Escola Politècnica Superior d'Edificació de Barcelona
UNIVERSITAT POLITÈCNICA DE CATALUNYA

EDIFICATION ENGINEERING

FINAL DEGREE PROJECT

EVALUATION, ENERGY REHABILITATION, THERMAL-ACOUSTIC CONDITIONING AND MAINTENANCE PLAN OF THE COMMERCIAL CENTRE DECATHLON CIUTAT VELLA, BARCELONA

ENGLISH ANNEX

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ABSTRACT

This final degree project got the purpose of starting the path of energy rehabilitation in the commercial field. The energy demand limitation is the fundamental tool to use in existent buildings and the sustainable construction in the new buildings. The work and the in-situ methodology analysis, the data collection, the informatics simulations by specialized software, etc. develop in a basic key for commercial buildings analysis to obtain objective data that allows to do reliable diagnosis and then, work in action lines that keep on in improvement proposals, always taking care of the environmental impact of these.

The commercial centre Decathlon Ciutat Vella, object of this study, is located in a 1960's building but the centre was opened in the year 2001. This is a perfect example, how our results of analyzing and evaluation show, of a high internal charge because of the commercial character and the associated problems in the thermal envelope or the management of systems (lightening and climate).

After all evaluation, we can highlight that the improve points are related with a energy demand that overcomes the reference one and an incorrect management of the climate and lightening systems. The action lines are focused basically to the reduction of the center energy demand, energy saving measures and the correction of unconformities in the general users comfort.

The pretensions of this study, in a general and commercial field, are working on energy saving measures that can reduce the related emissions of CO_2 of the Decathlon products, taking part of the life cycle of the products.

This project is based on:

- **Previous study of the building, making sense on its constructive typologies and updating all of the graphic documents, making a better reference of it.**
- **Analysis of the energy demand, consumptions and climate and lightening systems.**
- **Study of thermal comfort parameters through monitorizing and users interaction.**
- **Establishment of actions lines focused on the energy saving and sustainability.**

RESUM

El present treball final de grau té la intenció d'iniciar el camí de la rehabilitació energètica dins de l'àmbit del comerç. La limitació de la demanda energètica és l'eina fonamental a emprar en els edificis existents i la construcció sostenible en el cas dels nous edificis. El treball de camp, la recollida de dades, les simulacions amb eines informàtiques, entre altres eines, es converteixen en peces claus a l'hora d'analitzar els edificis comercials obtenint dades objectives que permetin fer diagnòstics fiables i posteriorment, treballar en unes línies d'actuació que desemboquin en propostes de millores, sempre tenint present l'impacte mediambiental d'aquestes.

El centre comercial Decathlon Ciutat Vella, objecte d'aquest estudi, s'ubica en un edifici de l'any 1960 però el centre en sí va ser inaugurat l'any 2001. Aquest és un clar exemple, com mostren els resultats obtinguts del nostres anàlisis i avaluacions, d'un centre amb molta càrrega interna degut al caràcter comercial i amb problemàtiques associades a l'envoltant i a la gestió dels sistemes.

Després de tota l'avaluació, podem destacar que els punts de millora a treballar estan relacionats principalment a una demanda energètica per sobre de la de referència i una mala gestió dels sistemes de climatització i il·luminació. Les línies d'actuació van dirigides principalment a la reducció de la demanda energètica del centre, mesures d'estalvi energètic i correcció de les disconformitats en el confort general dels usuaris.

Les pretensions d'aquest estudi són, en un àmbit més general i comercial, treballar mesures d'estalvi energètic que puguin reduir les emissions associades de CO_2 dels productes venuts a les botigues Decathlon entrant dins de l'anomenat cercle de vida del producte.

Aquest projecte es basa en:

- **Un estudi previ de l'edifici, centrant-nos en la seva tipologia constructiva i actualitzant tota la documentació gràfica, de tal manera que quedi ben referenciada i actualitzada.**
- **Anàlisis de la demanda energètica, dels consums i dels sistemes de climatització i il·luminació.**
- **Estudi dels paràmetres de confort tèrmic mitjançant la monitorització i la interacció amb els usuaris.**
- **Establiment de línies d'actuació enfocades a l'estalvi energètic i la sostenibilitat.**

1 INTRODUCTION

This project born from the will of a Decathlon Ciutat Vella's sales assistant to develop an idea that can improve his place of work from the side of sustainability and energy saving applying his knowledge that he acquired while he was coursing the Edification Engineering Degree.

The used methodology in this study is the same methodology that others PFG or TFG used in their energy evaluations about schools under the supervision of the Energy Efficiency Department of the EPSEB. We wanted to do a different point of view than the study of scholars centers and we decided to focus in the commercial sector, using Decathlon Ciutat Vella as a building object. The used methodology takes this phases:

FASE 0	**PRE-DIAGNOSIS**
FASE 1	**DATA COLLECT**
FASE 2	**EVALUATION**
FASE 3	**DIAGNOSI & ACTION LINES**
FASE 4	**ACTION PROPOSALS**

Following this methodology, we take care of all of the defined parameters in the regulations and following their evaluation processes. We must analyze the energy balance of the centre, studying all the transmittances of the thermal envelope, using software like LIDER for the energy demand limitation and the CALENER VYP for the energy certification of the building doing an analysis of the climate system. In the case of the lightening system, we used the DIALUX software to evaluate the energy efficiency of the system.

The detailed study of the energy consumption of the centre allowed to evaluate the saving potential and detect disconformities while the users interviews and the monitorizing of the centre has helped to find thermal comfort in the users of Decathlon Ciutat Vella. All of this working tools has been able to help us for a diagnostic realization and establish a list of action lines which objective is improve the energy efficiency and the users thermal comfort.

Finally, we did a maintenance plan that will complement the intervention proposals and will improve the operation of the installations and will extend its useful life.

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1 INTRODUCCIÓ

Aquest projecte neix a partir de la voluntat d'un treballador del centre comercial Decathlon Ciutat Vella de desenvolupar una idea que pogués millorar el lloc on treballa des del punt de vista de la sostenibilitat i l'estalvi energètic aplicant els seus coneixements adquirits durant els seus estudis del grau en Enginyeria de l'Edificació.

