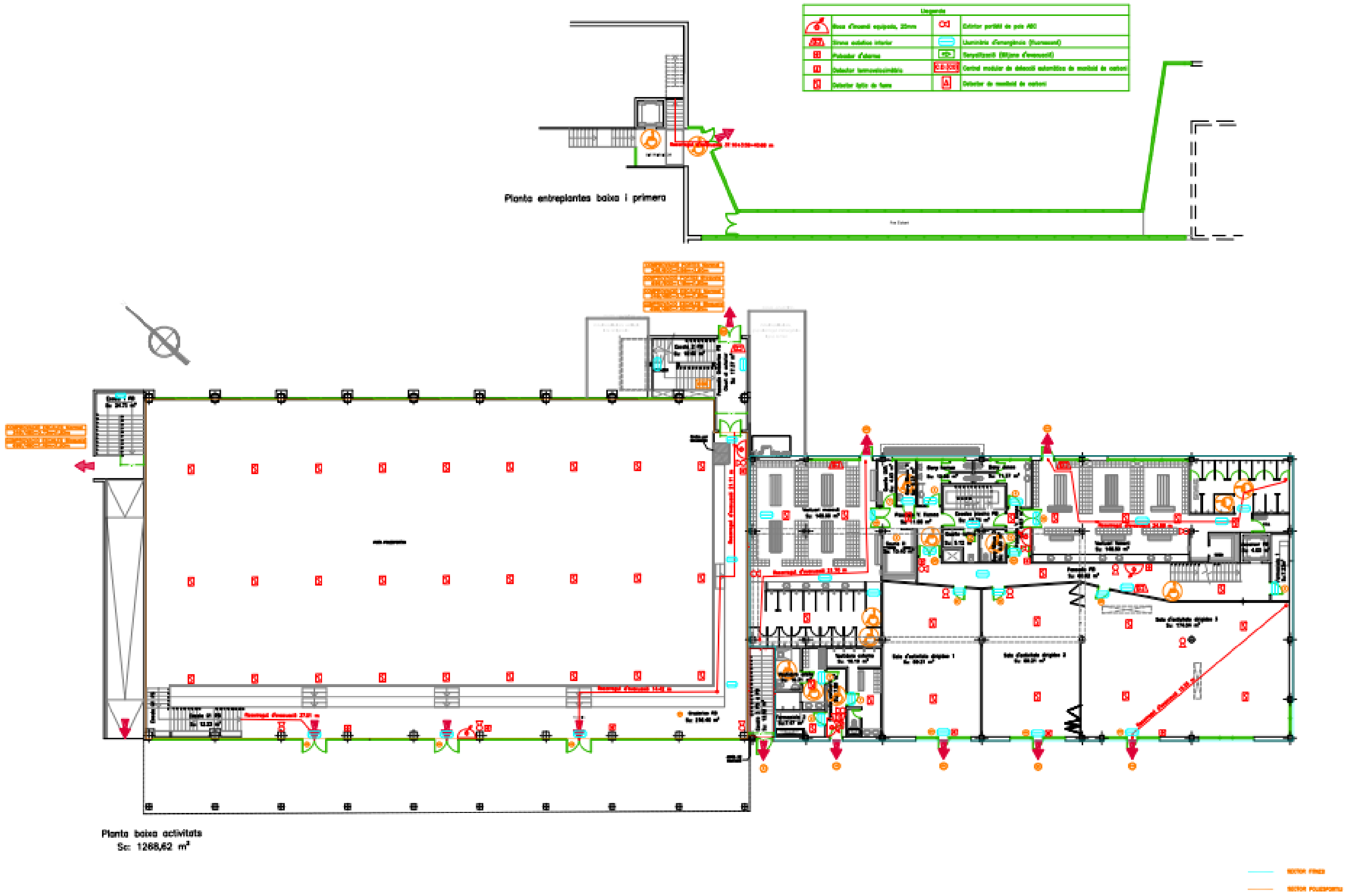


Figure 10. Ground floor plan Activities Building

-First floor plan

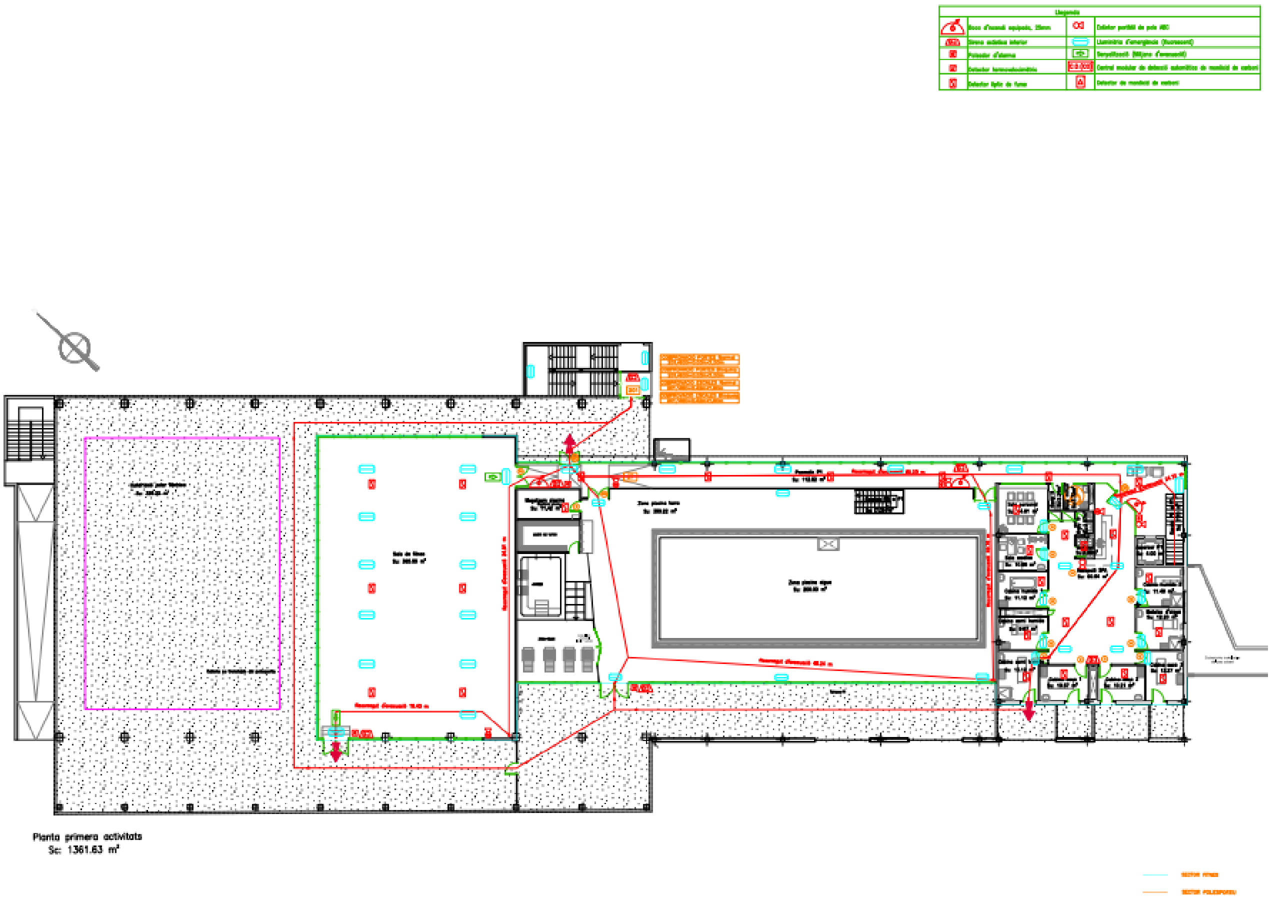


Figure 11. First-floor plan Activities Building

10. BASIC CERTIFICATION

10.1 APPLIED METHODOLOGY

As it is a simplified certification, the default properties provided by the CE3X software will be used.

10.2 DATA ENTRY

10.2.1 ADMINISTRATIVE DATA

As mentioned earlier, this is the first step in carrying out the project.

When starting the CE3X program, it is required to select the type of building to be studied: residential, small tertiary, or large tertiary. In the case of residential buildings, unlike tertiary ones, lighting equipment is not included.

In general, the characteristics that differentiate residential buildings, small tertiary buildings, and large tertiary buildings include their main use and size. There are also differences in their structure, design, and services offered to their users.

Considering that Club Egara is a large-sized building, the option of a large tertiary building will be chosen in the CE3X program for the energy study.

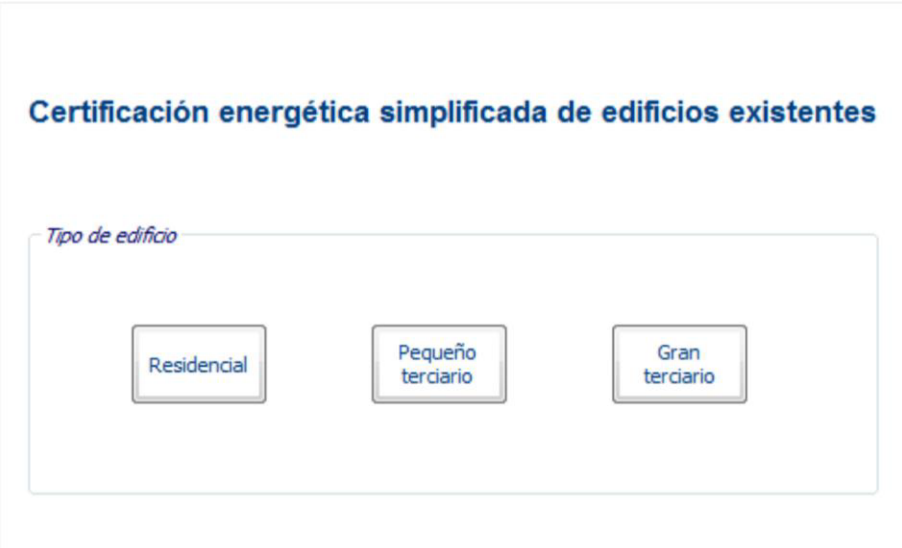


Figure 12. Building typology selection

The administrative data to be provided to the program is as follows:

-Location and identification of the building: It is necessary to provide information about the building's location, as well as its cadastral identification and the characteristics of the building, such as the construction date, number of floors, built area, among others.

-Client data: It is necessary to provide the data of the building owner(s), such as name, address, tax identification number (NIF) or company tax identification number (CIF), among others.

Certifier data, in this case, my personal data (33).

Figure 13. Cadastral reference: Club Egara. (33)

10.2.2 GENERAL DATA

Next, we proceed to enter general data about the building, which will already be significant for the final results of the certification.

The activities building and the renovation of the headquarters building took place in 2005, so the applicable regulations at that time were the NBE-CT-79.

The club has approximately 2800 members. Taking into account that there is a significant decrease in attendance during the month of August due to summer vacations, we consider that the club operates intensively for approximately 320 days per year, around 8 hours per day. This amounts to a total of 2560 hours per year. According to the program's guide, this corresponds to a high-intensity usage profile.

The usable floor area is 5961 m^2,the clear height between floors is 3m, and the number of habitable floors is 6 (3 for the headquarters building and 3 for the activities building).

Simultaneously, the program also requests information about the total daily consumption of domestic hot water (ACS) in liters per day. The club has provided the information, and the value for ACS is 10000 liters per day.

Finally, the interior partitions are relatively lightweight.

It is important to note that this is an estimation, and the actual consumption may vary depending on various factors such as water temperature, appliance usage, pipe insulation, among others.

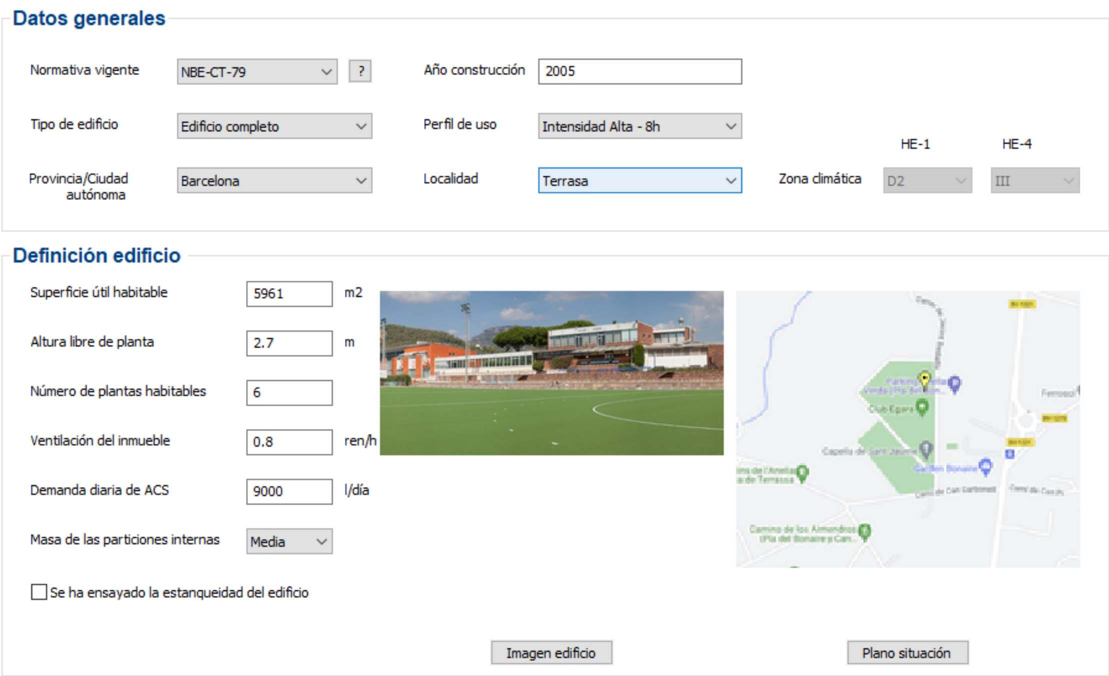


Figure 14. General data

10.3 BUILDING THERMAL ENVELOPE

In this section, the data related to the thermal envelope of the building is introduced. In this certification, only the dimensions and orientation of the different parts of the thermal envelope will be taken into account, while all other values, such as thermal transmittance among others, will be defaulted by the program itself. All the necessary information to carry out this section will be extracted from both the building's construction project and various plans of it.

10.3.1. ROOFS

Firstly, we will focus on the roofs of the building. These horizontal layers serve to separate the interior of the building from the external environment and their main function is to protect the residence from natural elements (16).

As mentioned earlier, the program offers us two options for roofs, those that are in contact with the atmosphere and those that are in contact with the ground.

Next, with the help of the plans provided by the club, the roofs of the social building and the activities building are shown.

