RELEVANCE OF THERMAL FLUXES THROUGH THE BUILDING'S INTERIOR PARTITIONS

Roger Llorens Viader
Research Associate
at *Laboratori d'innovació i Tecnologia a l'Arquitectura* [LiTA] and architecture student at *Universitat Politècnica de Catalunya*,
Barcelona,
Spain
rogerllovi@gmail.com

Joan-LLuís Zamora i Mestre
Chief Research at LiTA and Professor at *Universitat Politècnica de Catalunya*,
Barcelona,
Spain
joan.lluis.zamora@upc.edu

Summary

Efficient thermal insulation has so far been aimed at improving building envelopes, understanding a building as a unique thermal space. Although it could be the case in some kinds of constructions, because of the higher degree of independence of individual persons and the concentration of people in multi-story buildings internal energy fluxes are generated and this caused us to wonder about the relevance of climatic energy loss through interior partitions according to different occupancy patterns. We tested one real Uni-thermal-Zone-Buildings and one virtual Multi-thermal-Zone-Buildings in order to determine the relevance of these thermal losses in the main buildings typology to identify a week point to focus on.

Keywords: thermal energy fluxes; occupancy patterns; thermal insulation; interior partitions.

Extended abstract

Thermal efficiency in buildings is becoming one of the most useful parameters to improve our buildings and contribute to save energy and money for both inhabitants and countries. Furthermore, it could suppose an opportunity to redefine the goal of architecture, which would then center on the building's utilization stage instead of its design or construction stage. However, thermal efficiency in buildings has so far focused on improving building envelopes and concentrating on the relation between interior and exterior spaces. This is a very important approach to the topic and has been deeply studied all over the world by very efficient teams and companies, but we wondered about what happens inside the building. As we know, buildings do not work as a single space with only one activity, but rather function as a conglomerate of activities and spaces with different heating needs. In consequence, we focused on calibrating the relevance of thermal fluxes through these interior building partitions comparing them with thermal fluxes through all exterior enclosures. That way we could determine the importance of incorporating thermal insulation in these interior partitions to achieve a better thermal efficiency in buildings.

Aiming to answer this question, we designed a progressive approach to the phenomenon by dividing our research project into two main building typologies. The first ones are called Uni-thermal-Zone-Buildings (UZB) and consist of all those buildings using a programme with no big heating need differences between spaces. Public facilities are usually included in this building typology due to the missing physical partitions between different utilizations. The UZB case study we chose is the Vallès Higher School of Architecture (ETSAV) from the Polytechnic University of

Catalunya (UPC). The second building typology we used in our research are the Multy-thermal-Zone-Buildings (MZB) which encompasses all residential buildings. In this case, the main feature is the great fragmentation of the spaces. In residential buildings, for instance, each dwelling has six surfaces through which to gain or lose heat. The same thing happens in hotels and all those buildings with a high physical, if not thermal, space compartmentalization.

Once this first classification was completed, we started studying UZB as we supposed them to be conceptually simpler than MZB, which could subsequently help us to properly understand the phenomenon. First of all, we developed a surface and ambiance temperature measurement protocol with the objective of proving the phenomenon's existence. For that reason, we registered the ambiance temperature of some ETSAV's spaces during six months, to then compare them with the surface temperatures of the same specific spaces chosen for their characteristic conditions. The results pointed out that there were energy fluxes through all partitions we tested, and so we delved farther into the research. The second step, according to UZB, consisted in developing a thermal calculation model in which we would be able to compare energy losses through interior and exterior partitions. To achieve this, we selected the ETSAV building, which is fully monitored by SIRENA systems from the UPC (http://www.upc.edu/sirena), thereby providing us with the electricity and gas value used in the building, as well as enabling us to calibrate our model according to real energy consumption. To develop this thermal model we chose to work with the excel format and calculate the parameters of thermal loss through the building's envelop, interior partitions and through air renovation. To gauge thermal gain we took occupation, electric consumption and gas consumption into account. With these basic items we were able to calculate and compare thermal losses through interior and exterior partitions. The results show that, in our UZB case study, 20,46% of heat loss occurs through interior partitions, which might not appear to be a great amount but is actually significant if we review the building's construction. It is a building with an enormous air volume along with low variability of temperature between different spaces and a very low thermal efficiency in the façade because of the seen structure, which constitutes a big cold bridge, in addition to the simple windows designed without considering the transmittance value.