La metodologia adoptada durant aquest estudi és la mateixa metodologia emprada en els PFG i TFG d'avaluacions energètiques d'escoles que es porten a terme sota la supervisió del Departament d'Eficiència Energètica de l'EPSEB. Es volia donar un enfocament diferent a l'estudi de centres escolars i es va decidir enfocar-ho de cara el sector comercial, utilitzant com a objecte el centre comercial Decathlon Ciutat Vella. La metodologia emprada comporta les següents fases:

FASE 0	**PREDIAGNOSI**
FASE 1	**AIXECAMENT DE DADES**
FASE 2	**AVALUACIÓ**
FASE 3	**DIAGNOSI I LÍNIES D'ACTUACIÓ**
FASE 4	**PROPOSTES D'ACTUACIÓ**

En el seguiment d'aquesta metodologia s'han tingut en compte tots els paràmetres establerts dins la normativa i seguint els seus procediments d'avaluació. Ha calgut analitzar el balanç energètic del centre, estudiant les transmitàncies de la seva envoltant tèrmica emprant programes informàtics com el LIDER per a la limitació de la demanda energètica i el CALENER VYP per a realitzar la certificació energètica de l'edifici fent un anàlisi del sistema de climatització. En el cas de la instal·lació d'il·luminació hem emprat el programa DIALUX per avaluar l'eficiència energètica del sistema.

L'estudi detallat del consum energètic del centre ha permès avaluar el potencial d'estalvi i detectar disconformitats mentre que les enquestes als usuaris i la monitorització del centre han ajudat a trobar disfuncions de confort tèrmic entre els usuaris del mateix centre. Totes aquestes eines de treball han sigut capaces d'ajudar-nos a realitzar un diagnòstic i establir un seguit de línies d'actuació destinades a millorar l'eficiència energètica i el confort tèrmic del centre. Per finalitzar, s'ha realitzat un pla de manteniment que complementarà les propostes d'intervenció i millorarà el funcionament de les instal·lacions del centre i allargarà la seva vida útil.

2. COMMERCE, SUSTAINABILITY AND ENERGY SAVING

Approximately, a 30% of the use of energy in Spain is consumed for the residential and third sector. This 30% includes the commercial sector, for that it's the proportional part that our study object building takes. We got to consider that this sector includes the tourism sector, very important for Spain and that increases the number. Anyways, the global scale consumed energy in the buildings overcomes the 40% and in national level it takes more than a 30%.

It's for that reason that we can't obviate the commercial sector at the time to adopt measures to achieve the energy saving and the energy demand limitation. This project proposes a list of actions to intervene in those factors. Anyways, there are a lot of factors that we can't see and mind it.

At the moment, the only one approach to sustainability that is happening in the commercial sector goes to new ways of selling including products with supposed more sustainable materials or produced by less aggressive processes with the environment, but really this measures got superfluous character, and it's not very clear if these are achieving any environmental aim. It doesn't mind if the product is realized with a new organic cotton if that cotton is produced in India and the related emissions of CO_2 in the transport keep hurting the environment.

In big surfaces, few companies got energy saving plans at store level, the place where you can do big energy efficiency improvements and where is the true energy saving potential. These actions, in complement of actions at production and transport level, can also get off the related emissions of the product. Small actions that do big changes are the easy measures to adopt, it's not necessary big projects to accomplish with the pretensions of energy saving that you want to achieve.

But we must avoid fall in the ideas that are exposed in the Kazzhoom-Brookes postulate, from the 1980, done by two economists in the United States. That postulate explains the paradox that it could happen when you increase you energy efficiency, so you can increase your energy consumption. That inconsistency is done because of the inversion of the saved capital from energy saving in new decisions that increases your energy consumption.

We believe in the big potential of energy saving that the commerce got and this project shows it by proposals of energy saving related with edification field.

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2. EL COMERÇ, LA SOSTENIBILITAT I L'ESTALVI ENERGÈTIC

Aproximadament un 30% de l'ús de l'energia d'Espanya s'utilitza per al sector residencial i terciari. Aquest 30% engloba el sector del comerç, per tant, és la part proporcional que es refereix al nostre edifici objecte d'estudi. Hem de tenir en compte que aquest sector engloba el sector del turisme, molt important en aquest país i que infla la xifra. De totes maneres, l'energia consumida pels edificis a nivell mundial supera el 40% i a nivell nacional més d'un 30%.

És per aquests motius que no podem obviar el sector del comerç a l'hora d'adoptar mesures per aconseguir l'estalvi energètic i la limitació de la demanda energètica. Aquest treball proposa un seguit d'actuacions per tal d'intervenir en aquests factors. Igualment, hi ha molts factors que poden escapar-se de la nostra vista i a tenir en compte.

De moment, l'únic enfocament cap a la sostenibilitat que s'està donant en el sector del comerç va dirigit a noves formes de venta incloent productes amb suposats materials més sostenibles o produïts amb procediments menys agressius amb el medi ambient, però realment aquestes mesures són de caràcter superflu i no queda massa clar si estan aconseguint cap objectiu mediambiental. Tant se val si el producte està realitzat amb un cotó orgànic si aquest està realitzat a l'Índia i les emissions associades de CO_2 al transport del producte segueixen fent estralls en el medi ambient.

Pel que fa a grans superfícies, poques empreses tenen plans d'estalvi energètic a nivell botiga, lloc on es poden realitzar grans millores d'eficiència energètica i on està el veritable potencial d'estalvi energètic. Aquestes accions, complementades amb accions a nivells de producció i transport, també fan que baixin les emissions associades del producte. Petites accions que realitzen grans canvis són les mesures més fàcils d'adoptar , no calen grans projectes per complir amb les pretensions d'estalvi energètic que es vulguin assolir.

Però hem d'evitar caure dins de les idees que exposa el postulat Kazzhoom-Brookes, realitzat el 1980 per dos economistes a Estats Units. Aquest postulat parla de la paradoxa que es pot donar a l'incrementar la teva eficiència energètica, on també pots augmentar el teu consum d'energia. Aquesta incoherència es deu a invertir el capital estalviat mitjançant l'estalvi energètic en noves decisions que augmenten el consum energètic.

Creiem en el gran potencial d'estalvi energètic que tenen els comerços i aquest projecte ho demostra mitjançant propostes d'estalvi energètic en l'àmbit de l'edificació.

3. CURRENT SITUATION IN DECATHLON SPAIN STORES

Decathlon is an affiliate company of Oxylane, the purpose of Oxylane is “Together, create desirability and make the pleasure and benefits of sport accessible to everyone”. Decathlon is based in Spain since 1992; the first centre was in Badalona, actually Decathlon Montigalà. Normally, all of Decathlon centers are located in big buildings in commercial parks, although there are exceptions like our shop in Ciutat Vella.

We can consider this study of this final degree project pioneer in Decathlon scope, because it has never done any study with concrete interventions proposals. Once time a energy evaluation company, Asena, did a register of electric consumptions of all Decathlon centers in Spain with the intention of do a little energy study. Despite of that, in Decathlon Ciutat Vella, we have never received any concrete energy saving proposals.