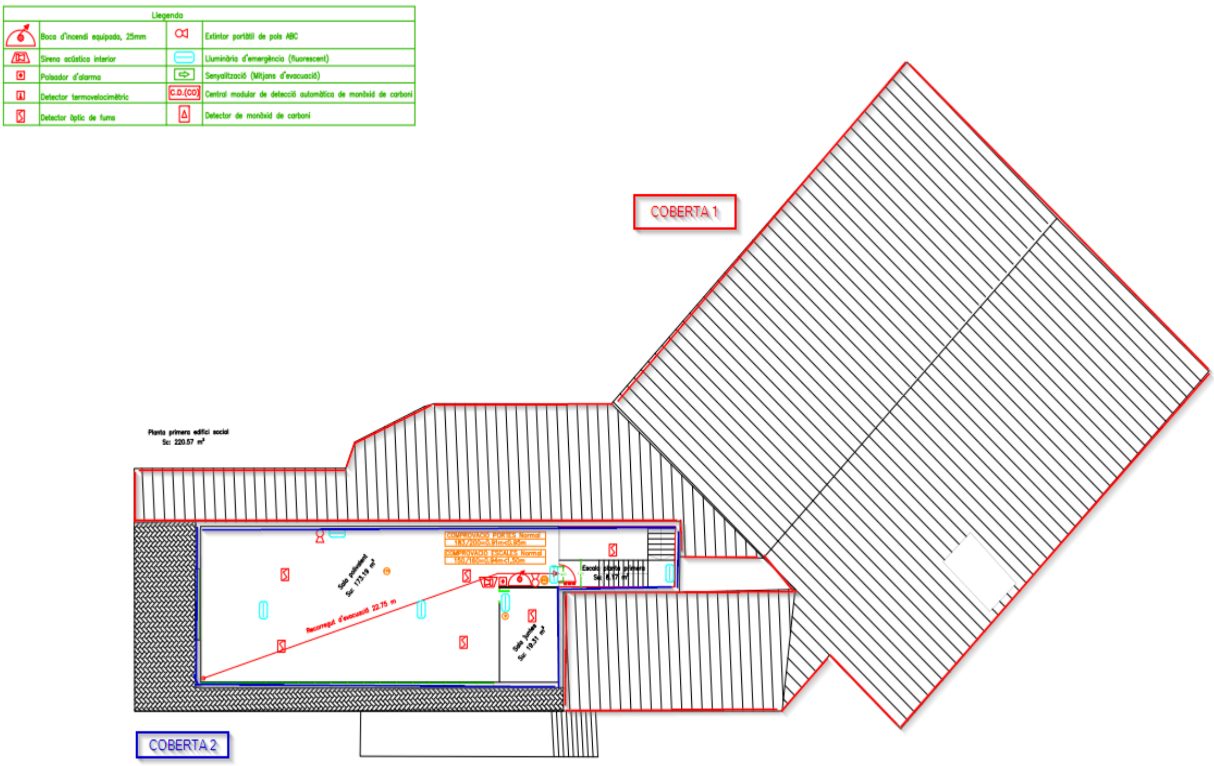


Figure 15. Roofs of Social Building

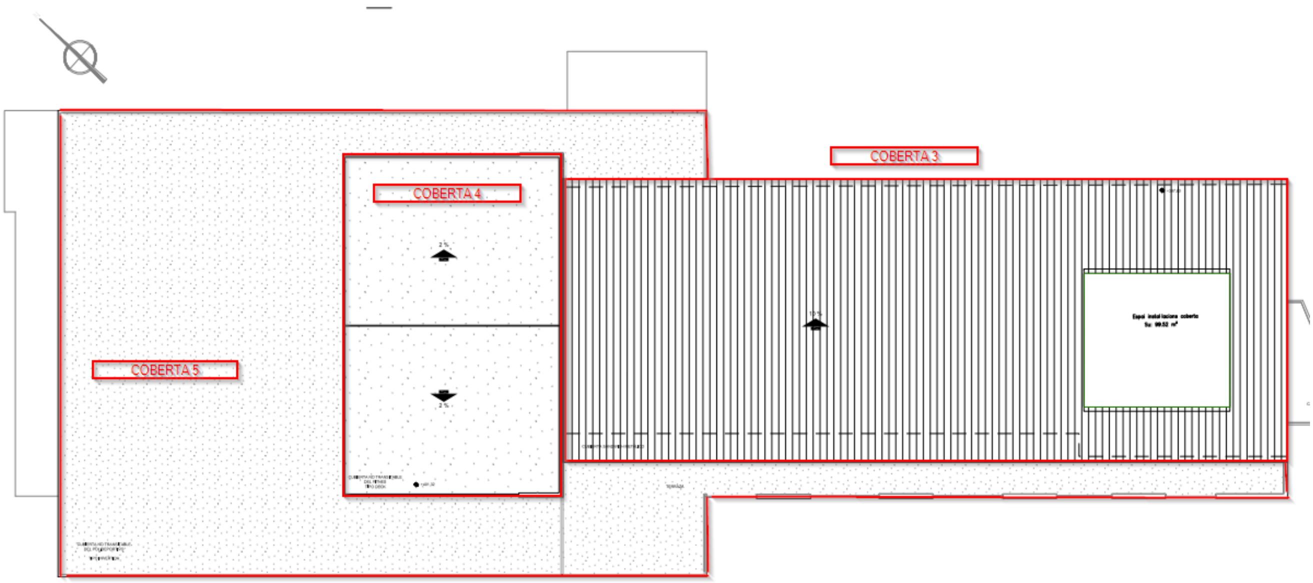


Figure 16. Roofs of Activities Building

All of them are in contact with the air.

Name	Type	Surface	Thermal properties
Roof 1	sloping	1033,79 m^2	by default
Roof 2	sloping	264,91 m^2	by default
Roof 3	sloping	1139,66 m^2	by default
Roof 4	sloping	415,51 m^2	by default
Roof 5	flat	1529,15 m^2	by default

Table 9. Roofs frome Club Egara

10.3.2. WALLS

There are three types of walls. Depending on whether they are in contact with the ground, a façade wall, or another building. Egara is not in contact with any external building (17).

In this section, I have the issue that for the Social building, I don't have the building elevation, so all the data related to this building is estimated by the author of the study. It was discussed with the tutor, and this agreement was reached.

Having said that, we begin with the activities building.

<u>ACTIVITIES BUILDING</u>

To know the dimensions and characteristics of this building, we will use the plans provided by the club.

We have the following views:

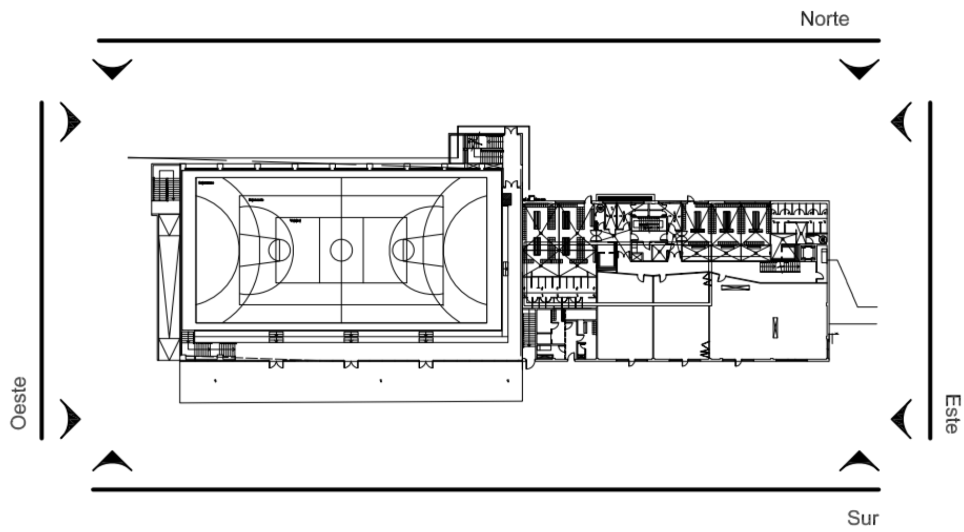


Figure 17. General views of Activities Building

Elevation view from the west:

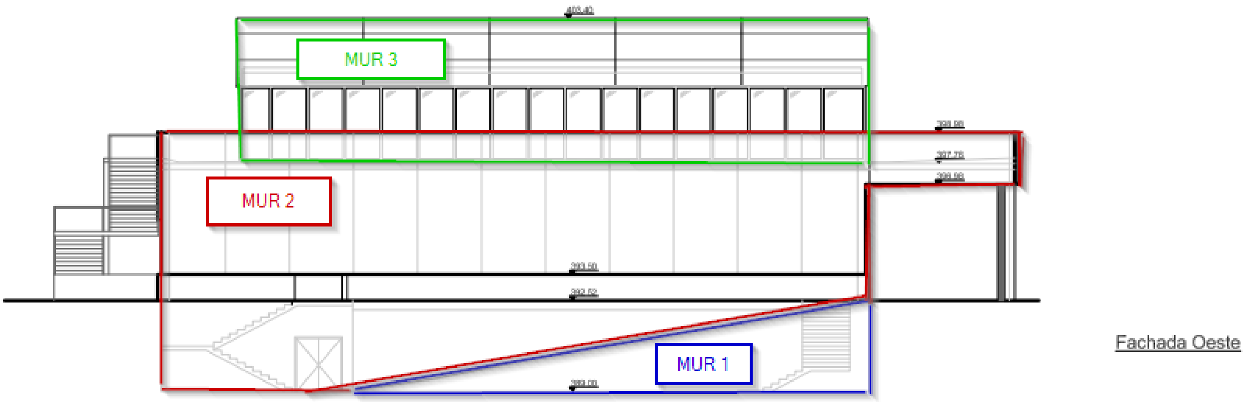


Figure 18. Elevation view from the west

Name	Type	Surface	Orientation
Wall 1 EA O	Wall in contact with the ground	34,65 m^2	
Wall 2 EA O	Facade wall	251,21 m^2	NO
Wall 3 EA O	Facade wall	134,90 m^2	NO

Table 10. Walls from west

Elevation view from the North:

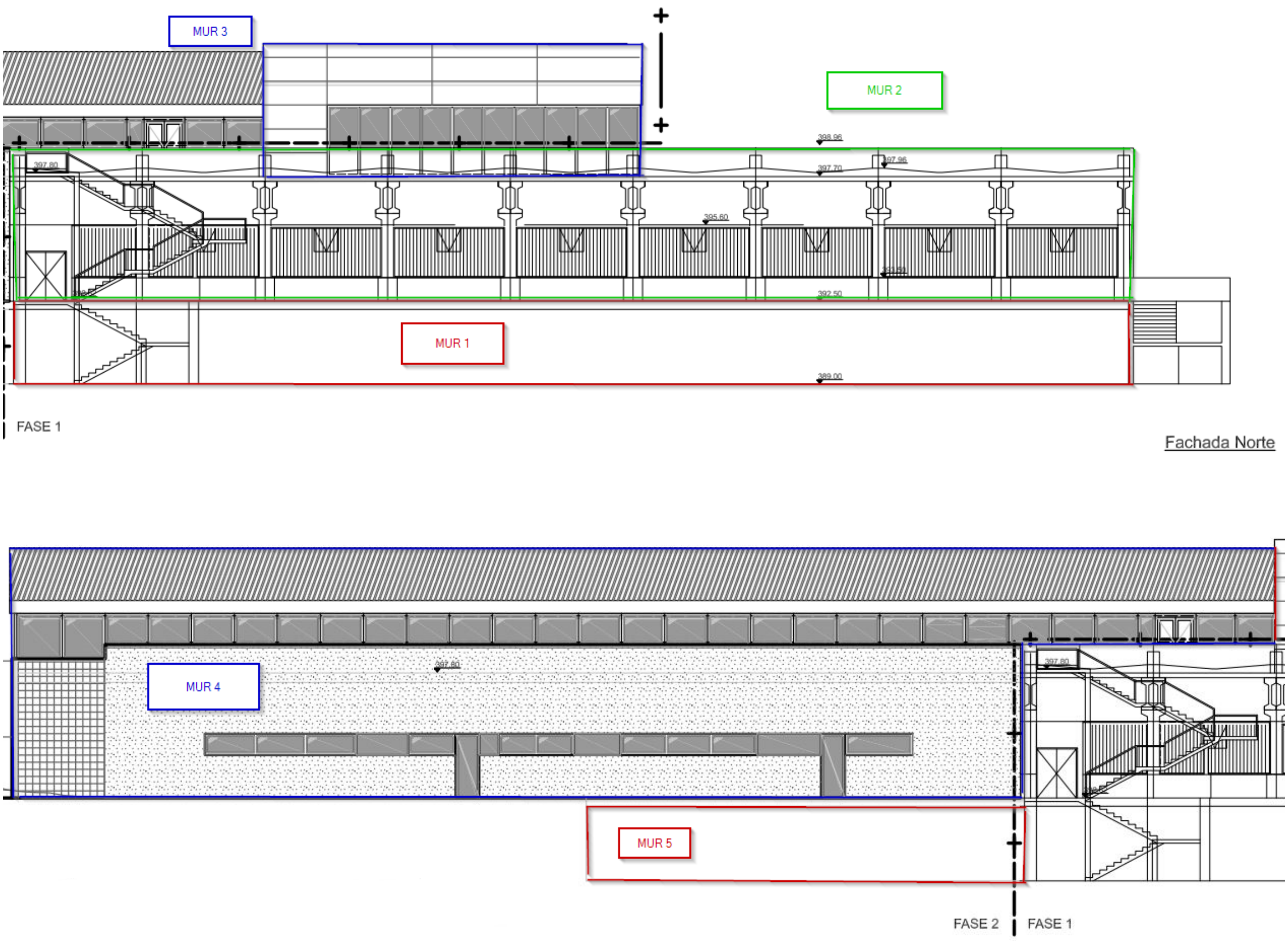


Figure 19. Elevation view from the north

Name	Type	Surface	Orientation
Wall 1 EA N	Wall in contact with the ground	170,67 m^2	
Wall 2 EA N	Facade wall	487,60 m^2	NE
Wall 3 EA N	Facade wall	91,54 m^2	NE
Wall 4 EA N	Facade wall	453,33 m^2	NE
Wall 5 EA N	Wall in contact with the ground	66,43 m^2	

Table 11. Walls from north

Elevation view from the South:

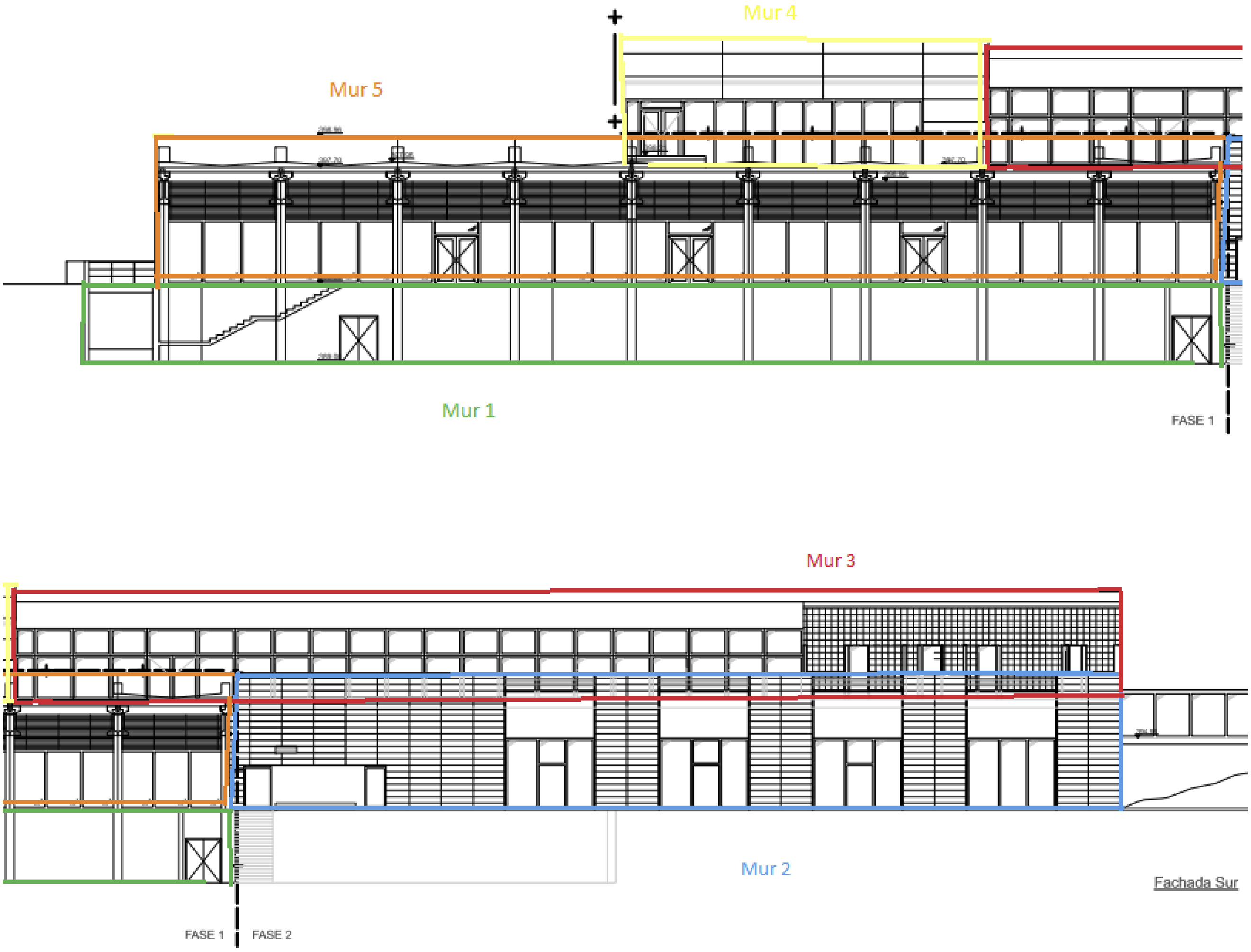


Figure 20. Elevation view from the south

Name	Type	Surface	Orientation
Wall 1 EA S	Wall in contact with the ground	170,67 m^2	
Wall 2 EA S	Facade wall	266,02 m^2	SO
Wall 3 EA S	Facade wall	250,78 m^2	SO
Wall 4 EA S	Facade wall	91,54 m^2	SO

Table 12. Walls from south

Elevation view from the East:

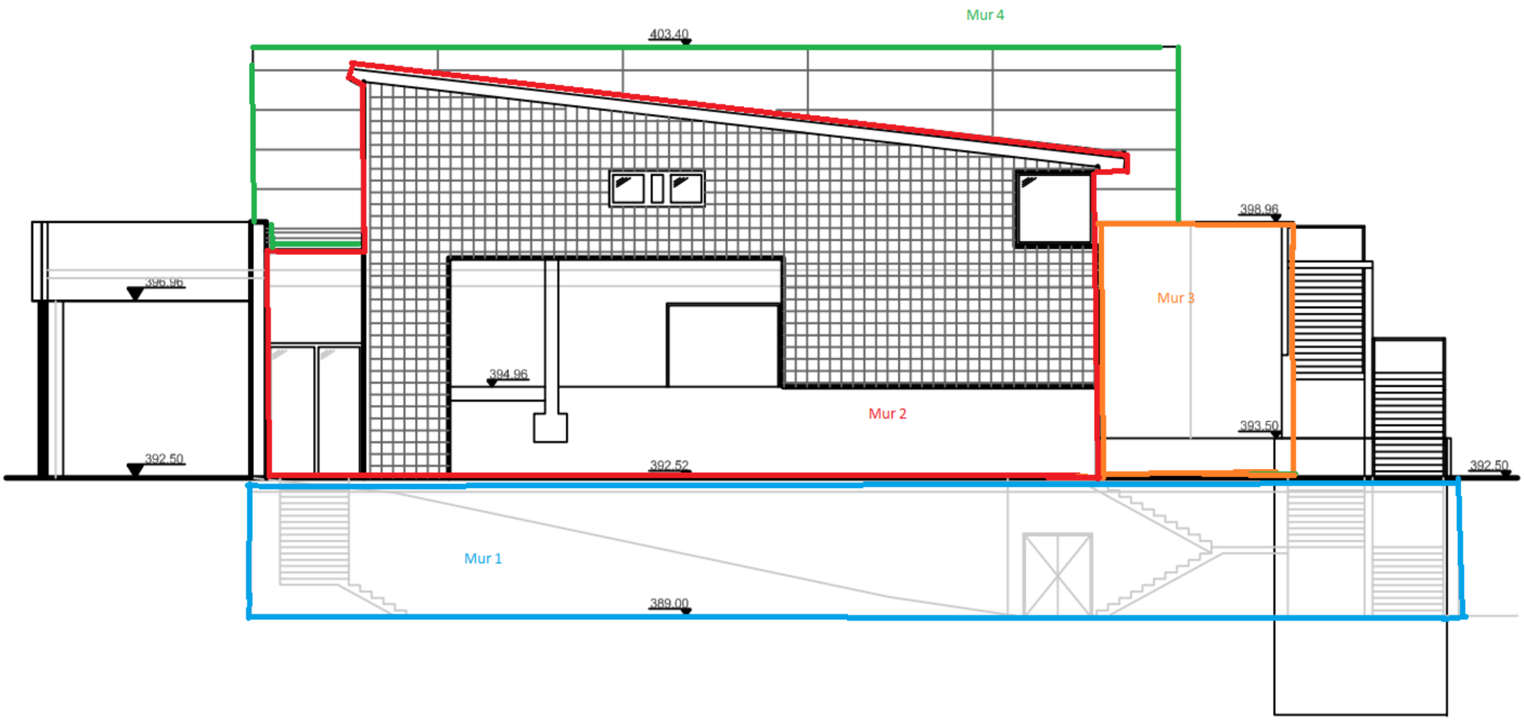


Figure 21. Elevation view from the east

Name	Type	Surface	Orientation
Wall 1 EA E	Wall in contact with the ground	105,04 m^2	
Wall 2 EA E	Facade wall	92,24 m^2	SE
Wall 3 EA E	Facade wall	23,89 m^2	SE
Wall 4 EA E	Facade wall	63,64 m^2	SE

Table 13. Walls from east

SOCIAL BUILDING

This building is the oldest building in the Club, and the Club does not have any information about its elevation. Therefore, it has been agreed with the tutor to make an estimation of the dimensions of its walls.

The Club has been visited, and photographs have been taken and distances have been measured to make the estimations as realistic as possible.

Wall 1 ES

Figure 22. Wall 1 Social Building

Wall 2 ES

Figure 23. Wall 2 Social Building

Wall 3 ES

Figure 24. Wall 3 Social Building

Wall 4 ES

Figure 25. Wall 4 Social Building

Wall 5 ES

Figure 26. Wall 5 Social Building

Wall 6 ES

Figure 27. Wall 6 Social Building

Wall 7 ES

Figure 28. Wall 7 Social Building

Wall 8 ES

Figure 29. Wall 8 Social Building

Wall 9 ES

Figure 30. Wall 9 Social Building

Wall 10 ES

Figure 31. Wall 10 Social Building

Wall 11 ES

Figure 32. Wall 11 Social Building

Wall 12 EA

Figure 33. Wall 12 Social Building

Wall 13 ES

Figure 34. Wall 13 Social Building

Wall 14 ES

Figure 35. Wall 14 Social Building

Wall 15 ES

Figure 36. Wall 15 Social Building

Name	Type	Surface	Orientation
Wall 1 ES	Facade wall	68,05 m^2	E
Wall 2 ES	Facade wall	16,32 m^2	N
Wall 3 ES	Facade wall	80,05 m^2	N
Wall 4 ES	Facade wall	62,50 m^2	NO
Wall 5 ES	Facade wall	67,40 m^2	S

Wall 6 ES	Facade wall	24,00 m^2	E
Wall 7 ES	Facade wall	33,10 m^2	S
Wall 8 ES	Facade wall	27,65 m^2	O
Wall 9 ES	Facade wall	43,17 m^2	SO
Wall 10 ES	Facade wall	76,35 m^2	SO
Wall 11 ES	Facade wall	74,63 m^2	SO
Wall 12 ES	Facade wall	73,28 m^2	NE
Wall 13 ES	Facade wall	24,00 m^2	NO
Wall 14 ES	Facade wall	16,27 m^2	SE
Wall 15 ES	Facade wall	14,11 m^2	SO

Table 14. Walls from Social Building

The walls in contact with the ground of this building are not taken into account due to the lack of information.

10.3.3. FLOOR

In the CE3X program, it is important to consider whether the floor is in contact with the ground or with the air for the energy certification of the building (18). This is because the heat that the floor absorbs or releases varies depending on whether it is in contact with the ground or with the air.

The CE3X program takes this information into account to calculate the amount of energy needed to maintain the appropriate temperature inside the building. If the floor is in contact with the ground, the CE3X program recommends measures to reduce the heat transfer between the floor and the ground, such as the use of insulation materials. If the floor is in contact with the air, the CE3X program recommends measures to reduce the heat loss or gain through the floor, such as the use of thermal insulation(18).

In our case, we have two floors in contact with the air, one in each building.

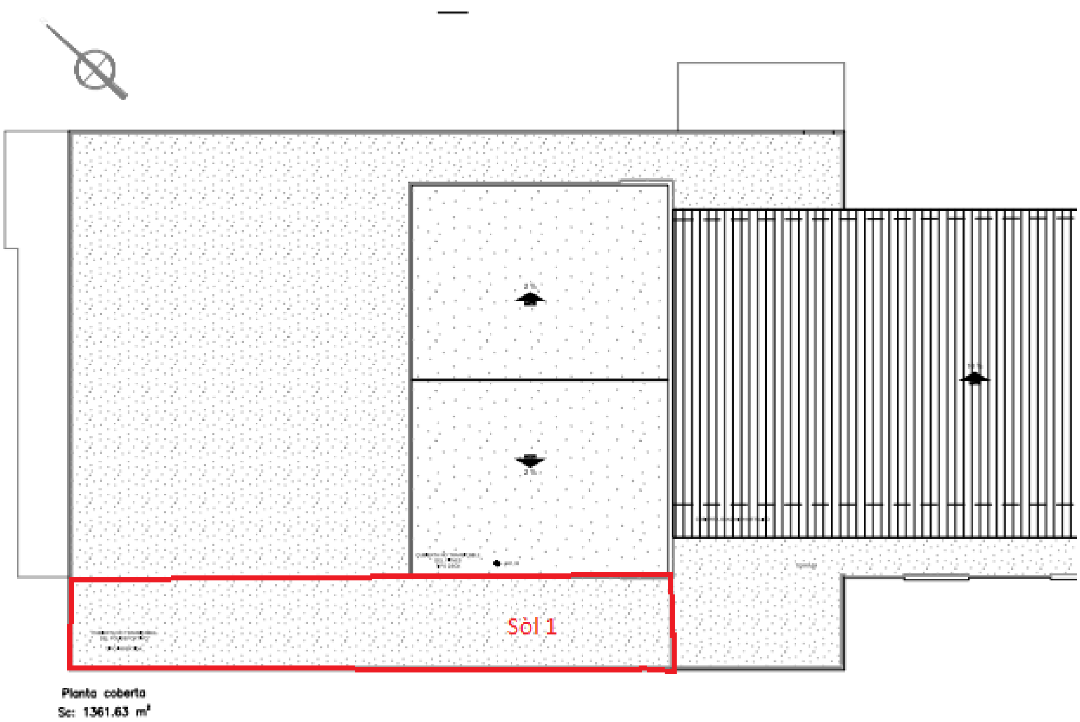


Figure 37. Floor 1 Activities Building

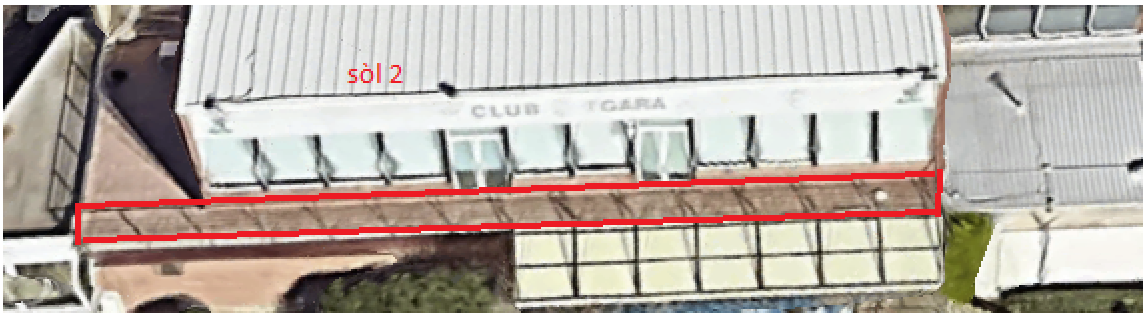


Figure 38. Floor 2 Social Building

Name	Type	Surface
Floor 1	Floor in contact with air	210,15 m^2
Floor 2	Floor in contact with air	40,20 m^2
Floor 3	Floor in contact with the ground	3102,32 m^2

Table 15. Floors in contact with air

10.3.4. INTERIOR PARTITIONS

In the case of our building, there are no interior partitions in contact with a non-habitable space (18).

10.3.5. VOIDS AND SKYLIGHTS

Openings and windows in a construction are architectural elements that facilitate the entry of natural light and the ventilation of fresh air (19).

Windows are openings located in the exterior or interior walls that promote air circulation, allow the entry of natural light, and in some cases, offer a view to the outside.

Skylights, on the other hand, are windows located in the ceiling of the building that allow natural light to penetrate into the interior spaces. Skylights can be fixed or operable and can be designed to allow direct entry of sunlight or to diffuse light through translucent materials.

In our buildings, most windows and doors are equipped with double-layer laminated insulated glass, which is transparent and 3 to 6 mm wide, with a 10 mm air gap. This glass is installed with a glass profile resting on a wooden, steel, or aluminum structure. The frame used has a thermal break and can be made of wood. This type of glass offers good thermal and acoustic insulation, as well as high thermal resistance.

Due to the large number of doors and windows in the club, the facades will be studied separately. Combined windows will be grouped together.