With these first results in hand, and knowing more about what the phenomenon represents, we walked into MZB, to check the relevance of thermal fluxes through interior partitions in that building typology. In this case, we used a basic virtual 3D shape to represent our building. We put together a 3x3 mesh with two-façade units, resulting in an overall of nine spaces. We worked on the most basic model of multi-story building using the same excel styled model and the same parameters as we did with the UZB. In this case, the amount of energy lost through interior partitions ranged from 25,7% to more than 70% of the total heat loss. We can hence see that these interior energy loses can reach very high values in MZB and could thereby expose an important area to work on if we want to improve the thermal efficiency of this building.

To conclude, we would like to point out the relevance of the typology-dependent thermal behaviour of buildings. There is not just one approach or solution to improve a building's thermal efficiency. As we see, the main problem to achieve a correct energy efficiency in UZB is not thermal loss through interior partitions. In MZB, on the other hand, it plays a key role in this. It could therefore be interesting to think about independent thermal zones in MZB overlapping each housing unit, allowing the users to consume just what they need. Moreover, the residential sector is the most usual in building typologies and could represent an excellent opportunity to further improve inhabitants' comfort. Finally, we realized that, according to thermal efficiency, the more the façade is improved, the more significance heat loss through interior partitions acquires. This point leads us to wonder whether both interior and exterior partitions should be drawn up together in order to reach a balanced thermal behaviour of the buildings. Otherwise, we could have been working on just half the problem.

Short bibliography

:: paper: "Una visión-país para el sector de la edificaicón en España. Hoja de ruta para un nuevo sector de la vivienda". Grupo de Trabajo sobre Rehabilitación [GTR]. Albert Cuchí i Peter Sweatman. Novembre 2011.

RELEVANCE OF THERMAL FLUXES THROUGH THE BUILDING'S INTERIOR PARTITIONS

summarized paper.

1. Introduction

For some years now our country has been working towards a greater efficiency in the use of energy through passive measures such as the improvement of thermal insulation of building's enclosure walls that enables it to lower its cost. The progress in this field has been tremendous compared to some years back. However, it is fairly clear that this progress was headed in one direction only: improving the external envelope.
It is true that the greatest amount of heat loss occurs through these enclosure walls. Nevertheless, once they are improved, we realize we still have heat losses in our buildings probably through openings, ventilation systems, towards the interior of the building through internal partitions and so on.
This research will attempt to identify and quantify one of these possible thermal vanishing points using different thermal measurements and elementary computational modelling. The phenomenon to be recognized in this project is the one on thermal losses through interior partitions that divide properties or spaces with different degrees of climate control.
The building tradition within the Spanish state displays a systematic lack of thermal insulation in these partitions, since the *Codigo Técnico de la Edificación* (CTE) has not included them explicitly until 2006. Currently, due to a much more dynamic and heterogeneous society where individuals are becoming more and more independent from their environment, we believe it to be necessary to review the lack of thermal insulation of interior partitions and review the effectiveness of incorporating, or not, thermal insulation in its composition.

1.1 Goals

The main aim of this research is to confirm the existence of this phenomenon and find out its current reflection in the energy loss of both uni-zone and uni-heat-generator buildings such as in the study case (Escola Tècnica Superior d'Arquitectura del Vallès. UPC_ETSAV), and in collective housing blocks where the compartmentalizing takes special weight and thermal energy management is monitored entirely by each inhabitant due to a predominant system of individual thermal generation.

Consequently, this research will connect the winter term thermal balances sheets of two significant building typologies such as a high volume public building (equipment) and multistori family blocks (residential), since they have a higher impact on our territory.

1.2 Initial hypothesis

Because of the change in the way society functions, caused by a higher concentration of people in apartment blocks along with a higher independence of the block's inhabitants from their neighbours, we consider the heterogeneity of the patterns of employment inside the same building as a significant value to take into account. We plan to verify the relevance within their performance and the thermal fluxes of two prevailing building typologies: large facilities and residential buildings. In line with this idea, we contemplate several departure hypothesis regarding the thermal fluxes with the aim of checking the relevance of considering the thermal insulation on building’s interior partitions or, if not, whether they represent too small a percentage to be taken into account.

1.2.1 The temperature difference between two spaces will cause the energy flux through the partitions separating them. Therefore, a space loses energy while the other gains it. Consequently, we will check that the parameters involved in the energy flux modify the surface temperature in relation to the room temperature. This might be useful as an indicator of the phenomenon's existence.