That’s true that a lot of decisions were reached, like the change of the climate system in 2011, that makes the center more efficient with a better performance. Although the background of this interventions is guarantee the general comfort of users and customers, not many times we associate that to the energy saving. It’s for that I want to put emphasis in this project, in the sustainability as adoption motor of new measures that brings more energy saving, related to a economy saving.

As an innovative company and promoter of big changes, Decathlon values very positively any measure in a environmental level that always brings energy and economy benefits well justified. We can’t obviate that for big companies this point is very important, and in this project we wanted to argue economically any decision.

But we should repeat that the great saving potential is in the little actions and we should do a very strong animation of these. We must give to the users all of the importance in this plan through environmental awareness programs. One of the big values of Decathlon is the passionate people with their jobs who work in, it’s for that reason that all of purposes of sustainability and environment that we want to establish will be achieved.

Big actions always are in time to be done and these must be managed by anyone engaged, but if we don’t work from the foundations, the ecological pyramid that we want to build won’t reach very up.

Font: www.decathlon.es

3. SITUACIÓ ACTUAL A LES BOTIGUES DECATHLON A ESPANYA

Decathlon és una empresa filial d’Oxylane, el propòsit de la qual és “Crear junts el desig i fer accesible el plaer i els beneficis de l’esport a tothom”. Decathlon porta instaurada a Espanya des de l’any 1992, amb el seu primer centre a Badalona, Decathlon Montigalà. Normalment, tots els Decathlon s’ubiquen en grans naus en parcs comercials, tot i que hi ha excepcions com la nostra botiga de Ciutat Vella.

Aquest estudi en el qual es basa aquest treball final de grau, el podríem considerar pioner dins l’àmbit Decathlon, ja que mai s’ha realitzat un estudi amb propostes concretes d’intervenció. Hi ha constància que una empresa externa, Asena, ha realitzat registres de consums elèctrics a tots els Decathlon Espanya per tal de realitzar un petit estudi energètic. Malgrat això, a Decathlon Ciutat Vella mai hem rebut propostes d’estalvi energètic concretes.

Si que és cert que s’han pres decisions, com el canvi del sistema de climatització l’any 2011, que fan que el centre com a edifici tingui un rendiment millor i sigui més eficient. Tot i que el rerefons d’intervencions d’aquest tipus és garantir el confort general dels usuaris i els clients, poques vegades ho associem a un estalvi energètic. És per això que vull fer èmfasis en aquest projecte en la sostenibilitat com a motor d’adopció de noves mesures que aportin un estalvi energètic, associat evidentment a un estalvi econòmic.

Com a empresa innovadora i promotora de grans canvis, Decathlon valora molt positivament qualsevol mesura a nivell mediambiental sempre que reporti uns beneficis energètics i econòmics ben justificats. No podem obviar que per a les grans empreses aquest aspecte és molt important, i en aquest projecte s’ha volgut argumentar econòmicament qualsevol decisió.

Però hem de remarcar que el gran potencial d’estalvi està en les petites accions i que hem de fer una animació molt forta d’aquestes i fer tots els usuaris actors d’aquestes mesures mitjançant programes de conscienciació ecològica. Un dels grans valors de Decathlon són les persones apassionades pel seu ofici que hi treballen, és per aquest motiu que tots aquells propòsits de sostenibilitat i medi ambient que vulguem proposar-nos seran sempre assolits.

Les grans accions sempre som a temps de realitzar-les i hauran de ser coordinades per alguna persona competent al càrrec però si no treballem la base, la piràmide ecològica que volem construir no arribarà molt amunt.

COMMERCIAL CENTER DECATHLON

CIUTAT VELLA, BARCELONA

PROJECT DEVELOPMENT

This practical cases present's the uniqueness of encompass of two branches of specialization, a brief a analysis of acoustic comfort and a complex analysis of thermal comfort.

The techniqs used to be able to do this study are diferent, as each of the branches nature is, so they have to be treated seperatly, even though to find a solution is has to be done together so that it is adequat for the final spaces in the building, we have adapted performance methodology to be able to fix correctly both aspects.

4. PROJECT DEFINITION

4.1 Methodology

The procedure to establish energy-saving criteria in the buildings needs media's and collaborations at diferent levels. So, from the begining it is important to be able to count on the participation and involvement of all the agents that colaborate in the proceedure.

Inicially in the introduction of the memory, an outline is presented of the methodology of the work, that is organized in four big diferent fases, over the prior fase 0 of pre-diagnosis, is the one that serves to define the begining of the work.

PHASE 0: Pre-diagnosis

The pre-diagnosis es the first in all the proceedure, it is orientated to find out what the disfuntions are presented in the buiding. Finding this out, the building will be presented, it's position and its geometry, it is the starting point and where the problems are found and main objectives to follow.

This way we can appreciate the magnitude if the problem and determine the potential for improvement and viability of the objectives. This scene needs enough information to be able to dentify the tendency of the parameters, a according to the level of information in hand, identify the específic lines they can develope.

Because we have to define the starting point from the information available, in reality what we are doing is a **pre-diagnose**, as the actual diagnose is what we will achieve once we have done a study, with a much more complex analysis at a diferent level after recollecting al the necessary especific information. In case of having to act at a bigger level, the study itself can also have the need of a complete comprehensive energy audit.

In my case, there has been a pre-diagnose performed depending on the available information.

- Level 1: analysis of the global resource consumption of the building.
- Level 2: analyses of environmental comfort to develop the activity.

According with the valuation levels analysed possible lines of action may be defined:

- Especific actions in the building:
  - Energy and waste evaluation.
  - Analysis of indoor air quality.
  - Analysis of the management of the building.

PHASE 1: Lifting Data

It is the first fase of all the excersise, and it depens on a good result and of the reliability that can derive the next fases of the work. the accessibility to the different sources of information needs to be provided to maximum number of different users and managers of the buildings. In this sense, three type's of accessibility have been considered:

- Basic level of accessibility BL: for buildings with not a lot of information or data's that need to veryfied.
- Medium level of accessibility ML: for buildings with parcial data's and that their quality and quantity need to be improved.
- Detailled level of accessibility DL: for buildings with a great amount of data's available, good quality and that only needs verifying.

The data's collected also need to be diferenciated as “static data's” and “dinamic data's”, according to the modifications that they present along time. With that we have the arquitectual overview of the building, which if nothing goes wrong, won't change and are considered “static”, while the intensity of use or comfort of a building's conditions are considered “dynamic”. This diference is made because each of these data's need a diferent kind of work applied and will also have to be reflected in specific documents.