ACTIVITIES BUILDING

Associated closure	Type	Surface	Units	Glass	Frame
Wall 2 EA O	Door 1	3,32 m^2	1	Metallic	Metallic with RPT
Wall 3 EA O	Window 1	4,33 m^2	17	Double laminated	Metallic with RPT
Wall 2 EA N	Door 2	3,32 m^2	1	Metallic	Metallic with RPT
Wall 3 EA N	Window 2	4,33 m^2	10	Double laminated	Metallic with RPT
Wall 4 EA N	Window 3	1,90 m^2	26	Double laminated	Metallic with RPT
	Door 3	3,20 m^2	1	Double laminated	Metallic with RPT
	Window 4	22,32 m^2	1	Double laminated	Metallic with RPT

	Window 5	3,50 m^2	2	Double laminated	Metallic with RPT
Wall 1 EA S	Door 4	3,32 m^2	1	Metallic	Metallic with RPT
	Door 5	3,32 m^2	1	Metallic	Metallic with RPT
Wall 2 EA S	Window 6	4,82 m^2	9	Double laminated	Metallic with RPT
	Window 7	1,36 m^2	3	Double laminated	Metallic with RPT
	Door 6	2,41 m^2	3	Double laminated	Metallic with RPT
Wall 3 EA S	Window 8	4,82 m^2	21	Double laminated	Metallic with RPT
Wall 4 EA S	Door 7	5,22 m^2	1	Double laminated	Metallic with RPT
Wall 5 EA S	Window 9	3,18 m^2	9	Double laminated	Metallic with RPT
Wall 2 EA E	Door 8	5,25 m^2	1	Double laminated	Metallic with RPT
	Window 10	3,33 m^2	1	Double laminated	Metallic with RPT
	Window 11	1,82 m^2	1	Double laminated	Metallic with RPT

Table 16. Voids and skylights of Activities Building

SOCIAL BUILDING

The dimensions of the windows and doors, as well as the type of glass in this building, are approximations due to the lack of information provided by the club regarding its oldest part.

Associated closure	Type	Surface	Units	Glass	Frame
Wall 1 ES	Window 12	25,03 m^2	1	Double laminated	Wood
Wall 2 ES	Window 13	16,32 m^2	1	Double laminated	Wood
Wall 3 ES	Window 14	76,21 m^2	1	Double laminated	Wood
	Door 9	3,65 m^2	1	Double laminated	Wood
Wall 4 ES	Window 15	3,20 m^2	4	Double laminated	Wood
	Window 16	5,35 m^2	1	Double laminated	Wood
Wall 5 ES	Window 17	67,40 m^2	1	Double laminated	Wood
Wall 6 ES	Window 18	24,00 m^2	1	Double laminated	Wood
Wall 7 ES	Door 10	2,50 m^2	1	Double laminated	Wood
	Window 19	1,75 m^2	1	Double laminated	Wood
Wall 8 ES	Window 20	4,25 m^2	4	Double laminated	Wood
Wall 10 ES	Window 21	2,10 m^2	12	Double laminated	Wood
	Door 11	2,50 m^2	1	Double laminated	Wood
Wall 11 ES	Window 22	4,80 m^2	10	Double laminated	Wood
	Door 12	5,15 m^2	2	Double laminated	Wood
Wall 12 ES	Window 23	3,50 m^2	4	Double	Wood

				laminated	
	Window 24	1,20 m^2	8	Double laminated	Wood
Wall 13 ES	Window 25	4,80 m^2	4	Double laminated	Wood
Wall 14 ES	Window 26	0,87 m^2	2	Double laminated	Wood
Wall 15 ES	Window 27	3,50 m^2	4	Double laminated	Wood

Table 17. Voids and skylights of Social Building

It is also important to identify the solar devices available in some of the glazed areas to protect them from direct sunlight. Wall 3 ES is protected by a porch to prevent direct sunlight from hitting the glass. The same applies to Wall 5 EA S, which has an awning that shields it from the impact of the sun.

Although the program does not provide the option to enter exposed concrete porches, they have been included as awnings.

ES	Social Building
EA	Activities Building
N	North
S	South
E	East
O	West
NE	North-East
NO	North-West
SE	South-East
SO	South-West

Table 18. Legend of all the abbreviations used in all tables

10.3.6. THERMAL BRIDGES

The thermal bridges of the building will be considered by default in the CE3X program, as we don't have the necessary information in the construction project. In the following image, we can see the different types of thermal bridges.

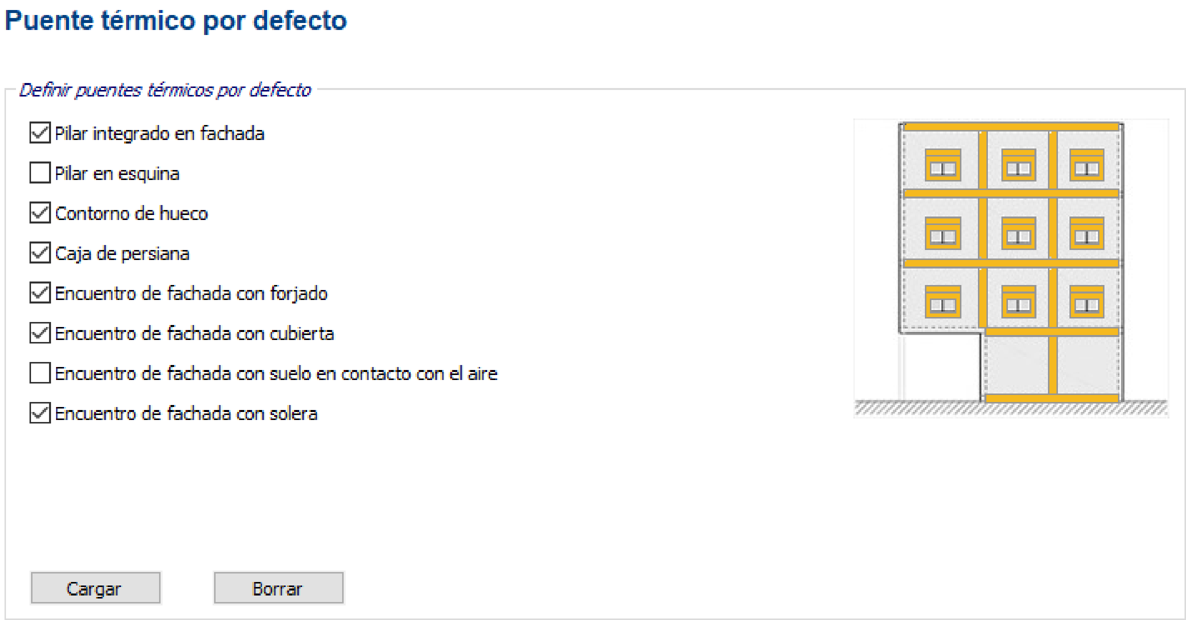


Figure 39. Thermical Bridges data

10.3.7. SHADOW PATTERNS

Shadow patterns are used to analyze the shadows cast on a building. These patterns are influenced by various factors and can have an impact on the energy performance of the building (20). Shadows are typically caused by neighboring buildings or elements within the building itself.

To create a shadow pattern, the CE3X program offers two different options. The first option involves calculating the azimuth and elevation for each facade. The second option is a simplified approach that involves defining rectangular obstacles. In this case, we will use the second option as we do not have sufficient data or tools to accurately calculate the azimuths.

For the second option, we will need the following data:

- Distance between buildings.

- Distance from the left and right sides of the building.

- Elevation.

- Orientation of the building.

Club Egara is not surrounded by any buildings as it is located in an open space. There are no structures that can cast shadows on it.

However, there are natural elements such as trees that cast shadows on certain facades of the club's social building. We will treat these trees as rectangular buildings that create shadows on our wall.

This wall is referred to as Wall 5 SE and it is shaded by three 8-meter tall pine trees.

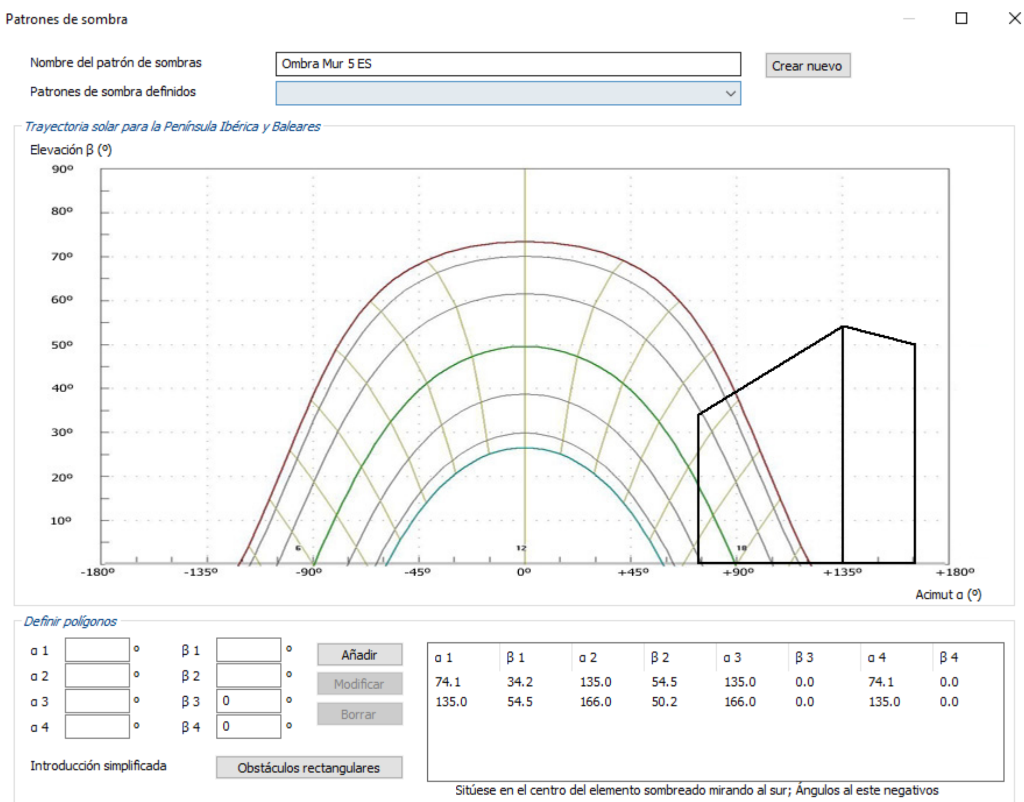


Figure 40. Shadow Patterns ce3x software

10.4 INSTALLATIONS

The final important aspect to consider before completing the basic energy certification is the building's installations. The program requires defining the following installations of the building:

- Domestic hot water equipment
- Heating-only equipment
- Cooling-only equipment
- Heating and cooling equipment
- Heating and domestic hot water equipment
- Heating, cooling, and domestic hot water equipment
- Energy contributions
- Lighting equipment
- Primary air equipment
- Fans
- Pumping equipment
- Cooling towers

Based on these options, the following installations have been found in our Club:

- Cooling-only equipment.
- Heating and domestic hot water equipment.
- Lighting equipment.

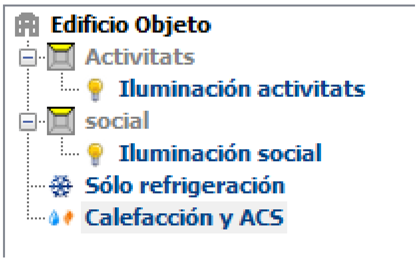


Figure 41.Defining the installation of Club Egara

<u>Cooling-only equipment.</u>

The Club has an HPAT/LN-1104 chiller with a nominal power of 271.4 kW, which provides cooling for the entire Club.

Figure 42. Cooling equipment

Figure 43. Cooling equipment 2

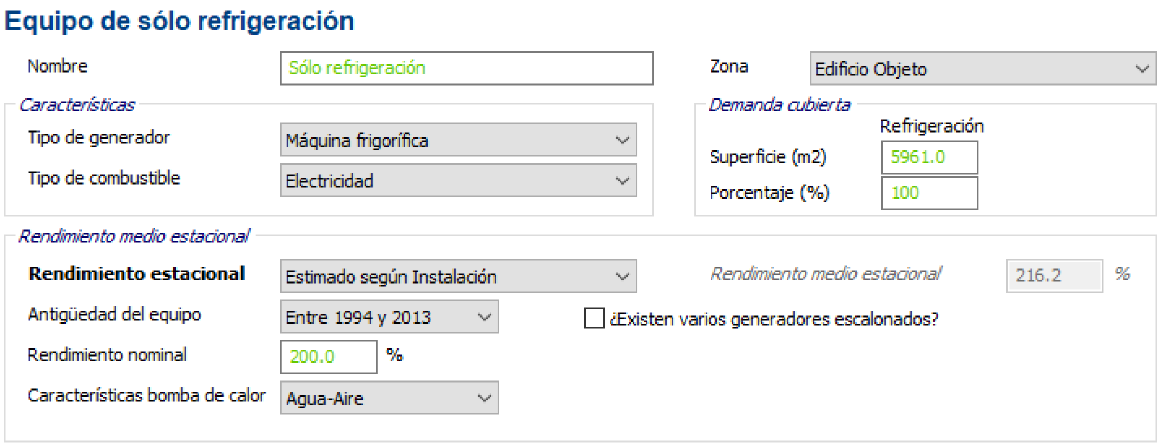


Figure 44.Defining Cooling-only equipment

<u>Heating and domestic hot water equipment.</u>

We have two natural gas boilers that operate simultaneously and serve both for heating the entire building and producing domestic hot water (ACS).

Figure 45. Natural Gas boiler 1

Figure 46. Natural Gas boiler 2

The total nominal power of both boilers is 606 kW.

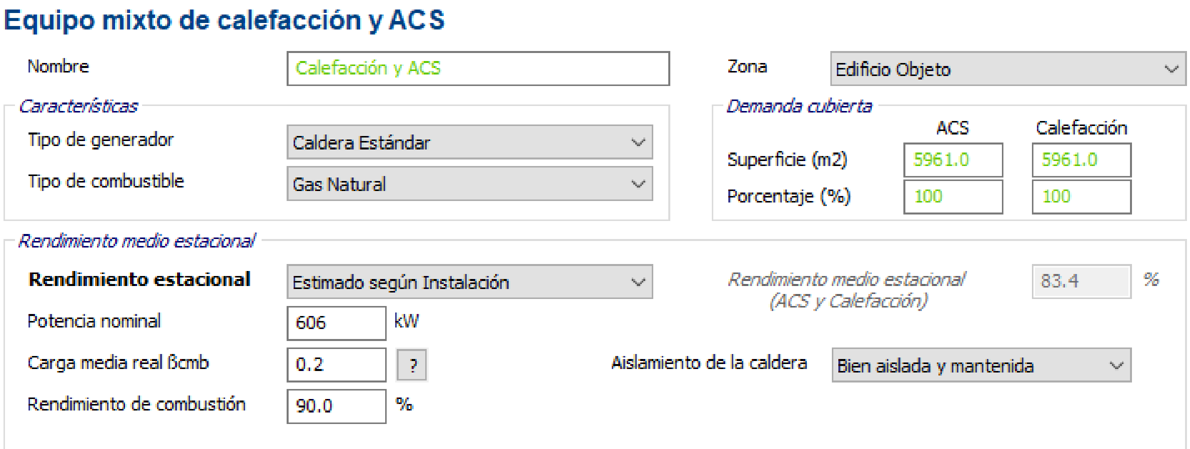


Figure 47. Defining Heating and domestic hot water equipment

<u>Lighting equipment.</u>

At the club, 200 kW are contracted to meet all the lighting needs. It is important to note that a large part of the lighting consumption at the club is dedicated to the hockey fields, paddle courts, and tennis courts, so we will subtract them from the total as they do not affect the certification of the building.