1.2.2 The more insulated the building façade is the more the percentage of internal thermal loses will grow since, if untreated, the phenomenon will keep within constant values while we continue decreasing the energy transmission to the outside. This leads us to think that, in order to improve the energy efficiency of the buildings, it is necessary to consider both interior and exterior enclosure walls as “thermal frontiers” that must be treated simultaneously.

1.2.3 In buildings such as public facilities, managed by only one air conditioning system, the interior thermal transmission will be less relevant due to the large volumes of air to move, the homogeneity of uses and the interior temperatures. However, it is necessary to see what values are achieved.

1.2.4 In residential buildings such as collective apartments or hotel complexes, the great fragmentation of spaces into little unities means a larger contact area between internal spaces with different levels of heating. Hence we suppose that there will be a higher percentage of internal losses. A priori, we assume that this sector is the most appropriate to apply our theories.

1.3 Methodology

In order to make the research rigorous enough, a methodology must be based on the progress of the stages within the considered stages. Therefore, we have divided the work in two main stages: Study of one Uni-thermal-Zone Building (UZB) and Study of one Multi-thermal-Zone Building (MZB). We can thus do a progressive approximation to the phenomenon, as the progressing research becomes increasingly complex.

1.3.1 Typology 01 :: Uni-thermal-Zone Buildings [UZB]

In this first stage, we are going to focus on doing the first verification of the phenomenon in the Escola Tècnica Superior d’Arquitectura del Vallès’ building, which is linked to the Universitat Politènica de Catalunya [ETSAV]. This process is going to be divided into two stages in order to be able to continue with the progression mentioned above.

Fig. 1: ETSAV's building

Stage 01
The first stage consists in choosing different characteristic spaces from ETSAV's building and carrying out a field campaign to prove both the air and surface temperatures of all the enclosure walls using a thermographic camera and a surface thermometer. This test will determine if it is true that rooms are gaining or losing energy through their enclosure walls in contact with other interior spaces.

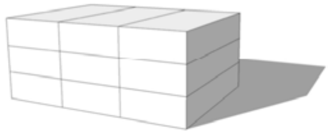
Stage 02
Afterwards, in stage 2, we will find out what areas of ETSAV are heated and which areas are not. Therefore, we will be able to determine one hot perimeter enclosure and one cold one. This will be used for quantifying the total area of what we suppose is the one that is losing part of the energy.

With all this data, we are likely to move on to develop an unchanged and simplified thermal model of the Escola Tècnica Superior d'Arquitectura del Vallès, on an Excel* spreadsheet format where the flux values of will be reflected through both interior and exterior parameters, as well as reflecting what percentage they represent of the total.

In order to make this model as reliable as possible, we are going to evaluate it along with the SIRENA data (http://www.upc.edu/sirena/). This is a computing system which enables us to check the energy consumed in the UPC buildings and the historical archive of both electrical and gas consumptions, in real-time and with disaggregated values.

Fig. 2: virtualized building

1.3.2 Typology 02 :: Multi-thermal-Zone Buildings [MZB]



Once the situation has been verified in a simple model such as the UZB, we are going to approach another building typology such as residential blocks or multistory housing units. In this case, we are going to focus on a hypothetical model in order to simplify concepts.

So as to start familiarizing ourselves with this second model we will devise a multistory housing unit in the shape of a grid of 3x3 boxes, which will allow us to quickly and intuitively corroborate the main differences between the thermal flux of basic MZB and the UZB that we would have made previously. The first step will be to work out every aggregation unit that makes up the grid to see how much energy is lost in each and every type of enclosure wall, both exterior and interior. We will use the same environmental data as for the UZB.

Finally, still using this simplified model, we will introduce the concept of synchronous combinations. This concept is aimed at moving us closer to a real situation where the building remains energetically activated, yet or entirely so. The aim is to “switch on” certain buildings and find out how the contact surfaces increase or decrease in each type of non-heated spaces, thus pinpointing the relevance of the losses through the internal partitions as opposed the ones that are produced through external enclosure walls.

At this very point, if the results are favourable, we would suggest to begin a new research line to delve further into the concepts that appear in this paper, this time with real buildings and more sophisticated software in order to add certain complexity and realism to both the usage patterns of each unity and the thermal fluxes that they generate.