As it has been said, the lifting data process aims to collect all the information of the building so that it's funtion is understood, in which condition it's at and what it's generating resource consumption is. Because of this, it is necessary to diference clearly what will be: “arquitectual data's” which will help to understand how the building works towards the environment (the orientation, the volume or the shadows that occur on the facade, for example)and the “constructive data's” that have to give information about how the building works on it's own and what role does the energetic balance bound and the “data's relating to the facilities”, like the diferent cooling systems and heating, if networking exsist's, or lighting quality sectoralization achieved.

There is a final valuation made where the data's are collected, under a reasonable criteria, and differentiate between quantity and quality. In order to implement the quantity of data, under reasonable criterias, we can: improve de quality of the plans available of the building, perform constructive sections, take photo's and in special cases perform special measurements.

Once you have acces to the most amount of information and data's, the quality has to be improved, that will be achieved by transforming the plans on paper to digital format, doing surveys to users of the building to detect conflicts or desconforts, etc.

The data's that will be collected firstly and the one's collected during the lifting are determined, since the will mark the direction in which how approach the direction in which we should complete process and will allow us also to descry intervention proposals that may result. We have to be realistic and seek to conform to the possibilities and peculiarities of the building to be able to get out the maxium profit of it's singularities.

PHASE 2: Evaluation

Once all the hard work is done searching for all the details, as been stated, it the most entertaining and requires a significant degree of reliability so that all the documentation is reliable, an assessment must be made that will serve to complete the building's diagnostic.

It is then time to process all the details collected in order to evaluate the following concepts:

- Resource consumption from the counters monitoring when possible.
- Resource consumption from the reading and computerisation of the billing details.
- The characterization of systems and appliances that consume energy and covering the demand for air conditioning and lighting.
- The results of test made in-situ.
- And when possible, operating conditions (regarding employment, maintenance , management, and comfort settings).

With these results, we can extract, what we call index o meaningful values, which will allow us to personalize the building.

We must'nt forget the global evaluation of the energetic efficiancy of a building which is done through the comparison between the theory of energetic demnand and the effective consume that can been seen on an anual bill. The analisis of what the building consume's, and what in theory it ought to, will allow us to evaluate the potential saving and the opportunity to save potential and the opportuniy to get better. So, in other aspects such as thermal transmitation, light quality or loudness of the workspaces will have to work through the current regulations.

With that, the study of the routines of the management and maintenance of building systems is handy to detect funtion defaults of the instalations and, at the same time, to determine the fit between the actual level of employment and the degree of response to the systems in their demand for energy and resources. The possible desviations in theses aspects can offer the answer to the diference between theoretic demand and the real consumption registered.

Finally, the assessment of resource consumption must not leave aside the confort assessment of the users of the building: It's about knowing if the building is effective considering the energy needs, but most important, if it's efficiant in relation to the resources consumed to achieve it.

With the index's or significant values we can achieve transform lifted details, in diferent units and with diferent tools, in unified values and compareable (kW/m²), lux/espai, etc) with the other similar building's. Because lots of index's exist that try and characterized the energy use in building,

we must choose the most appropriate according to the objectives of the analysis.

At this point it's when the lifting data's start making sense, because the mechanical task of gathering and registrating transforms into one of the significant index's that allow to compare the building with those index's of reference parametre's, that will help define the starting point from which we will be able to identify the opputunaties to improve the building.

At this point of the work diagnose's can be done, in which you get after evaluating the data and compare with the reference values, and from here, we can define lines of action on which we must intervene.

PHASE 3: The diagnose

The recognition of the general behaviour of the building and it's improvement possibilities are obtained from partial diagnose's of each areas analyzed: architectural energy systems, bound, use and management. This diagnose can start to define lines of action with that can help to improve the service efficiancy (education in first place), energetic use and the resourse consumption of the building, always bearing in mind its viability, tecnicly, economicly and logisticly.

With the diagnose, we should we able to detect the diferent options of improvement in each area of action mentioned, you should also be able to value the proposals in funtion of the dificulties they present when inherent difficulties appear in its execution and maintenance. If a building should present improvement actions in its boundries as in it's air conditioning apparatus, and suposing that they both present a similar energy saving, you must determine what sort of investment is needed for each of them, cost and logisticly wise, before deciding a intervention proposal.

So, the adjustment and the degree of certainty of the diagnose will directly depend on the quality of the information recollected during the lifting data's, and of seriousness of the evaluation of results has been made.

PHASE4:The lines of action

Finally, from the diagnose's we can identify the building's needs so specific plans to improvement can be made to resolve them. The diferent proposals will have to gruped in what is called, line's of action, that are determined by the methodology used during lifting data and evaluatio. And is defined like this:

- Actions related to bound: they are the one's related with the arquitectual and constructive feature's of the building and especialy with it's boundries and interior sections. With these type of actions they imposed on the energetic demand with the aim to reduce it and also the confort of spaces thanks to the correcte development of the activity.
- Actions related to sistems and instalations: where all the intervention's that can be improved the funtion of aparatus and sistem's that atend to the energic demand of a building (lighting, climatization sistem's, flow regulators, etc) are collected.
- Actions that are related to the management of energetic resourses: they will collect all thoses actions indentified with the building's occupational feature's, to it's uses and functions (timetable's, period's, etc).

Each of the actions identified will have to be valuated in four aspect's: it's impact on energy demand of the building, global consumption or saving percentage, that can effect the confort of the users, and both technical and economic viability.

4.2. REGULATORY MARK

The Directive 2002/91/EC's objective is to foster the energy efficiency of the buildings of the European Community, considering the exterior climatic conditions and distinctiveness, as well as indoor environmental requirements and cost-effectiveness.

This Directive establishes requirements according to:

- The general mark of a methodology to calculate the integrated energy efficiency of buildings.
- The application of minimum requirements for energy efficiency in new buildings and existing larger buildings that are subject to major renovations.
- Energy certification of buildings.
- The periodic inspection of boilers and air conditioning systems of buildings and the evaluation of the status of the heating installation with boilers over 15 years.

The transposition in Spain of the objectives of the Directive 2002/91/EC (has recently been amended by Directive 2010/31/EU) has been carried out through a series of regulations:

- **Royal Decree 314/2006** 17th of March 2006, in which the Technical construction Code is approved. The basic requirements laid down in articles 4, 5 and 6 of Directive 2002/91/EC is included in the technical construction Code in the Basic Documents of low power (DB-HE).
- **Royal Decree 1027/2007** 20th of July, where pursuant to the Regulation of thermal facilities in the building. This Royal Decree and the scholarship scheme replaces the Regulation of Thermal installations in buildings (RITE), approved by the Royal Decree of 3st of July 1998/1751.
- **Royal Decree 47/2007** 19th of January, whereby Energy certification of new buildings is approved. This Royal Decree establishes the basic procedure that must comply with the methodology of calculation of the energy efficiency rating, which initiates the certification process, considering those factors which have impact on the energy consumption.