The emergency lighting is also not taken into account.

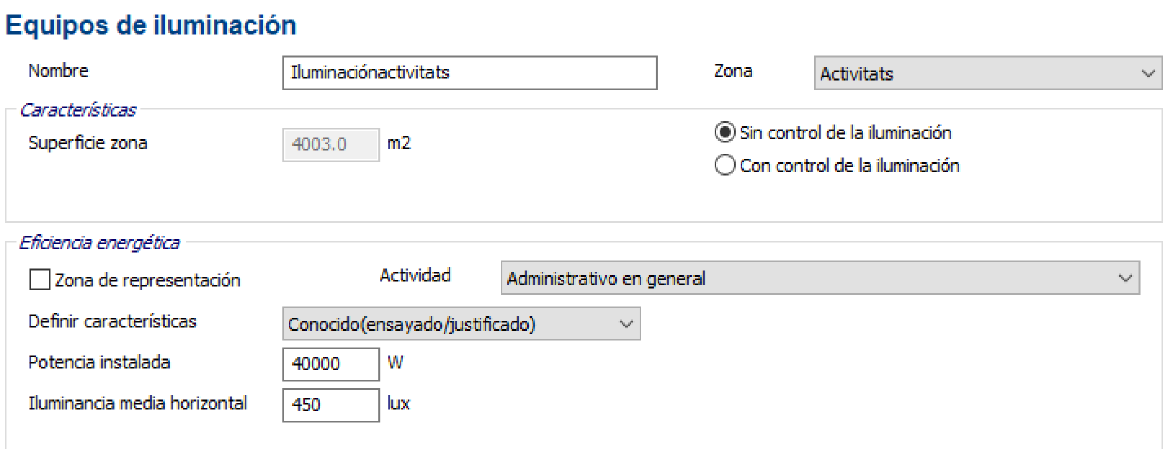


Figure 48. Defining lighting equipment Activities Building

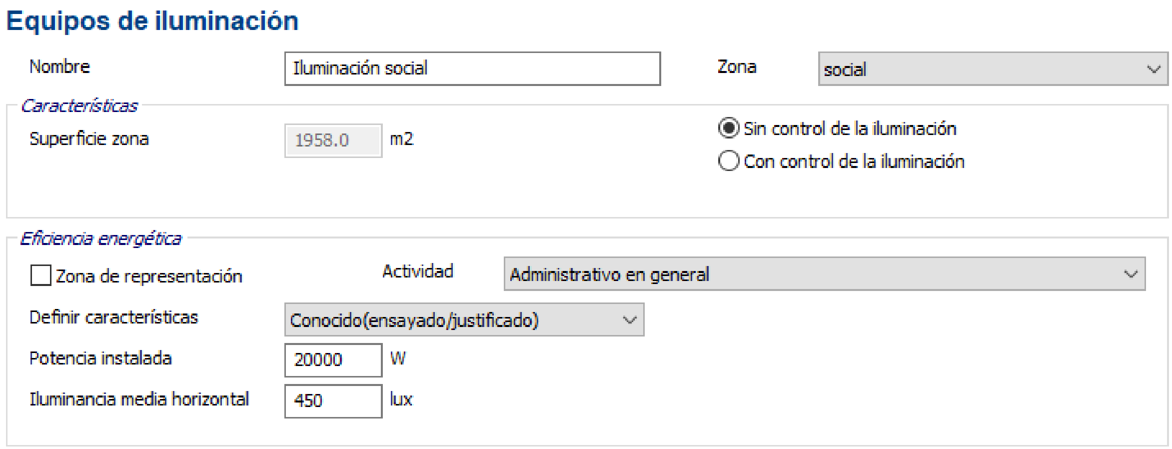


Figure 49. Defining lighting equipment Social Building

10.5 BASIC ENERGETIC CERTIFICATION RESULTS

Once all the data has been entered into the CE3X program, it will be possible to obtain the energy rating results for the building. It is important to note that the data provided in this energy rating is simplified and default values have been used in some cases (21).

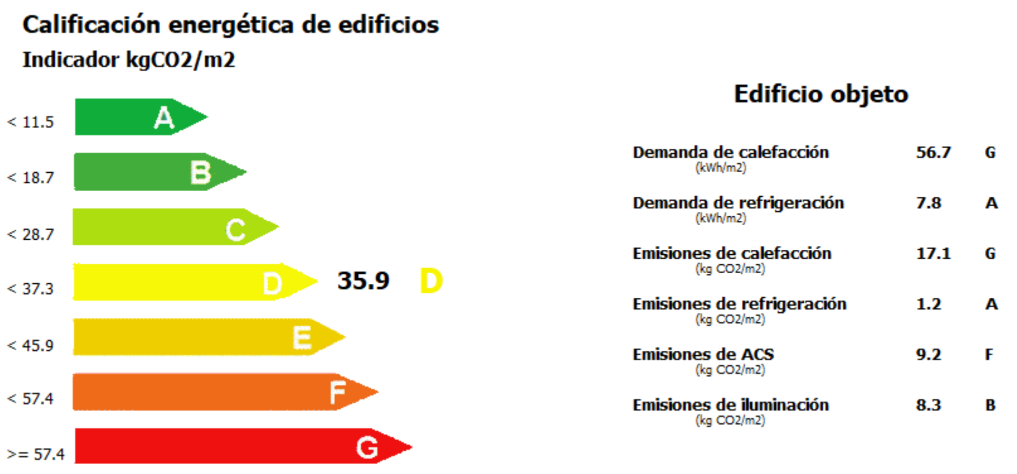


Figure 50. Basic energetic certification results

Based on the simulation results, it can be observed that the club has obtained an energy rating in terms of CO_2 emissions of D, with a value of 35.9 kg CO_2/year. This represents a moderate certification, considering that the social building of the club is over 50 years old and has undergone few renovations, so it is understandable that the results are not entirely satisfactory.

Regarding the energy rating, it is important to highlight that the results vary depending on the specific installation. The most negative indicators are the emissions caused by the ACS equipment and the heating demand and emissions. On the other hand, the parameter with the most positive rating is cooling, which has obtained an A rating.

It is important to note that in this energy rating, the thermal properties of the building materials have not been defined specifically but have been assigned default values. The final conclusions will be presented once a exhaustive certification is conducted, taking into account actual energy consumption and comparing the results obtained from both evaluations.

11 . EXHAUSTIVE ENERGY CERTIFICATION

The exhaustive certification takes into account the thermal characteristics of the building, which are not considered by default in the basic certification. It considers the materials used for roofs, walls, floors, and, if necessary, openings and windows of the building. This certification approach allows us to obtain a more precise and accurate result of the energy efficiency of the building (22).

Only the areas where data needs to be modified or added compared to the basic certification are taken into account.

11.1 THERMAL ENVELOPE

11.1.1 ROOFS

As seen previously, the club has 5 roofs:

Name	Type	Surface
Coberta 1	Inclined metal sandwich roof.	1033,79 m^2
Coberta 2	Inclined metal sandwich roof.	264,91 m^2
Coberta 3	Inclined metal sandwich roof.	1139,66 m^2
Coberta 4	Non-walkable Deck-type roof.	415,51 m^2
Coberta 5	Non-walkable Inverted Flat Roof.	1529,15 m^2

Table 19. Roofs materials

Both Roof 1 and Roof 2, we don't have any additional information beyond what is provided in the table, as the club cannot provide it.

Roof 3: This roof will be solved with a single slope towards the north side, made with a prefabricated sandwich panel.

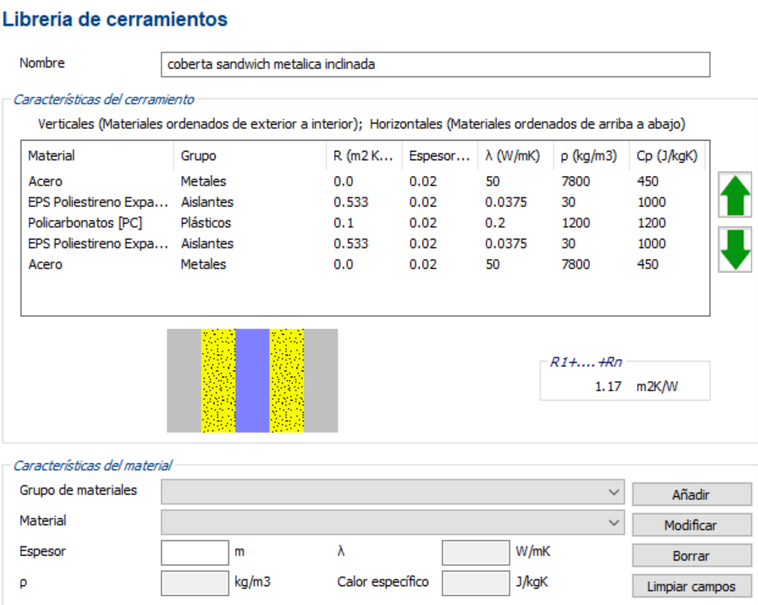


Figure 51. Entering of Sandwich roof to CE3X

Both Roof 1 and Roof 2 are provided with the same properties as they are described as similar in the Club's report.

Roofs 4 and 5: They will be composed of a sloping formation made with lightweight concrete, waterproofing using two interconnected asphalt sheets, insulation with extruded polystyrene panels, separating layer, and heavy protection with gravel.

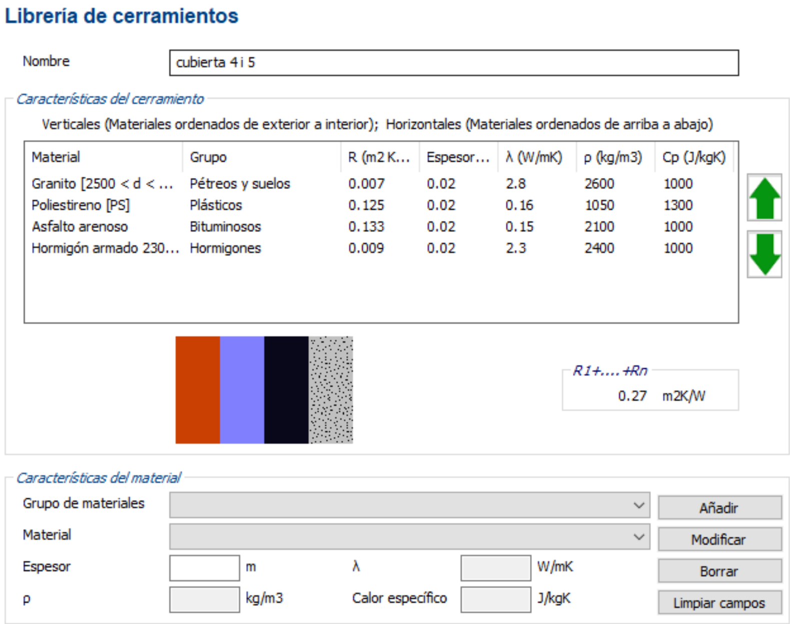


Figure 52. Entering of Roof's 4 and 5 to CE3X

11.1.2 WALLS

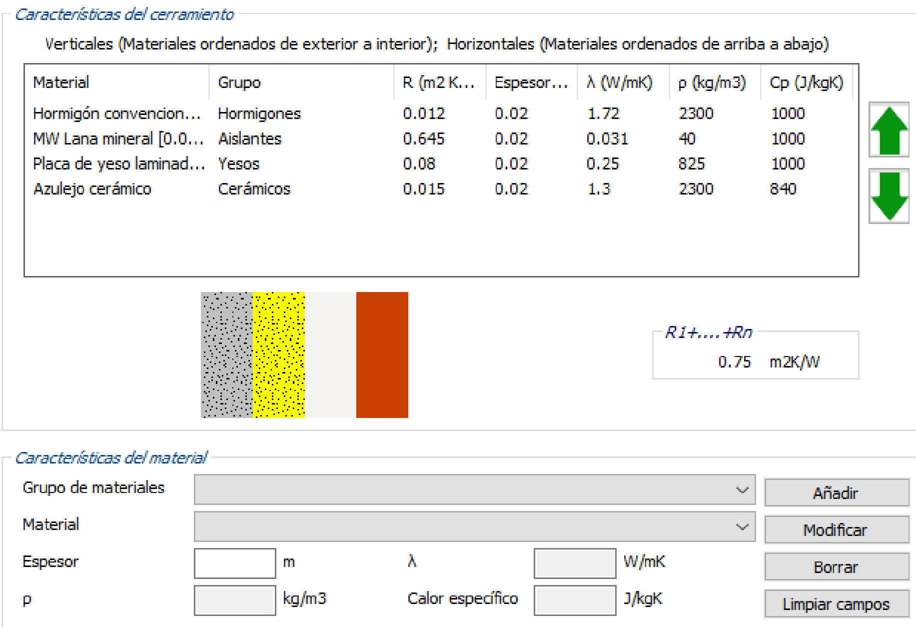
As seen in the basic certification, the program distinguishes between walls in contact with the ground, facade walls, and party walls. It has been mentioned that the club only has walls in contact with the ground and facade walls.

For this section, we will only add information about the activity building as we don't have the necessary information for the social building.

In this building, two types of walls can be distinguished:

Wall 1:

- Façade with non-ventilated air gap finished with concrete panels.
- External prefabricated concrete panel.
- Non-ventilated air gap.
- Thermal insulation with glass wool boards.
- Self-supporting partition made of fiber-gypsum boards.



Material	Grupo	R (m2 K...	Espesor...	λ (W/mK)	ρ (kg/m3)	Cp (J/kgK)
Hormigón convencion...	Hormigones	0.012	0.02	1.72	2300	1000
MW Lana mineral [0.0...	Aislantes	0.645	0.02	0.031	40	1000
Placa de yeso laminad...	Yesos	0.08	0.02	0.25	825	1000
Azulejo cerámico	Cerámicos	0.015	0.02	1.3	2300	840

Figure 53. Entering Concrete walls to CE3X

This type of wall is found in the sports building pavilion.

- Wall 2: In the rest of the building, facing brick and monocapa mortar are used as facade materials. They are used in separate facade panels, combined with aluminum carpentry, accentuating the play of volumes.