2. Typology 01 :: UZB

As a starting point for this first challenge, we take the main building of ETSAV, which is attached to the *Universitat Politècnica de Catalunya* as a reference building.

The building, as a public facility is characterised by being isolated, with huge air volume and little compartmentalization of the interior space. In this sense, we have anticipated that the distribution of the interior temperature is going to be more constant in the whole building. It should also become more difficult to notice the variations during the day.
According to the existence of heated and non-heated interior spaces in the same building, we notice that most of the spaces are heated, consequently few spaces remain unheated or receive air directly from outdoors. Thus, we expect a huge façade surface between interior and exterior conditions, while the total area that divides the heated interior spaces from the unheated ones will be significantly smaller. Up to this point, we can expect that we are dealing with an unfavourable case since we have to face huge losses through the interior partitions.

It is also important to take into account that, due to the construction practices from past years in our country, all the external enclosure walls, including the glazed ones, have high thermal transmittance values and therefore also have significant exterior losses, which will decrease the internal losses proportionally.

2.1 initial data

In order to position the modernized buildings in ETSAV in the first phase and the ideal building in the second phase, we will from now on place both models in the city of Sant Cugat del Vallès.
Area of the city: 48,32 Km^{2}. Height: I24m above SL. Rainfall: 600 mm annual. Average temperature: I4,2 ºC

fig.6: thermal imaging of one of the ETSAV's chosen spaces Fig. 3: ETSAV's PB Fig. 4: ETSAV's PB+1/2 Fig. 5: ETSAV's PB+2

2.2 Hypothesis

2.2.1 The surface temperatures of the enclosure walls that set out an interior space in relation to another interior spaces will be increased or decreased according to the ambient temperature in the event of loss through these enclosures.

2.2.2 Because of the construction systems used in the project and construction process (1989-1991), it will show several energy losses in the façade, particularly in the windows.

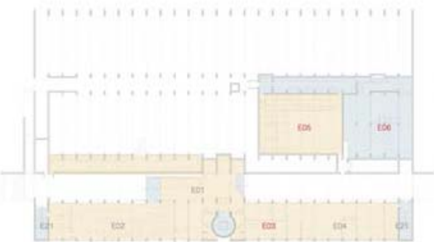
2.2.3 Since the building is highly compact with little unheated spaces remaining, the volume of the internal losses will attain a lower percentage in respect to the total of the losses.

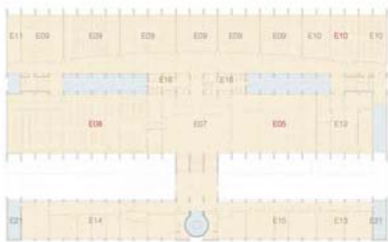
2.3 Stage 01 :: monitoring protocol

We will choose certain significant spaces of ETSAV and will do a real and punctual thermal monitoring, comparing the air temperatures to the surface walls with the aim of doing a first approach to the reality of this building regarding the internal thermal losses.

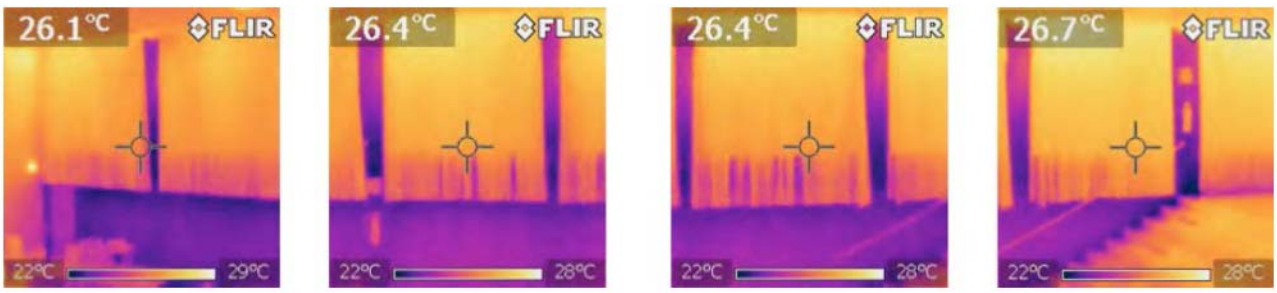
This first test will serve as a means of checking our initial hypothesis. This monitoring will serve to see how both surface and ambience temperatures of the different spaces change and will also serve to determine through which partitions the energy is gained or lost. In a nutshell, this will be our flux control.