The actual transposition also has the goals at regional level of the Generalitat of Catalonia, where we find:

- **Decree 21/2006**, 14th February 2006, regulating the adoption of environmental criteria and eco-efficiency in buildings.

From the normative point of view, the present study was carried out taking into account established on the building Technical Code, DB HE Energy Saving (part 1 “Limits of the Energetic demand”, part 3 “Energetic efficiancy in the lighting instalations”), DB HS Wholesomeness (part 2 “pick up and disposal of waste”, part 3 “Interior Air Quality”), RITE and the ecoefiaciancy; in terms of looks and appropriate sections on demand, efficiency of systems and internal conditions of thermal wholesomeness. In the Thermographic study has also been contemplated the UE – EN 13187:1999, that allows us to follow the proceedure.

On few topics concerning adapting acoustics has been downloaded on DB HR Protection against noise. Processes in evaluation techniques, reverbenació time UNE-EN ISO 3382:2001 and acoustic insulation, UNE-EN ISO 140-4:1999.

5. PHASE 0: PREDIAGNOSIS

In the first point of the study we are going to define the situation from where we start to evaluate the set of actual problems and then we can define the options of improvement and mark the objectives to achieve.

We will define the characteristics of the building, in this case of the commercial center object of our study. It's also important to complement the information with the interventions that it suffered, in a constructive field as in the maintenance field or installation and services, viewing the initial state from where we start in this evaluation.

5.1 Building description

5.1.1. Geographical location and climatology

The building was built in 1960, it's located in the Gòtic Town of Barcelona, in Ciutat Vella district. It's a segregated building delimited by Canuda St, Ferran Trujols St, Duc St and Vila de Madrid Square. The building is composed of a basement floor, ground floor and eight type floors. It was designed by Albert Argimon replacing the old former building in the same place, designed by Elies Rogent in 1870. It's important to say that in the information panel in the square, there's a façade draws and the reference of our building is Elies Rogent as the architect of the actual building. That information is mistaken and we make reference in the conclusions of this project.

Although the object of our study is only the commercial center Decathlon Ciutat Vella, placed in the basement, ground floor and first floor of the building. The facades of this building are oriented in every direction and the features of its is the number of holes that they have.

All of the nearest buildings are lower than ours, two or three floors respect the building that we treat in this energy evaluation, but our main object is the commercial center in the lower grounds of the building, the nearest buildings always shade it.

The Department of Environment and Housing of Generalitat de Catalunya catalogues Barcelonès climatology as Mediterranean of central litoral kind.

The yearly average rainfall is around of 600mm. The rainiest stations of the year are autumn and spring. And the driest station is summer, and July the driest month. In the metropolitan area of Barcelona, the yearly average of rainy days is 90 days.

The winter is smooth, average temperatures of 9ºC to 11ºC, meanwhile the summers are warm and wet, between 23ºC and 24ºC average. This means that we have an thermal range moderated without big contrasts, not as continental climatology.

Our object building, how is located in the centre of Barcelona city, we must make reference to the Heat Island Phenomenon that happens in the city of Barcelona, where the temperatures can have differences up to +6,9ºC with the suburbs.

Fig. 5.1. Emplaçament centre comercial Decathlon Ciutat Vella, c/Canuda 20, 08002, Barcelona. Font: Google Maps

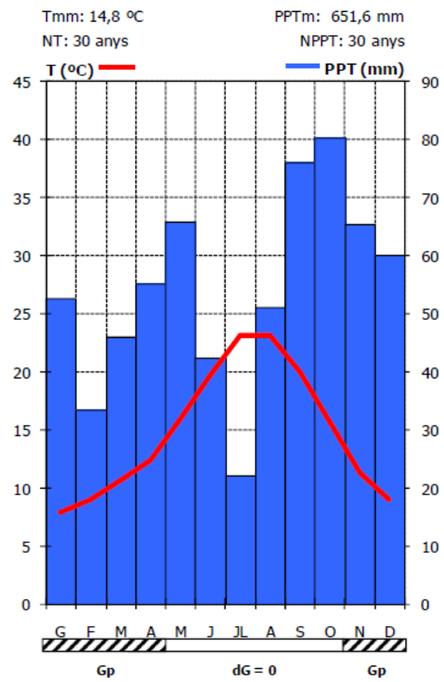

Fig. 5.2. Característiques meteorològiques comarca Barcelonès

Font: Servei Meteorològic de Catalunya

5.1.2. Urban planning and building data

The 12b zone includes the old urban cores of the needed towns of urban improvement, but without a sustainable change of its urban characteristics and the historical centre of Barcelona, with an special preservation and protection, where we locate our object building.

There's two different subzones, one subzone I, in substitution of old edification (12), apply to all the old town cores, not Barcelona, and the subzone II, of historical centre conservation (12b) in reference to the Barcelona's historical centre.

The building parameters in the old town zones changes in order of each subzone. Meanwhile the subzone I, of old edification replacement, is defined with a net building index of 1,40 m^2s/m^2s of application. In the subzone II, of old town conservation, it's not allowed to order volumes that can suppose modifications to the existent planning or the usual heights. The Interior Specials Plans are subjected to a maximum of 0.84 m^2s/m^2s.

Respect to building depth, the subzone I and a PE resulting from employment, the maximum height regulation of 60% of the surface of the island. The space inside the block will not be building on the ground floor but allows the construction of basements for parking, always make sure that the possibility of landscaping on the roof of it. A subzone II, building depth at most will be the existing adjacent buildings.

The Maximum Height have a marked values in the subzone I depending of the width of the streets.

Street width	ARM (m)	Maximum nº floors
Less of 8m	7,55	PB+1PP
From 8m to 12m	10,60	PB+2PP
From 12m to 15m	13,65	PB+3PP
From 15m or more	16,70	PB+4PP

In the subzone II, historic preservation, height in a section of road will be the average of the existing buildings, without calculated not built solar facades. The maximum number of plants will be admitted once made the calculation of the height, the resulting default suppose a minimum height of four feet of ground floor and a minimum height, floors including ground floor of three and five meters centimeters.

The minimum length of the facade is six and a half meters, except for single-family homes permitted on the building facade panels in no less than four meters and eighty centimeters. For parcels with existing structures made at least lateral ground floor and first floor, preventing these values allowed a reduction in the minimum front up to four and a half meters.