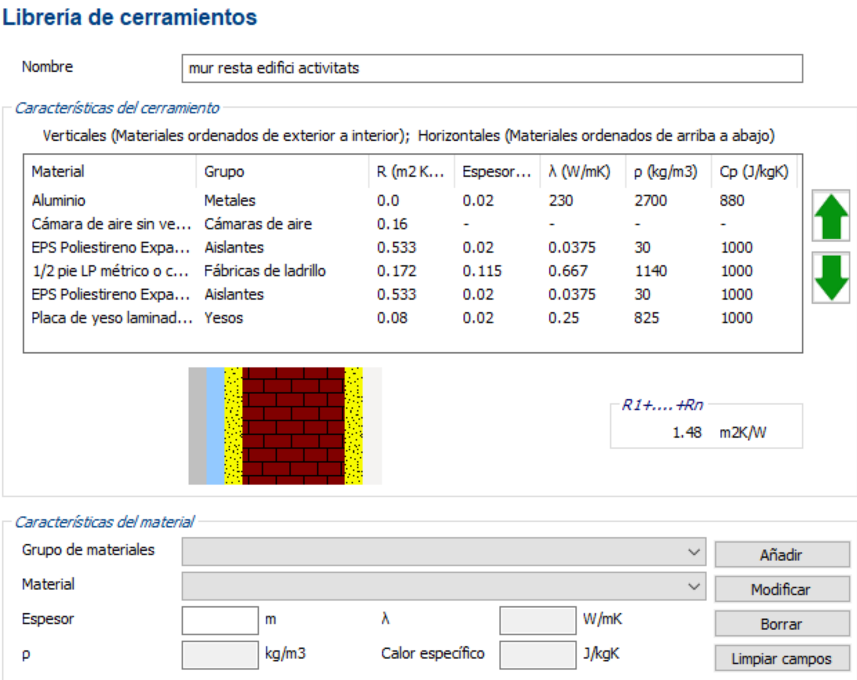


Figure 54. Entering of brick walls to CE3X

For the walls in contact with the ground, we have assigned the wall depth that is in contact with the ground.

Figure 55. Entering of walls in contact with the ground in CE3X

11.1.3 FLOORS

The program allows differentiation between two types of floors: those in contact with the ground and those in contact with the air. Floors in contact with the air can be classified based on their composition.

We have information about Floor 1, as it is part of Roof 5, so it is made of the same material.

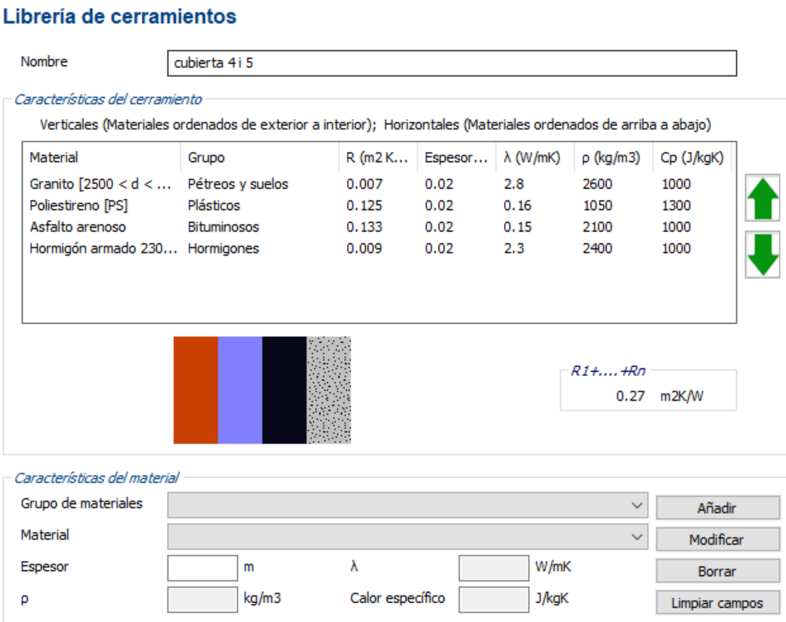


Figure 56 . Entering of floor in contact with air in CE3X

11.1.4. VOIDS AND SKYLIGHTS

In the exhaustive energy certification, the data related to the openings and skylights of the club have not been modified. Therefore, the dimensions, geometry, and orientation of the doors and windows, along with their thermal properties, remain as estimated in the basic certification.

11.1.5. PONTS TÈRMICS

This section will be defined by default since the club's documentation and the information we have collected do not provide enough data to define the parameters exhaustively.

11.1.6. SHADOW PATTERNS

We do not modify this part as it is already included in the basic certification.

11.1.7. INSTALLATIONS

In terms of the installations, the exhaustive energy certification has not undergone any changes, as the same parameters are considered in both cases. The data included in the program regarding the installations are already quite specific.

11.2. EXHAUSTIVE CERTIFICATION RESULTS

Once all the data, taking into account the thermal properties specified above for the building materials, has been entered, another energy certification has been obtained, which is defined as exhaustive.

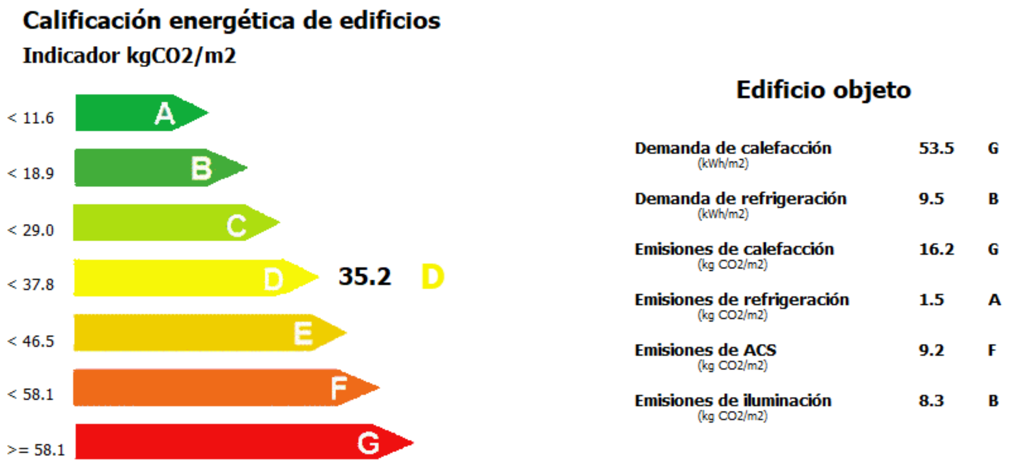


Figure 57 . Exhaustive energetic certification results

We can observe that there has been a slight improvement, as only the materials of the roofs and walls of the activity building could be specified due to lack of information about the social building due to its age.

In the obtained results, it can be observed that a qualification of letter D has been achieved again, with a value of 35.2 kg CO_2/m^2. Analyzing the result in the same way as in the simplified certification, it is evident that they still vary greatly depending on

the installation. The most negative indicator is the heating demand with a letter G, along with the heating emissions qualified with a letter G.

On the other hand, the most positive parameter has not changed compared to the other certification and remains the cooling emissions, qualified with a letter A.

12. REAL CONSUMPTIONS

Once the results of the basic and exhaustive certification have been obtained, a study of the actual energy consumption of Club Egara is conducted to compare it with the certification results. This comparison will allow drawing the necessary conclusions to develop the appropriate improvements to enhance the energy efficiency of the facility.

To gather this information, the energy bills provided by the administration of Club Egara will be analyzed, which will provide detailed data on the monthly and annual kWh consumed for the building under study.

Below, two graphs have been created using Excel to display the monthly energy consumption of Club Egara. The electricity and gas consumption will be analyzed separately, and later combined to obtain the total consumption. The results have been obtained by averaging the consumption data for the years 2021 and 2022.

12.1 ELECTRICITY CONSUMPTION

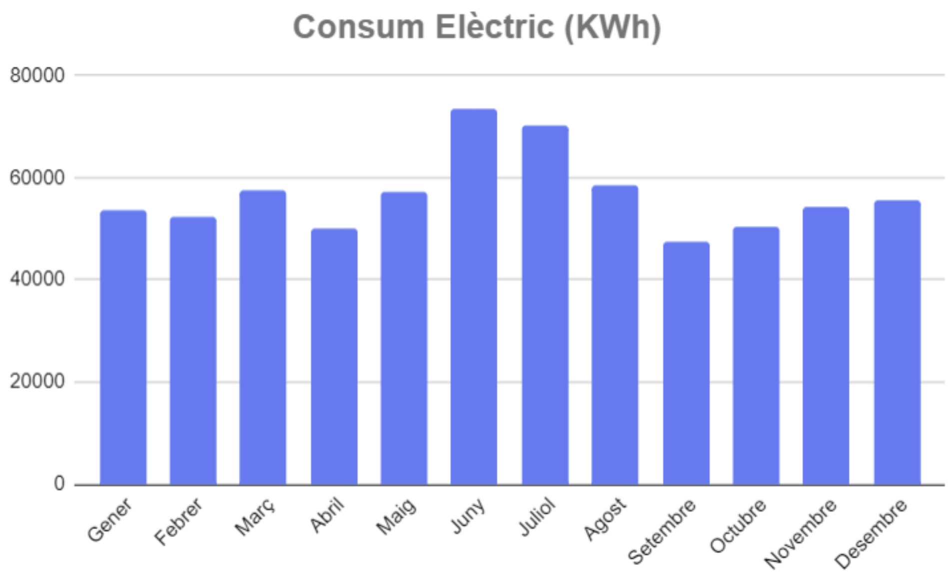


Figure 58 . Electric Consumption

As seen in the previous graph, the monthly electricity consumption shows a similar pattern during the months of the school period. The consumption increases in the summer months of June and July, which can be attributed to the high demand for air conditioning. Since a significant portion of the club allows natural sunlight to enter, it tends to heat up during the summer, requiring extensive use of air conditioning to maintain a comfortable indoor climate. Summing up the monthly consumption, we obtain an annual total of 680.697 kWh.

It should be noted that a portion of Club Egara's electricity consumption is attributed to the lighting of the hockey fields, paddle tennis courts, and tennis courts, which do not directly affect the building itself and should be excluded from the analysis. Additionally, electricity consumption for the kitchen is also excluded. It is estimated that approximately 40% of the electricity consumption is allocated to these excluded areas. Therefore, the final annual electricity consumption for the building is estimated to be 408.418 kWh.

12.2 GAS CONSUMPTION

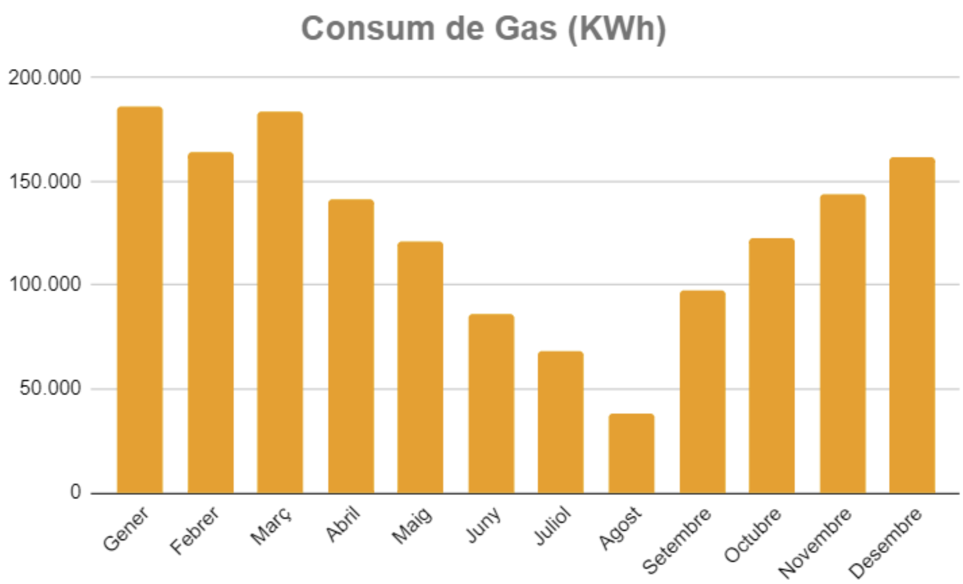


Figure 59 . Gas Consumption

In the previous graph, it is evident that the months with colder weather exhibit higher gas consumption, while the opposite is true for the warmer months. The significant difference in consumption can also be attributed to the reduced usage of the club during the months of June, July, and August. Summing up the monthly gas consumption, we obtain an annual total of 1.513.704 kWh.

Similar to the electricity analysis, it is important to note that the club has an indoor swimming pool measuring 25m x 12m, as well as a jacuzzi. The annual consumption of these facilities will be subtracted to obtain results that are more comparable to those generated by the program.

The indoor pool, together with the jacuzzi, consumes 687.042 kWh annually. Therefore, the final annual gas consumption will be 826.662 kWh.

12.3 TOTAL CONSUMPTION

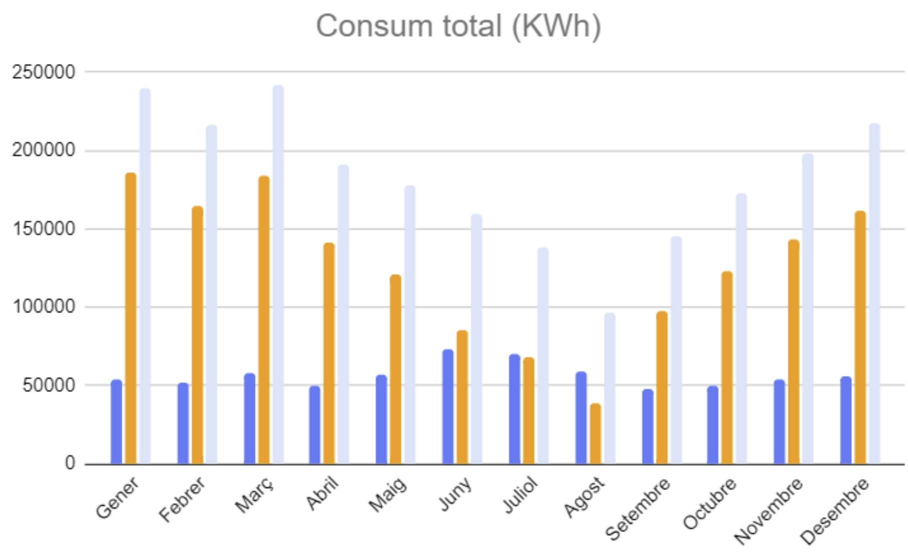


Figure 60 . Total Consumption

In the total consumption graph, we can observe the electricity consumption, shown in blue, the gas consumption, shown in orange, and the total consumption, shown in gray. As we can see, during the colder months, gas consumption is much higher than electricity consumption.

Only in the hotter months (July and August) does electricity consumption surpass gas consumption. Summing up the monthly total consumptions, we obtain an annual total consumption of 1,371,219 kWh.

Now we have the annual quantity of consumed kWh, but this is not the data we need, as the CE3X program uses primary energy data while we have secondary energy data.

Primary energy refers to the original or non-converted fuels, while secondary energy includes resources that have been converted or stored. To convert secondary energy to primary energy, various conversion factors are used. These conversion factors have been obtained from the document "Factores de emisión de CO_2 y coeficientes de paso a energía primaria de diferentes fuentes de energía final consumidas en el sector de edificios en España," a document recognized by the RITE (Regulation of Thermal Installations in Buildings)(23).