The chosen spaces are representatives of certain activities that are not exclusive to the university and can hence be found in other buildings. Therefore, the selection of spaces is as follows: the Event Hall, the Library, the Computer Room, the Workshop Classroom (open 24h, 7 days a week), a Bookshop and a Stationary shop, common Toilets and the Boiler Room. The exact location of the spaces can be found in the planimetry below, highlighted in red-marked text.





The result of this monitoring protocol is to draw some graphics with the values of both ambiance and surface temperature of each chosen space in order to compare them in a supposed stable thermal state. With these graphics we will be able to ensure that energy transmission is occurring through all those partitions with a surface temperature other than the ambiance one. This basic test will prove the phenomenon's existence and allow us to dig deeper into the research.



ig. 7: UZB thermal model calculation screen-captures

2.4 Stage 02 :: thermal model calculation

In order to continue progressively with the research's development, we have to check the total magnitude once we have confirmed the existence of the lost energy phenomenon through a building's interior enclosure walls. We will achieve this by taking the ETSAV's building as a reference, since we have easy access to all data, which offers the possibility of calibration and verification of the results.

With the purpose of carrying out this model we have access to the final plans of the School provided by ETSAV's Delegació d'Estudiants. Once we have studied them, we will determine the enclosure walls' thermal resistance. Afterwards, we will develop a spreadsheet model such as excel*. This format was chosen for its simplicity and reliability when developing a diachronic thermal model such as the one that we will develop later on. One of the main data needed for this calculation are the average temperature, both inside and outside the ETSAV. For this reason, we will contact Mr. Eduard Bravo, a professor from the Physics Department of the ETSAV, since he can provide us with the data of the automatic weather station located on the ETSAV'S roof.

Fig. 3: ETSAV's PB

These calculations will be made by March 2012 as it is the first month of the year in which the ETSAV recovers its full, all-day, all-month activity while still falling inside the winter term. All the work broken down here has been developed from the starting point that only in the cold season is calorific energy transmitted. None of the calculations that are generated from there will include the summer term or the consequences that could ensue. Our aim is to balance the equation of the thermal-flux balance in winter. Therefore, the initial unknown elements of the thermal flux balance equation that we will take into account are the following: Transmission through the enclosure walls, interior air renewals, internal load and electrical system emissions.

The value of the solar contribution is negligible due to the architecture of the building. On one hand, the final edge of the School is a layer of white paint that reflects most of this contribution. On the other hand the building's south façades have good protection systems against solar radiation, reducing the absolute value of the gains by solar radiation to minimum levels. All these concepts will be related in order to make it so that you can calibrate the model according to the consumption data through the initial data. In regard to the energy transmission assessment through the enclosure walls, both interior and exterior, we can differentiate three typologies in relation to the spaces they separate: Energy transmission from a heated interior space to an exterior space through the façade, energy transmission from a heated interior space to a unheated interior space and energy transmission from a heated interior space to an exterior patio area with conditions that differ from the environmental ones. This difference has been measured in order to take into account the different thermal behaviours between environments that can be found within the same building. So as to do this as accuratly as possible, but within the feasibility of a simple model, we will also take into consideration the losses through both the roof and the foundations in contact with the ground.

Finally, to facilitate the quantitative validation of the model, we will consult the consumption data which the SIRENA website provides, developed by the Universitat Politècnica de Catalunya. This will supply us with the values of the gas and electricity consumption of the ETSAV's building, in real and historical time. This will enable us to set out the flux balance in the system.