Regarding protruding elements in the subzone and are strictly prohibited except for:

- Balconies not protrude more than 20 cm below the streets 6m wide, and 45cm streets over 6m and less than 12m.
- Allowed outbound flight covered a maximum of 45cm.
- Protruding into buildings to 12 m wide roads, provided they do not exceed the line crane in an eighth of the width of the street

In horizontal projection, not occupy the total width more than half the length of the facade and have no wider than three meters and sixty centimeters.

In the subzone II, historic preservation shall apply the criteria set out in sub And while they are not subject to regulation based on detailed compositional character of each part of the street.

5.2. Initial Evaluation

When we speak of a shopping center, we can go to find out the possible shortcomings and problems related to energy efficiency and thermal comfort. Although most patent is if this mall is built in an old building, it planned to lodge a mall as a Decathlon.

The air-conditioning system, lighting system • lighting and computer equipment or communications involving energy waste sources if they are designed as they should be. At first glance, we found that the thermal conditioning system is sectored so that different rooms and offices for the rest of the center, which is basically any store and commercial meters. The zoning is required and the fact that accesses a control that regulates the temperature of the air-conditioning system is very important for the thermal comfort of users, although we found some criticism of the users with respect to thermal comfort.

We should mention that we found malpractices among users who misuse thermostats in the rooms and offices, or excessive

temperature rise in winter or reducing it too much in summer, leaving the air conditioning turned on when there's nobody in the room.

When analyzing visual system Lighting and see that it is a very great because it is a large commercial area, we appreciate that there are in this first evaluation and • lack of lighting in some areas and excessive and lighting in other areas, in addition to a poor distribution of the fixtures. This problem is due to the changes that have been made on a commercial shop, since the distribution of the lights never changed regarding commercial meters. Decathlon is a type of lighting distribution as orthogonal network that makes any change in the level of commercial meters not look concerned, but Decathlon object of our study is difficult to make an illumination distribution a network throughout the orthogonal overlap existing facilities • Installation and variations in ceiling height.

A new arrangement of lights and a new zoning that we believe was made for the convenience of users of light shopping and to reduce over-consumption that can be a bad light from the store.

If you look at the whole system or visual communication that contains the store, we see a point of energy savings if we use the right management tools that can be proposed to reduce the consumption of these systems, despite there is no specific strategy to deal with it, there are users who have chosen to store measures but not others. This presents us ask ourselves standardization of management strategies for all to be participants in the energy saving shop.

Analyzing visually the construction system of the building, especially the thermal envelope, we see that the front of the premises is a series of thermal bridges because it has large windows and they do not have to break the frame and the glazing is thermal twice but only for security and thermal comfort.

All the facades of the premises are of the same type and are oriented to the four directions, both in the direction we should note that the front covers mostly the northeast entrance hall of the hotel in the of Duke street, while the southwest facade (Pl.Vila Madrid) is the window openings and more are available at an orientation that receives more sunlight. This orientation makes it to the final hours of the day the temperature rises in areas that are located on this facade, fortunately, many of these areas have adjustable thermostat (offices, break room and training room) but the store does not exist and sometimes suffers from excessive heat during this time.

Although I think it should be an intervention in the building envelope, the most effective way to save energy and have a faster payback would act in the management of systems to reduce consumption and increase the thermal comfort of users.

Before establishing goals and understand the mall which we are doing this study was to establish a list of actions and changes that have been happening at the store in terms of thermal conditioning systems , lighting, etc. or just trade have been important changes that have taken without being planned problematic on several levels. There is no evidence anywhere since 2001, the year of creation of shop, all changes or changes in trading systems that have been happening, so we've highlighted the most important in the last 5 years.

- • 2009: New flooring on all floors, retired classic green carpet for flooring Decathlon plastic..
- 2010: • Will the new air-conditioning system, replacing the old system was outdated and did not ensure that the thermal comfort. During the installation of this fan is placed to smooth excessive warmth that existed during the change.
- 2011: Change in the commercial department, Running went from the basement to the ground floor down to the basement by the Department of Fitness Equipment.
- 2011: the painting of all the Sprinklers system.
- 2011: Redistribution download truck room.
- 2012: Creation of the new section of bike in the basement, to occupy nearly half of the plant. We created a lot unconformities regarding the distribution of lights, since it upset the established order of the aisles with another commercial management of the meters and the construction of all new samples of bicycles.
- 2012: Creating new visual (decorative translucent vinyl) in the windows of the mall.
- Actions planned short and long term: Standing in the living room floor of truck unloading and installation of a ramp motorized redistribution zone boxes and installing new models of boxes, change the system of lights (although there is nothing concrete but the intention is to change it).

5.3. Aims

Viewing the initial evaluation of the project, the objectives we want to achieve in this project are:

- Inventory all installations of air conditioning and lighting of the center.
- Control and monitoring of user comfort conditions Decathlon Ciutat Vella shopping center and identify current problems.
- Identify the problems of lighting system to improve it and make it more effective and efficient energy and lightly. Adapted to the morphology of the current store.
- Perform an energy balance of the mall, watching what creates the demand and consumption of energy resources.

- Create strategies for management, maintenance and use of spaces that are standard for all users and to facilitate energy saving.
- Promote all strategies and measures between users Decathlon Old Town shopping center because they become effective.

6. Phase 1: Data Lifting

In this phase we do a data collect, classifying it in two groups: static or dynamic, it depends if the data refers to the building, its architecture, constructive composition, installation systems, etc. or if it is data that makes sense on the users and his behaviors, consumption analysis, etc.

We also make the classification of the accessibility to the Decathlon Ciutat Vella data and we can say that this data accessibility is Medium Level, the existent data from we started are the next ones:

- A kit of plans of 2006, of the floors plants of the commercial centre with the distribution of the commercial meters in this moment. It was created by PROJECTES S.A., Oficina d'Enginyeria for an Ambient Evaluation which we haven't found more information about because this bureau doesn't exist now.
- S.A. de Electrificaciones y Suministros (SADES) give to us part of the acclimatization project from the year 2011 where there was all the technical data of the used machines.
- ONBRAND, a design company, in 2012, did the project of changing the banners of the windows of the commercial centre with a new vinyl.
- A maintenance manager from Decathlon Spain gave me the data of the electrical consumption from 2010, 2011, and 2012 in an excel document from Decathlon Ciutat Vella.
- In the Arxiu Històric Contemporani and the COAC Archive we found the original project from Albert Argimon, 1960. Floor plans of all the building, many sections of the building, a descriptive memory and an old budget, but it wasn't construction details and it was difficult to determinate the used construction systems.

Because I work in this commercial centre, I've could entered in every space without problems during all the data lifting process.

I've got to update all the graphic information because the existent isn't correct and then I did an accurate inventory of all the systems, consumption machines, uses, etc.