Factores de conversión de energía final a primaria					
		Valores aprobados			Valores previos (****)
	Fuente	kWh E.primaria renovable /kWh E. final	kWh E.primaria no renovable /kWh E. final	kWh E.primaria total /kWh E. final	kWh E.primaria /kWh E. final
Electricidad convencional Nacional	(*)	0,396	2,007	2,403	
Electricidad convencional peninsular	(**)	0,414	1,954	2,368	2,61
Electricidad convencional extrapeninsular	(**)	0,075	2,937	3,011	3,35
Electricidad convencional Baleares	(**)	0,082	2,968	3,049	
Electricidad convencional Canarias	(**)	0,070	2,924	2,994	
Electricidad convencional Ceuta y Melilla	(**)	0,072	2,718	2,790	
Gasóleo calefacción	(***)	0,003	1,179	1,182	1,08
GLP	(***)	0,003	1,201	1,204	1,08
Gas natural	(***)	0,005	1,190	1,195	1,01
Carbón	(***)	0,002	1,082	1,084	1,00
Biomasa no densificada	(***)	1,003	0,034	1,037	
Biomasa densificada (pelets)	(***)	1,028	0,085	1,113	

(*) Valor obtenido de la Propuesta de Documento Reconocido: **Valores aprobados en Comisión Permanente de Certificación Energética de Edificios de 27 de Junio de 2013, actualizado al periodo considerado.**

(**) Según cálculo del apartado 5 de este documento.

(***)Basado en el informe "Well to tank Report, versión 4.0" del Joint Research Intitute.

(****) Valores utilizados, a fecha de redacción del informe, en CALENER, CE3 y CEX según Documento reconocido "Escala de calificación energética para edificios existentes"

Figure 61 . Final to primary energy conversion factors (34)

As shown in Figure 61, the values used by the CE3X program are marked with (****), which can be found in the right column. In our case, we are interested in the value for gas (1.01) and the value for conventional peninsular electricity (2.61).

	Annual Secondary Energy Consumption (kWh)	Conversion Factors	Primary Energy Consumption Total Annual (kWh)
Electricity	408.418	2,61	1.065.971
Natural Gas	826.662	1,01	834.928
Total			1.900.899

Table 20. Conversion to primary consumption.

The total annual primary energy consumption is 2.256.222 kWh. Finally, to calculate the kWh/m^2, the result is divided by the total habitable area of Club Egara, which is a total of 5.961 m^2. The final result is 297,43 kWh/m^2, corresponding to a rating of F in the CE3X program.

13. COMPARISON OF RESULTS

Once the three sets of results have been obtained and analyzed, which include the two energy certifications performed with the CE3X program and the actual energy consumption of the building, we will proceed to compare them to draw final conclusions.

Firstly, we will compare the three main results of the energy certifications, which are the total emissions, the non-renewable primary energy consumption, and the energy demand for heating and cooling.

This comparison will allow us to analyze and assess the differences and similarities between the estimates based on the certifications and the actual consumption, thus obtaining an exhaustive view of the energy efficiency of the building.

	EMISSIONS			
	Basic Certification		Exhaustive Certification	
	$KgCO_2/m^2$year	Qualification	$KgCO_2/m^2$year	Qualification
ACS	9.21	F	9.21	F
Illumination	8.34	B	8.34	B
Heating	17.13	G	16.18	G
Cooling	1.19	A	1.46	A
Global	35.8	D	35.2	D

Table 21. Comparison of the emissions of the two certifications

	NON-RENEWABLE PRIMARY ENERGY CONSUMPTION			
	Basic Certification		Exhaustive Certification	
	kWh/m^2	Qualification	kWh/m^2	Qualification
ACS	43.49	E	43.49	E
Illumination	49.25	B	49.25	B
Heating	80.87	G	76.39	G
Cooling	7.01	A	8.6	A
Global	180.6	D	177.7	D

Table 22. Comparison of non-renewable primary energy consumption of the two certifications.

	HEATING AND COOLING ENERGY DEMAND			
	Basic Certification		Exhaustive Certification	
	kWh/m^2	Qualification	kWh/m^2	Qualification
Heating	56.7	G	53.5	G
Cooling	7.8	A	9.5	B

Table 23. Comparison of the heating and cooling energy demand of the two certifications.

Once the results in tables 21, 21, and 23 have been compared, significant differences can be observed between the certifications. In terms of overall performance, both the basic and exhaustive certifications obtain a D rating, but a detailed analysis reveals important changes.

Firstly, there is a slight improvement in the heating system in the exhaustive certification, reflected in reduced consumption, demand, and emissions. This

improvement is made possible by a better definition of the thermal properties of various parts of the thermal envelope.

On the other hand, in contrast to heating, the cooling system has experienced a slight impact on all three aspects due to the same improvements made in the thermal envelope.

Regarding the partial indicators of domestic hot water and lighting, no changes have occurred as their values have not been modified.

It can be observed that the changes are not very significant, and introducing the thermal properties of part of the building envelope has not made a major difference in the certification.

	NON-RENEWABLE PRIMARY ENERGY CONSUMPTION	
	kWh/m^2	Qualification
Basic certification	180.6	D
Exhaustive certification	177.7	D
Real Consumptions	297.43	F

Table 24. Comparison of the two certifications and actual consumption.

Comparing the three results, we can see that the reality is far from what the program has certified.

This could be due to many factors that may affect this discrepancy. The factors that I believe have the most impact are the lack of data on the Club's Social Building, as well as not knowing the actual electricity consumption from the hockey fields and tennis and paddle courts, as well as not knowing the electricity and gas consumption of the kitchen, as it has been estimated.

14. ENERGY IMPROVEMENT STUDY

Once the results of the energy certifications and real consumption have been obtained, examined, and analyzed, the goal is to improve the energy efficiency of the club. In this section, various improvement proposals that can be implemented in the club are considered. The presented proposals will be analyzed using the CE3X program to assess their impact on the final outcome.

To determine the different proposals to implement, the results have been taken into account to identify areas with the greatest potential for improvement. The amortization and environmental impact of each proposal have also been considered.

The first proposal consists of improving the heating system by replacing the gas boilers with biomass boilers, which use biomass as fuel.

Lastly, the installation of photovoltaic solar panels for electricity production is another proposal to be studied. Renewable energies are always a very positive aspect to consider.

14.1. REPLACEMENT OF GAS BOILERS

Once obtained, examined, and analyzed the results of the energy certifications and real consumption, we aim to improve the energy efficiency of the club. In this section, we will consider different improvement proposals that can be applied to the club. The presented proposals will be analyzed using the CE3X program to assess their impact on the final outcome.

To determine the various proposals to implement, the obtained results have been taken into account to identify areas with the greatest potential for improvement. The amortization and environmental impact of each proposal have also been considered.

The first proposed improvement is the replacement of gas boilers. As previously mentioned, the Club Egara currently has a heating system consisting of two natural gas boilers used for both heating and domestic hot water. Gas boilers use natural gas as fuel, emitting carbon dioxide and nitrogen oxides, which are harmful to the environment.

Next, the feasibility of replacing the gas boilers with biomass boilers will be studied. Biomass boilers utilize biomass, usually in the form of pellets, as fuel. This fuel emits fewer pollutants and has a higher efficiency compared to natural gas.

Replacing a natural gas boiler with a biomass pellet boiler offers several benefits and some aspects that may not necessarily be advantages. The potential benefits and non-benefits of this change are outlined below (24):

Benefits of replacing a natural gas boiler with a biomass pellet boiler:

1. Reduction in emissions of harmful gases: Biomass pellet boilers emit less carbon dioxide and nitrogen oxides compared to natural gas boilers, contributing to a lower carbon footprint and improved air quality.

2. Use of renewable fuel: Pellets used as fuel in biomass boilers are derived from residual biomass such as sawdust or wood waste. This helps reduce dependence on fossil fuels and promotes the use of more sustainable energy sources.

3. Improved energy efficiency: Biomass pellet boilers have high efficiency, effectively utilizing the energy content of the fuel. This can result in lower energy consumption and long-term cost savings.

Aspects to consider that may not necessarily be benefits:

1. Initial cost: Biomass pellet boilers often have a higher initial cost than natural gas boilers. This may involve a larger upfront investment to make the change.

2. Space required for pellet storage: Biomass boilers require additional space for pellet storage, as an adequate quantity is needed for the efficient operation of the boiler. This can be a drawback if space is limited.

3. Maintenance and cleaning: Biomass boilers require regular maintenance and, in some cases, more frequent cleaning compared to natural gas boilers. This may incur additional costs and require more time dedicated to maintenance.

In summary, replacing a natural gas boiler with a biomass pellet boiler can provide environmental and energy benefits, but there are also economic and practical considerations to take into account before making a decision.

To carry out this proposed improvement at Club Egara, a series of steps will be necessary, as outlined below:

- Remove the existing gas boilers.

- Install the biomass boilers.

- Install a feeding system.

Currently, the club has a boiler room located in the semi-basement of the activities building. This room has a surface area of 49,95 m^2, where the two natural gas boilers are situated, occupying approximately 5 m^2 each.

There is ample space to install the two biomass boilers (4,5 m^2 each) and sufficient space for pellet storage, so no modifications or renovations to the installation are required.

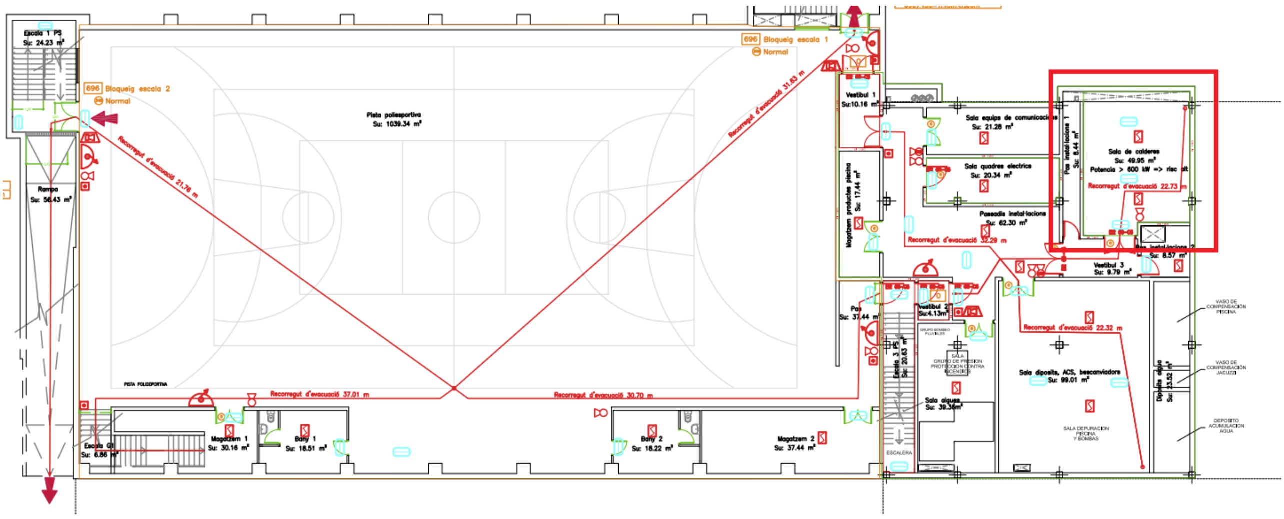


Figure 62 . Location of natural gas boilers

14.1.2. BUDGET

The following are the data for the replacement with biomass boilers using pellets.

INSTALLATION COST OF BIOMASS BOILERS	
Name	**Price (€)**
Caldera de Pellet Domusa BIOCLASS IC 300 kW (2)	72.436,47
Pellet Storage	3.433,15
Feeding System (2)	5.288,14
Total	81.157,62

Table 25. Cost of Biomass Boilers

MAINTENANCE COST OF BIOMASS BOILERS	
Name	**Price (€)**
Caldera de Pellet Domusa BIOCLASS IC 300 kW (2)	7.315,11
Pellet Storage	26,2
Feeding System (2)	246,74
Total	7.588,05

Table 26. Cost of Maintenance of Biomass Boilers

14.1.3. EXECUTION TIME

The time required to carry out the boiler replacement is also an important aspect to consider.

INSTALLATION OF BIOMASS BOILERS	
Name	**Time (h)**
Caldera de Pellet Domusa BIOCLASS IC 300 kW (2)	15
Removal of Natural gas boilers (2)	15
Pellet Storage	3
Feeding System (2)	2,5
Total	35,5

Table 27. Time of installing the Biomass Boilers

The tasks to be performed total 35,5 hours. Considering that the installation is carried out by two workers, the boilers will have to be installed one by one, so the time cannot be simplified. The working day for a skilled worker is 8 hours, and the total required time is 5 working days.

14.1.4. ENERGETIC IMPACT

The energy efficiency is a key aspect in the evaluation of the improvement proposal. To analyze the energy impact of the new boilers, we will make the corresponding changes in the CE3X program, using the exhaustive certification, which is the most accurate and closest to reality (25).

Calificación energética del edificio con el conjunto de medidas de mejora

RESULTADOS	Medidas mejora	Caso base	Ahorro
Demanda de calefacción	53.5 G	53.5 G	0.0 %
Demanda de refrigeración	9.5 B	9.5 B	0.0 %
Emisiones de calefacción	1.2 A	16.2 G	92.9 %
Emisiones de refrigeración	1.5 A	1.5 A	0.0 %
Emisiones de ACS	0.7 A	9.2 F	92.9 %
Emisiones de iluminación	8.3 B	8.3 B	0.0 %
EMISIONES GLOBALES	11.6 A	35.2 D	67.0 %

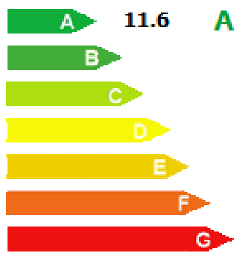


Figure 63 . Energetic certification adding Biomass boilers

As we can see in Figure 63, the replacement of the boilers results in a significant reduction in heating demand and ACS emissions, achieving savings of over 90% in both installations. However, the heating demand remains the same. Finally, the overall emissions have received an A rating, reducing them by 67%, which is a very positive outcome with a significant energy impact.

14.1.5. AMORTIZATION

It is also essential to determine if it is economically viable to replace the gas boilers with biomass boilers. Next, we will analyze the annual savings provided by the biomass boilers. According to the previous calculations, the building consumes 826.662 kWh of natural gas. Considering that the current cost of natural gas is approximately €0,06/kWh, and the cost of pellets is €0,0535/kWh, we will proceed to calculate the annual consumption cost (26).

	COST OF GAS BOILERS (€/year)	COST OF BIOMASS BOILERS (€/year)
Maintenance	7.315,11+148,68*	7.315,11
Kwh	49.599,72	44.226,42
TOTAL	57.063,51	51.541,52
Difference	+5.521,99	-5.521,99

Table 28. Comparing boilers

The maintenance cost of the gas boiler remains the same as the biomass boiler due to lack of evidence, and the additional 148,68* mentioned is the monthly fixed fee for gas consumption (€12,39/month) (27).

Therefore, considering the calculations from Table 28, and the total installation cost of the new boilers being €81.157,62, it will be amortized in **14,7 years.**

14.2. INSTALLATION OF A SOLAR PHOTOVOLTAIC SYSTEM

The installation of photovoltaic panels in the warehouse will result in a significant reduction in electrical energy demand as these panels generate electricity through solar energy. This will lead to a decrease in energy consumption from the power grid and, consequently, a reduction in greenhouse gas emissions associated with electricity generation.