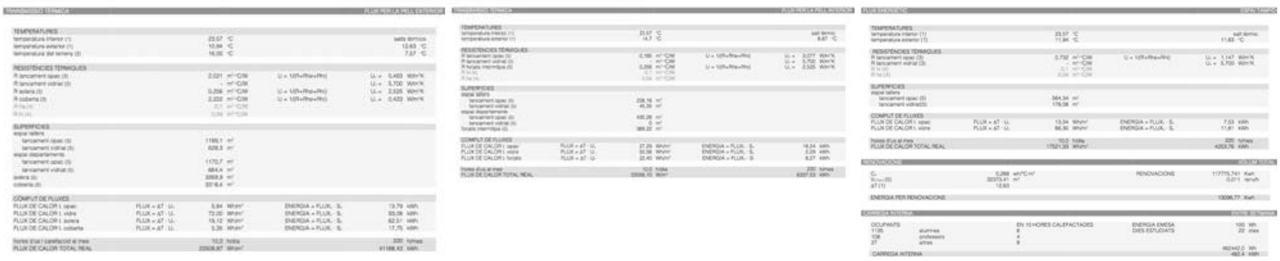
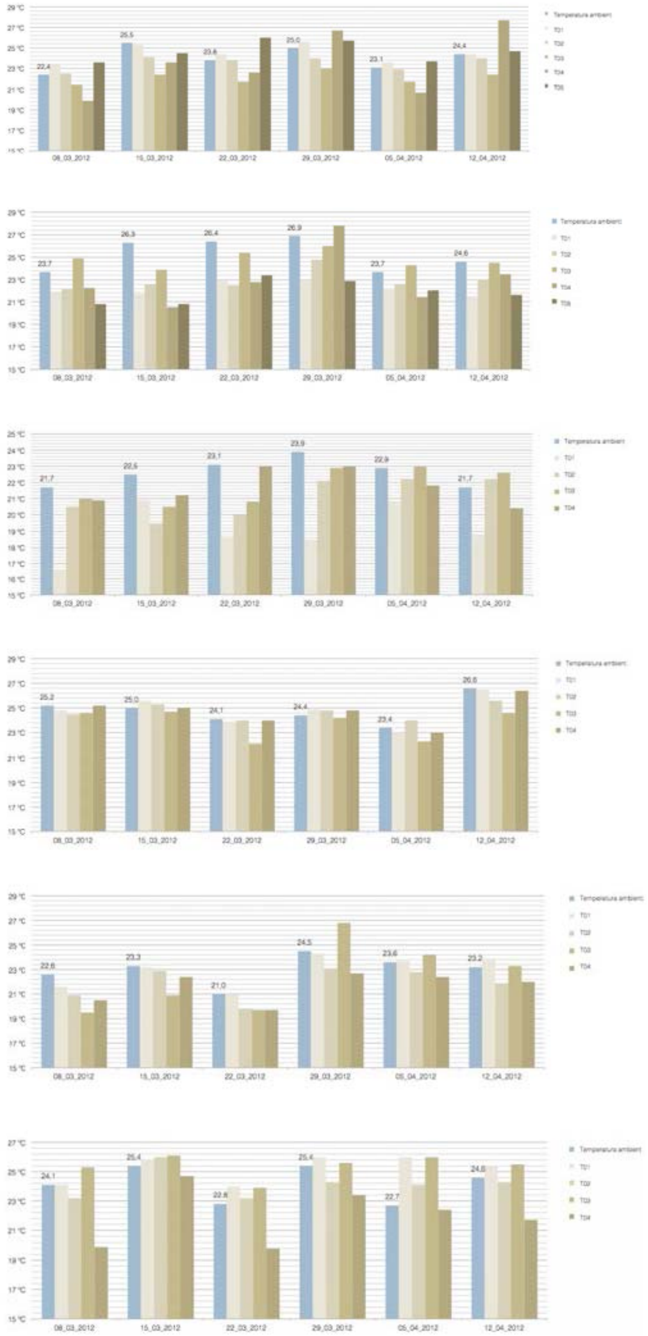


Fig. 13: ETSAV's bathroom thermal monitoring

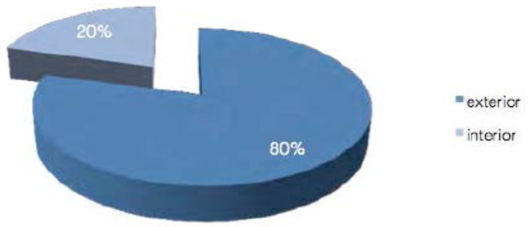
Fig. 15: parameters involved in UZB calculation