6.1. Static Data

6.1.1. Architecture

The building is located in the city center of Barcelona, in a very commercial area. It is an isolated building between plaça Vila de Madrid, carrer Duc, carrer Canuda and Francesc Trujols. It's a building composed by a basement floor, ground floor, seven floor and an attic floor.

The building was built the year 1960 and the architect was Albert Argimon. In a beginning it was designed as a block of five units destined to "Vivendas de Renda Limitada, Urbana de Edificios S.A.". The ground floor and the basement floor were originally designed for a commercial use and the first floor for office use. The actual situation is that in the basement floor, ground floor and first we can find the commercial centre, object of our study.

The facades of the Decathlon Ciutat Vella are characterized by a large number of openings of considerable size and occupy the four sides of the building. Create a trapezoidal shape in plan. We describe the walls one by one:

- Front of the Plaza Villa Madrid facing southwest is where is located the area of boxes, some of the same offices and rooms Decathlon. This is the facade that keeps more distance the building is in front, as is the square itself. It is also where the access to the upper floors of houses. Get a strong solar irradiation in the last hours of sun due to its orientation.
- Front Francesc Trujols Street: facing east is the facade that faces a side street. No entry exits only in the front.
- Front of Duc Street: facing north-east, this facade locate an emergency exit on the corner of Francesc Trujols Street. It corresponds to the front entrance of the hotel occupying the upper floors of the building. Also there is the entrance to the reserve is on the truck unloading product from the warehouse.
- Front Canuda Street: oriented to the west, is located on the front of all entrances to the mall. There is also a service entrance of the hotel which is located in the Duc Street.

As for the roof, we must keep in mind that occupies the central domed skylight where there is part of the roof.

It is noteworthy that the building has double height spaces, such as in the area of banks or the central core with three openings that connect to the mezzanine floor. These architectural features are important in particular when conducting this study.

Fig. 6.1. Façana Pl. Vila de Madrid. Font: Elaboració Pròpia

Fig. 6.2. Fotografia panoràmica Façana c/ Canuda. Font: Elaboració Pròpia

Fig. 6.3. Detall cúpula a la planta altell.

6.1.2. Construction

Here we will try to define the building constructive purpose to obtain the most accurate and clear materials that make up the envelope and interior partitions of the mall. Although we did not have construction details of the project we had a pretty poor memory which did not specify clearly what materials were used in the initial project in 1960.

I based this report, the construction techniques of the sixties, and our student's career has been defined building units.

- The external partitions of all the facades are stone finished and I've considered the next constructive composition:
    1. Porous natural rock d<1600 (5cm)
    2. Cement mortar (1,5cm)
    3. 1 metric brick feet 40mm<G<50mm (24cm)
    4. Air chamber no ventilation (5cm)
    5. ½ metric brick feet 40mm<G<50mm (11,5cm)
    6. High strength plaster 900<d<1200 (1,5cm)
    7. Light plaster d<1000 (1cm)
        - TOTAL: 49,5cm

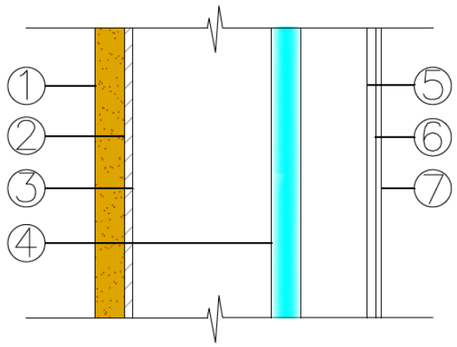

Fig. 6.4. Secció tipus façana. Font: Elaboració Pròpia

- The basement walls of the basement, we take it without waterproofing
    1. Reinforced concrete 2300<2500 (40 cm)
        - TOTAL: 40cm

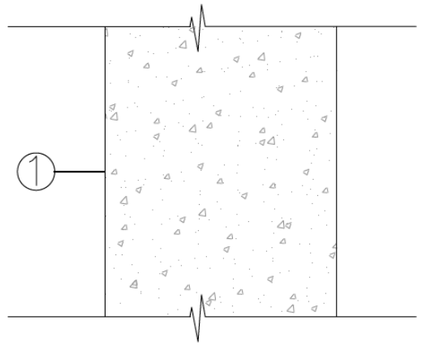

Fig. 6.5. Secció tipus mur de soterrani. Font: Elaboració Pròpia

- For the slab in contact with the ground, we choose this next composition:
    1. Gravel and sand (1700<d<2200) (25cm)
    2. Concrete 2300<d<2600 (30 cm)
    3. Cement mortar (3cm)
    4. Ceramic tile (2,5cm)
    5. PVC sheet (0,5cm)

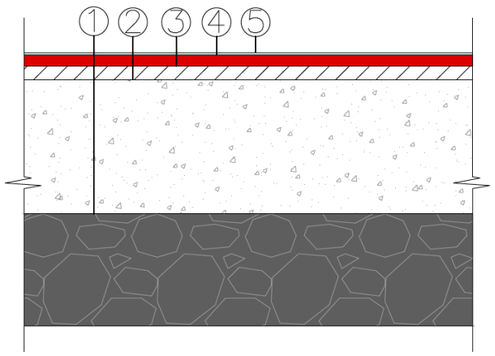

Fig. 6.6. Secció tipus Solera. Font: Elaboració Pròpia

- For the ceiling slabs, we choose the next composition:
    1. PVC Sheet for a pavement (0,5cm)
    2. Ceramic tile (2cm)
    3. Cement mortar (2,5cm)
    4. Unidirectional Ceramic Slab (width 30cm)
    5. High Strength Plaster 900<d<1200 (1,5cm)
    6. Light plaster d<1000 (1cm)

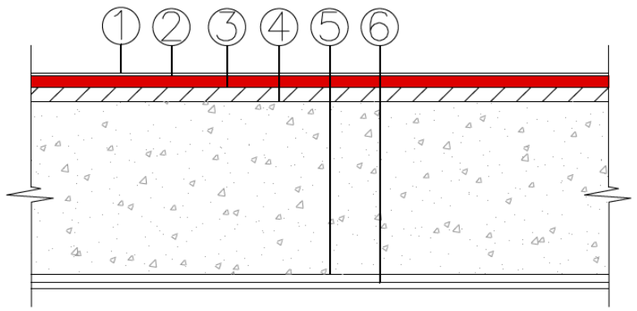

Fig. 6.7. Secció tipus Sostre. Font: Elaboració Pròpia

- In the roof that we have inside the dome court, the constructive solution that we've found is the catalan roof with the next composition:
    1. Triple ceramic tile (6cm)
    2. Ventilated air chamber (10cm)
    3. Lightweight aggregate mortar (7cm)
    4. Unidirectional Ceramic Slab (width 30cm)
    5. High strength plaster 900<d<1600 (1,5cm)
    6. Light plaster d<1000(1cm)