Additionally, if the production of photovoltaic energy exceeds the demand of the warehouse, the excess energy can be sold to the power grid, resulting in economic benefits.

Photovoltaic panels convert solar energy into electricity through photovoltaic cells composed of semiconductor materials. When sunlight hits the cells, electrons are set in motion, creating a potential difference that generates electric current.

The installation of solar panels on the roof of the club's activity building has several advantages. Firstly, it generates electricity from a renewable and clean source, reducing dependence on fossil fuels and their polluting emissions. Moreover, it helps to reduce long-term energy costs as solar energy production is not subject to fluctuations in fossil fuel prices (28).

Secondly, the installation of solar panels on the Club Egara's roof can contribute to reducing the thermal load of the building. The solar panels act as a barrier against direct solar radiation, which can maintain a cooler temperature inside the facility during the summer months. This, in turn, reduces the need for air conditioning and, therefore, the associated energy costs.

In conclusion, the installation of photovoltaic panels would directly impact our hot water systems and our heating and cooling equipment.

Figure 64 . Solar Panels (35)

14.2.1. DISTRIBUTION

As mentioned earlier, the panels will be installed on the roof 5, covering an area of 325 m^2. Assuming each solar panel occupies 2 m^2, a total of 160 solar panels will be installed.

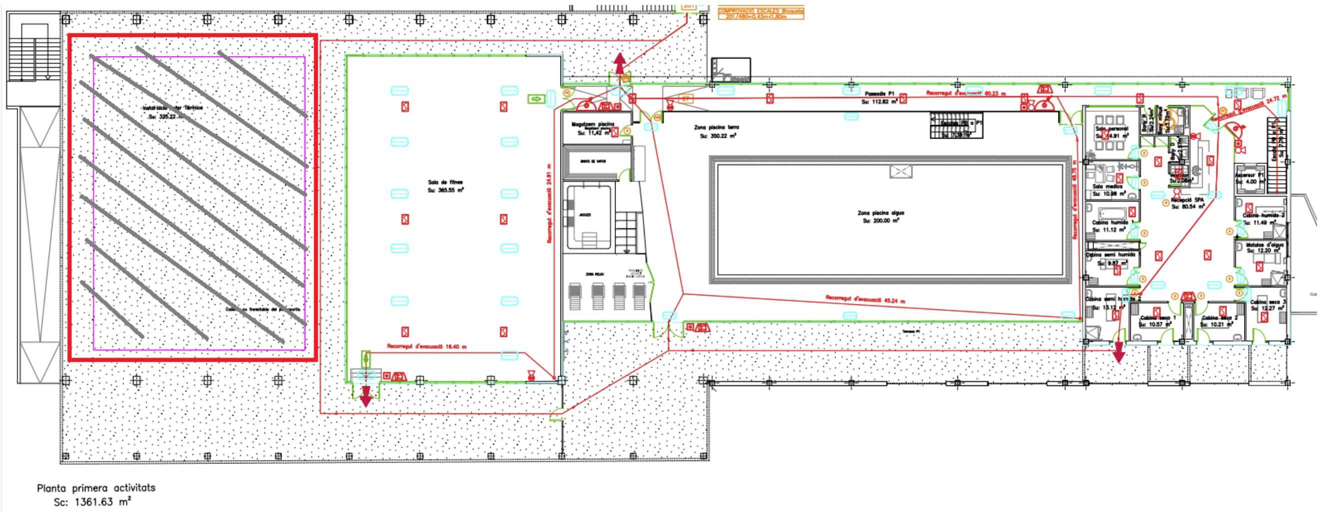


Figure 65 . New location of our Solar Panels

14.2.2. BUDGET

In order to implement this installation, several of the concepts mentioned earlier need to be taken into account. Below, we will see what they are and the general budget for each of them.

COMPONENT	PRICE/unit (€)	Units	TOTAL PRICE (€)
Photovoltaic Module	175,85	160	28.136
Structure*	480,29	27	12.807,73
Inverter	7.722,72	1	7.722,72

Protection Panel	95,64	1	95,64
TOTAL			**48.762,09**

Table 29. General cost of the photovoltaic solar system

*The structure consists of an adjustable inclined support for solar panels, which can be set between 20 and 35 degrees. Each structure can accommodate 6 solar panels measuring 2200x1150mm.

14.2.3. ENERGETIC IMPACT

To determine the energy impact, we first need to calculate the energy that the solar panels installed on the building can generate. To make this calculation, we need to consider the optimal daily sunlight hours available in Terrassa.

In Terrassa, there are approximately 2800 sunlight hours per year, which averages to about 8 hours per day. Of these hours, we will consider that 50%, or 4 hours per day, are optimal for achieving the maximum energy output from the solar panels.

Considering that the installation consists of 160 solar panels with a capacity of 400W each, we will perform the following calculation to determine the energy generated:

$$160\ panels\ x\ 400W\ x\ 4h\ =\ 256\ \frac{kWh}{day}$$

$$256\ \frac{kWh}{day}\ x\ 365\ days\ =\ 93.440\ \frac{kWh}{year}$$

We will consider that the installation has an efficiency of 85%. Therefore, we will obtain a total energy of:

$$93.440\ \frac{kWh}{year}\ x\ 0,85\ =\ 79.424\ \frac{kWh}{year}$$

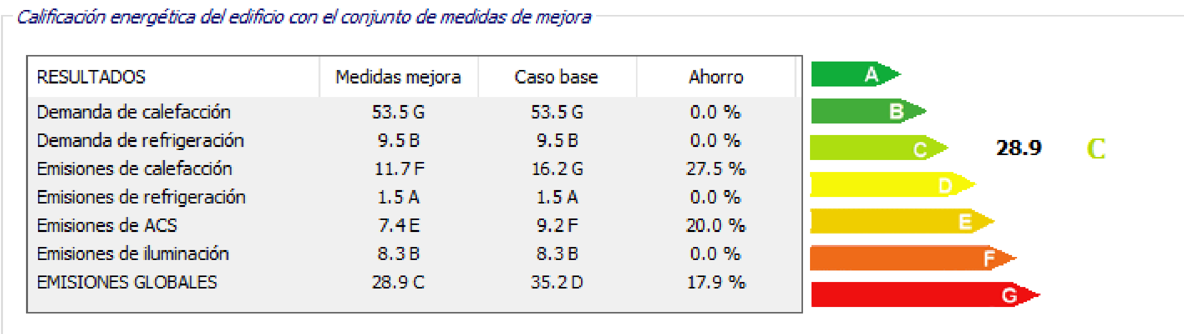
This calculation gives us an estimate of the energy that the solar panels can generate daily in Terrassa (29). It is important to note that this is an approximate estimation, and environmental factors and specific characteristics of the installation can affect the actual results.

Once we know the energy generated by the solar panels, we can calculate the annual economic savings.

	CURRENT CONSUMPTION (kWh/year)	ESTIMATED PRODUCTION (kWh/year)	ENERGY SAVINGS (%)	*ENERGY PRICE (€/kWh)	ECONOMIC SAVINGS (€)
Electricity consumption	408.418	79.424	19,45	0,18	14.296,32

Table 30. Annual economic cost estimate for the installation of solar panels

*The energy price has been searched on the internet by looking for the average price at a sports club in Spain.


Calificación energética del edificio con el conjunto de medidas de mejora

RESULTADOS	Medidas mejora	Caso base	Ahorro
Demanda de calefacción	53.5 G	53.5 G	0.0 %
Demanda de refrigeración	9.5 B	9.5 B	0.0 %
Emisiones de calefacción	11.7 F	16.2 G	27.5 %
Emisiones de refrigeración	1.5 A	1.5 A	0.0 %
Emisiones de ACS	7.4 E	9.2 F	20.0 %
Emisiones de iluminación	8.3 B	8.3 B	0.0 %
EMISIONES GLOBALES	28.9 C	35.2 D	17.9 %

Figure 66 . Energetic certification adding Solar Panels

As shown in the results, there is a 27.5% improvement in heating emissions and a 20% improvement in hot water emissions.

In terms of overall emissions, there is a 17,9% improvement, moving from a D rating to a C rating.

14.2.5. AMORTIZATION

Considering the high price of electricity currently, the amortization of the solar panel installation will be highly profitable. With a total cost of €48.762,09 and an annual energy savings of €14.296,32, it is expected that the amortization will be completed in approximately **3,5 years.**

It is important to note that this calculation does not take into account the annual maintenance cost, as this expense is low compared to the energy savings obtained and varies depending on the type of solar panels used.

15. COMPARISON OF RESULTS

Once the different improvement proposals have been studied, the results will be compared and analyzed. The following table and graph show the most relevant data for each proposal, both in terms of economic and energy aspects.

Proposal	INVESTMENT (€)	AMORTIZATION (years)	GLOBAL EMISSIONS (K CO_2/m^2)	ENERGETIC SAVINGS (%)
Biomass boilers	88.745,67	14,7	11,6	67
Photovoltaic solar panels	48.762,09	3,5	28,9	17,9

Table 31. Comparison of both proposals

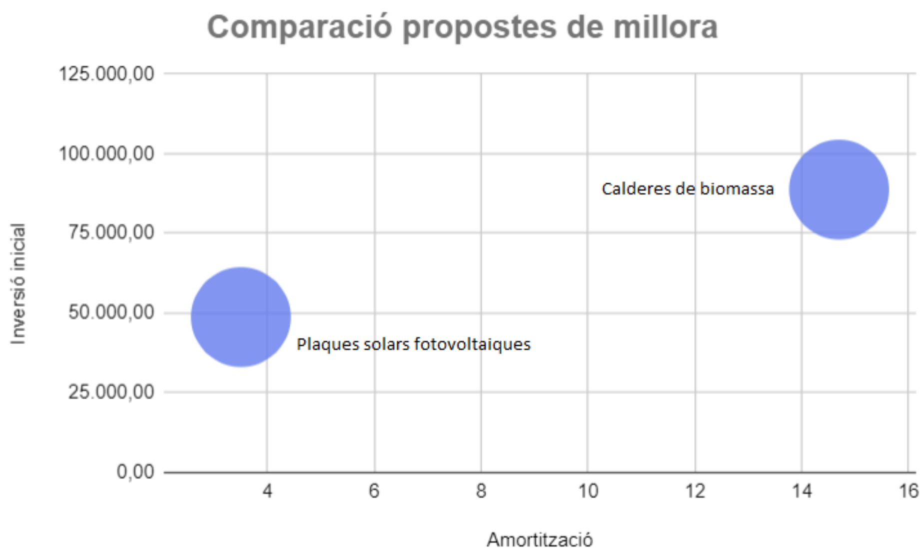


Figure 67 . Comparison of both proposals

Once the different improvement proposals have been studied, the results will be compared and analyzed. Below, a table and a graph are shown with the most relevant data for each proposal, both in terms of economics and energy.

The substitution of gas boilers with biomass boilers has led to a significant reduction in total CO_2 emissions, with a decrease of 67%. This proposal has allowed for a reduction of 92,9% in heating emissions and ACS emissions. This improvement is explained by the fact that biomass boilers use pellets as fuel, which is a completely natural product and emits fewer CO_2 emissions compared to natural gas.

However, it should be noted that the initial investment for biomass boilers is considerable, amounting to 88.745,67 euros. Considering the annual economic savings of 5.521,99 euros, the payback period for the new installation is 14,7 years. Therefore, from an economic point of view, this proposal is not very viable unless there is a significant increase in gas prices or a significant decrease in pellet prices.

In conclusion, although the substitution of gas boilers with biomass boilers has a very positive energy impact, it is not economically advisable unless there are exceptional circumstances in fuel prices. It is important to consider all these factors before making a decision on the improvement to be implemented.

With photovoltaic solar panels, a reduction of 17,9% in total emissions has been achieved, reaching 28,9 KCO_2/m^2. This measure has a direct impact on overall emissions, as it only provides electrical energy to the facilities. From an economic point of view, despite requiring an investment of 48.762,09 euros, this investment is recovered in a relatively short period of 3,5 years, thanks to the high price of energy currently. This makes it a very viable proposal, as it not only significantly improves environmental impact but also promotes the use of renewable energy.

In summary, the implementation of photovoltaic solar panels is a favorable proposal, as it brings advantages both from an environmental and economic perspective, with a reasonable payback time and the use of renewable energy.

In conclusion, both improvement proposals are viable, but considering all aspects, the installation of photovoltaic solar panels is the one I would recommend the most. It is important to highlight that if the necessary financial resources are available, the substitution of boilers would be a highly viable option due to the significant reduction in emissions it offers.

It should be noted that the proposed improvements have not been studied in detail, and the results may vary if explored further.

16. ENVIRONMENTAL IMPACT

The environmental impact is a growing concern in our current society, stemming from various human actions that have negative consequences on the environment. This has led us to adopt measures to address this issue and mitigate its effects.

In the field of construction, regulations have been established to reduce energy emissions and decrease consumption in buildings. Energy certifications have become an important tool for evaluating and identifying the most critical sectors in terms of energy consumption, with the aim of proposing improvements that can reduce the environmental impact.

Within the scope of this specific project, we have studied various improvement measures with the goal of reducing emissions and energy consumption in the building. Through this study, we have delved into the factors that contribute most negatively to the environment and proposed solutions that can help reverse this situation.

One key aspect we have considered is the promotion of the use of renewable energy sources, such as the installation of photovoltaic systems for solar energy generation. This proposal aligns with the current trend of resorting to cleaner and more sustainable energy sources, aiming to reduce the impact on the environment.

Through this work, we seek to raise awareness and engage individuals in the fight against climate change. We want to convey the message that we can all contribute

through small changes in our daily actions to achieve a more sustainable and environmentally respectful future.

17. CONCLUSIONS

In this project, an energy certification has been carried out at Club Egara with the aim of identifying and studying possible improvements to reduce emissions and energy consumption. This study has allowed for a deeper understanding of the current issue of climate change, with a focus on the construction sector, which represents a significant part of the energy crisis.

Despite existing regulations to address this problem, there are still many buildings that generate a high energy impact. It is important to note that reducing energy impact can be more accessible than it seems through the application of appropriate improvements to existing buildings.

Currently, there are several tools available for energy certifications, and in this project, the CE3X program has been used, which has proven to be useful, simple, and effective. Two energy certifications were carried out using this program, one being a basic certification that allowed for default values, and the other being an exhaustive certification that allowed for more detailed data input. Although there were slight differences in some aspects, the final results were similar and provided insights into the building's emissions. The exhaustive certification provided more precise and realistic results.

Based on the obtained results, two improvement measures have been studied. The replacement of gas boilers with biomass boilers has achieved up to a 67% reduction in the club overall emissions, albeit requiring a significant initial investment. The installation of a photovoltaic solar system, with a lower economic investment, has shown very positive results in energy efficiency, making it a recommended proposal.

It should be noted that there was a lack of data, such as the efficiencies of various installations, which would have allowed for more precise results. However, despite these limitations, the objectives of improving the building's energy efficiency have been achieved.

In conclusion, the completion of this project has been a success, and the objectives of improving the building's energy efficiency have been accomplished. Additionally, it has provided me with a different perspective on the impact that buildings can have and allowed me to explore and study possible solutions to make this world a better place.

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