Fig. 14: Thermal loss through interior/exterior partitions in UZB

2.5 UZM results



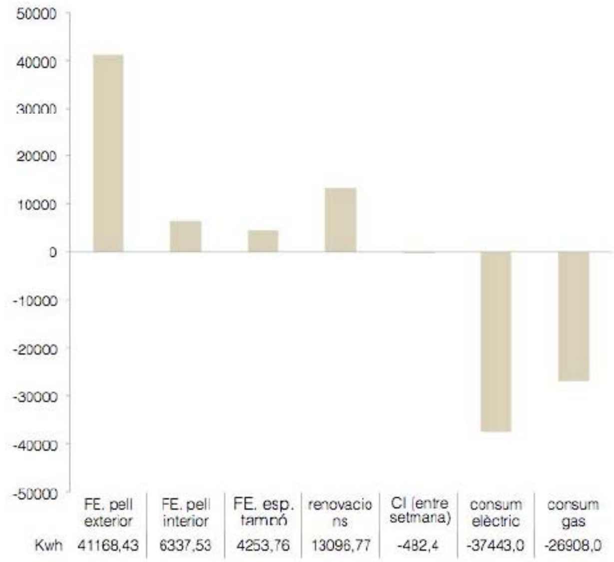
COMPARATIVA FLUXOS ENERGÈTICS			
	A través de la pell exterior	A través de la pell interior	
distribució pèrdues estimades	79,54	20,46	%



CONSUM GAS	DADES SIRENA	
consum març 2012	26.908,00	Kwh

CONSUM ELECTRICITAT	DADES SIRENA	
consum març 2012	37.443,00	Kwh

ELEMENTS QUE INTERVENEN EN EL CÀLCUL



With the first campaigns carried out in respect to the first proposed thermal model corresponding to a UZB, we can begin to draw reliable conclusions that will benchmark our first hypothesis thanks to the data extracted from the previous exercises. If we keep the developed process in perspective we can corroborate most of our initial hypothesis:

2.5.1 In a first instance, we have been able to verify our first hypothesis with the first test performed on a small scale, in which the different spaces that make up a building gain or lose energy not only through the enclosure walls in contact with the outside, but also through the interior enclosure walls that separate them from other spaces with different temperatures.

2.5.2 Once we have expanded the scale of work throughout the evaluation of the building, while not limiting ourselves to observation only, we have done a more detailed analytical approximation of the factors involved in the heat balance fluxes. At the same time, we have confirmed that these transmissions constitute 20% of thermal losses in a building such as the ETSAV with high form factor and limited energy efficiency.

2.5.3 We have confirmed that the ETSAV building as chosen prototype to carry out the evaluation, contributed several circumstantial variables that hinder the contrast of the expected results- 80% of energy loss through the façade is due to the large number of thermal bridges, the poor efficiency of its exterior walls, especially in the use of simple glass, and a large contact surface. In this sense, the number of unheated interior spaces is also reduced and could it thus be considered that the results obtained from the 20% correspond to a cautious scenario. Therefore, we can state that in a building with these characteristics, the usual minimum value of the thermal loss through interior walls rounds up to about 20% of the total flux of heat contributed.

2.5.4 Finally, we wonder that this phenomenon takes up a main role in well-insulated buildings, or those in which thermal efficiency in façades has been take into account during ithe designing stage. We consequently expect the problem of thermal loss through interior partitions to be more relevant in thermal efficiency oriented buildings.

3. Typology 02 :: UZB

In this second stage of the research, we propose tackling another building type, which is composed of small independent thermal units. Within this category we include office buildings, hotels, and multifamily apartment blocks with decentralized thermal management, which have more importance for us since they represent the largest concentration in Spain.

In order to make a progressive approach to the phenomenon we will divide the process into two stages: the first one will be carried out through two simple models, using the spreadsheets type Excel*once again. With these first models we will try to demonstrate the existence or non-existence of the phenomenon and will begin to quantify the values to evaluate their relevance. To allow us to do this, we will use an invented block of flats where some houses will be "activated" or "deactivated" in order to represent different patterns of use of the building. All the obtained values will be *synchronic*, and therefore, in a single moment in time, which we tell us how much energy the entire building has gained / lost during a given period of time.

In the second model, much more complex than the previous ones, we will be using the simulation program Design Builder with the collaboration of a team of researchers led by Javier Neila of the Universidad Politécnica de Madrid and with the main contribution of Maruxa Toucedo. In this case, the concept of time will be introduced to get a *diachronic* model through which you can go into play all the different utilization patterns of the Spanish society and so make a closer approach to reality.

3.1 Hypothesis

3.1.1 As Spain does not have a tradition of thermally insulating internal, property-dividing walls, we expect to find out that each thermal unit will have a larger surface of a lower energy efficiency through which it will probably lose energy.

3.1.2 In relative terms, we will see an increase in the thermal losses carried out through the interior enclosure walls compared to the UZB model.