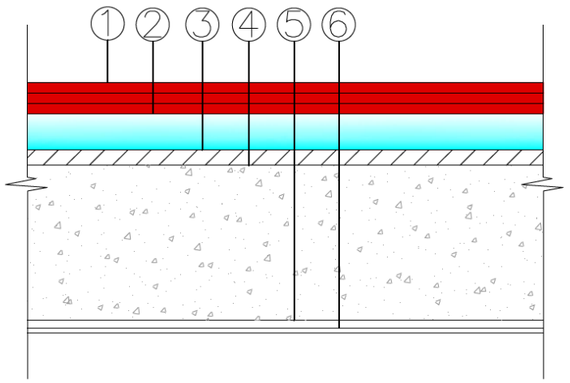

Fig. 6.8. Secció Tipus Coberta. Font: Elaboració Pròpia

- For he internal partitions :
    1. Medium strength plaster 600<d<900 (2cm)
    2. Double Hollow Brick (13cm)
    3. Medium strength plaster 600<d<900 (2cm)

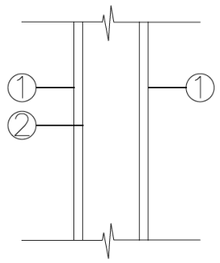

Fig. 6.9. Secció Tipus Partició Interior. Font: Elaboració Pròpia

- The windows carpentry is aluminum without thermal bridge crash, meanwhile the glass is double but without chamber.
- The dome of the first floor is of security glass but without any chamber, the structure of the doom is steel.

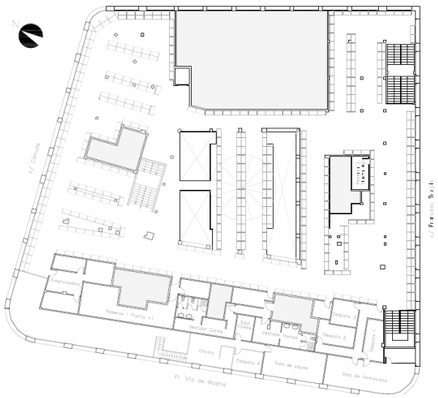

Fig. 6.10. Planta Altell. Font: Elaboració Pròpia

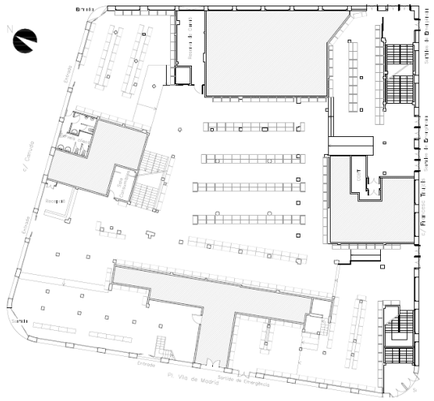

Fig. 6.11. Planta Baixa. Font: Elaboració Pròpia

Fig. 6.12. Planta Soterrani. Font: Elaboració Pròpia

6.1.3. Installations

In this section we defined the systems and devices that make up the whole installation facilities • Shopping Centre. Of course, there are the same systems in a building or other residential buildings in the tertiary sector. However, the intention is to identify and describe all the systems that create points of consumption.

I had to gather information visually, for example, inventorying all the lighting system or with recent documentation in the case of the HVAC system was replaced in the summer of 2011.

Regarding the air conditioning system is a heat pump with VRV system indoor units (cassette units, wall units, units of behavior, etc..) And can supply heat and cold. The system is composed entirely DAIKIN machinery. All the machinery pool, which are heat pumps (model DAIKIN VRV SYSTEM RXYQ-54P (A) _P8 (A)) is located on the roof of the building in a private area within the soundproof cover that is communal. The model unit is mainly dominated by inner drive four-way cassette, more commonly known as fan coils (model-DAIKIN FXFQ M8V3B). In fact, the entire basement is fitted with this type of indoor unit. As the ground floor and the mezzanine are other types of indoor units part of fan coils. In the area of boxes to cover the double height has installed a duct units (model-DAIKIN FXSQ P7VEB) to cover the area more efficiently because it is a very difficult area to double the height and the southeast orientation in the final hours of the afternoon in summer. The solution used in offices, meeting rooms and a solution with some reservations wall units (model-DAIKIN FXAQ Mave) with a thermostat that adjusts the temperature or turn on / off the unit inside. We also find some specific units in horizontal ceiling of four routes (model DAIKIN FXUQ-MV1), but more like a compact fan coils. Each model has the characteristics that we attached in the Annex and I had to use to make parts of this study.

The ventilation of spaces is done using mechanical heat recovers installed in openings made in the windows of the facades. The mall is not aired anywhere naturally, it is a shop completely watertight. These heat recovers are brand NOVOVENT and have installed a total of eight. NOVO-curd correspond to models 140, 190, 250 and 320. With these devices, the mall can ventilate but also reduce energy intake making machinery of the air-conditioning system because the air does not mix with the air conditioning off because of conditioning in the making temperature change is not very important and costs less heating or cooling as needed.

The lighting of the mall is one of the most important facilities in this project, which is vital when performing any activity on this site, but also in other building come to refer to the commercial sector lighting is very important because the more light there is, the more it sells. This is why we run a risk analysis of this system, we can fall into and a lack of or excess lighting • lighting • lights, depending on what we have in mind.

The lighting of the shop is done basically fluorescent lamps with electromagnetic ballast, hanging or fixed to the ceiling, strip sets consist of one or two fluorescent reflector lamp installed. Most fluorescent tubes that are in the retail space are 58W and 36W, while the offices and rooms predominate in fluorescent 18W fluorescent lamps four.

In the basement, in addition to fingers fluorescent exist 42W compact fluorescent lamps that illuminate the space and other specific lighting 2x26W commercial meters. The area of the dome is placed on a 150W and 100W halogen floodlights, a total of sixteen focus.

There is also the existence of a 60W incandescent bulb in the locker room and some of the workers.

Another system that exists in the store is based Fire Sprinklers system, consisting of a closed water circuit and a series of sprinklers activated when the temperature goes beyond the normal limits. Machinery, ie the pump drive this system is in a room in the basement and a pump power of 37kW power.

Regarding the ACS system, I have not covered in this paper because it consists only of a tank that also functions as heating water for two showers in the locker room. I think the demand for hot water is negligible and does not represent a significant value at the time of this study.

Fig. 6.13. Detall de la unitat de conductes del sistema de climatització a la zona de caixes. Font: Elaboració Pròpia