3.1.3 Proportionately, the internal losses will be much more relevant than the losses through the façade.

3.1.4 In the *synchronic* models we will find out that in many cases, the thermal losses through enclosure walls are balanced between themselves, while in the *diachronic* model it will be taken into account when a space is needlessly heated.

3.2 Synchronic model

Ha	Hb	Ha
Hb	Hc	Hb
Ha	Hb	Ha

unity dimensions		
façade length (l)	7	m
depth (d)	15	m
high (h)	3	m
utile surface	105	m²
volume	315	m²

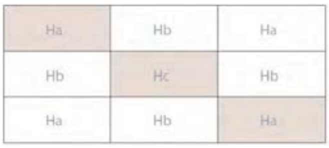
climatic data			
		difference	
T. ext	10,94		
T. ground	16,00	12,63	°C
T. int C	23,57	7,57	°C
T. int NC	15,70	7,87	°C

From the experience gained in the numerical UZB model, we suggest to make a leap of scale and generate a thermal model of multi-thermal-zone building with decentralized production of thermal energy for climate comfort. With this new model, we will try to get a first quantification of the thermal losses caused by the lack of thermal insulation on the interior enclosure walls in the case of discontinued use of the premises and their energy sources.

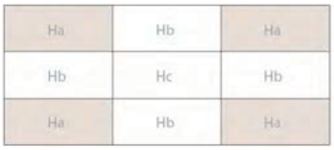
The process will be divided into two stages:
3.2.1 In the first one, we will idealize a multistory housing building organized by a grid of three by three houses on its façade, without communication nucleus. Once certain dimensions and characteristics of the block have been determined, we will perform the calculation of the energy fluxes of each unit to subsequently develop a series of synchronic combinations. In this first phase, we will not combine adjoining unites because we want to determine which the most punitive enclosure walls are in a situation with the greater number thermal transmission surface.

3.2.2 In the second one, we will complete the process accomplished in the first stage of this same model with all the remaining combinations involving adjoining houses so that we can extract a new interpretation of possible representative situations of different usage patterns.

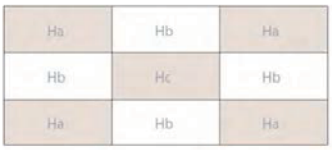
3.3 MZB firsts results



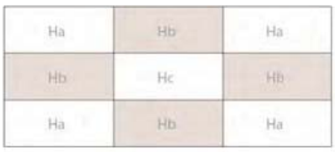
Ha :: coberta	on	x1 / 2	1.211,04	kWh
Ha :: solera	on	x1 / 2	1192,24	kWh
Hb :: coberta	off	x0 / 1	0	kWh
Hb :: solera	off	x0 / 1	0	kWh
Hb :: façana	off	x0 / 2	0	kWh
Hc :: central	on	x1 / 1	1582,69	kWh
FLUX TOTAL			3985,97	kWh
FLUX PONDERAT / UT ACTIVADA			1328,66	kWh



Ha :: coberta	on	x2 / 2	2.422,09	kWh
Ha :: solera	on	x2 / 2	2384,47	kWh
Hb :: coberta	off	x0 / 1	0	kWh
Hb :: solera	off	x0 / 1	0	kWh
Hb :: façana	off	x0 / 2	0	kWh
Hc :: central	off	x0 / 1	0	kWh
FLUX TOTAL			4806,56	kWh
FLUX PONDERAT / UT ACTIVADA			1201,64	kWh



Ha :: coberta	on	x2 / 2	2.422,09	kWh
Ha :: solera	on	x2 / 2	2384,47	kWh
Hb :: coberta	off	x0 / 1	0	kWh
Hb :: solera	off	x0 / 1	0	kWh
Hb :: façana	off	x0 / 2	0	kWh
Hc :: central	on	x1 / 1	1582,69	kWh
FLUX TOTAL			6389,25	kWh
FLUX PONDERAT / UT ACTIVADA			1277,85	kWh



Ha :: coberta	off	x0 / 2	0	kWh
Ha :: solera	off	x0 / 2	0	kWh
Hb :: coberta	on	x1 / 1	1252,59	kWh
Hb :: solera	on	x1 / 1	1233,78	kWh
Hb :: façana	on	x1 / 2	2164,08	kWh
Hc :: central	off	x0 / 1	0	kWh
FLUX TOTAL			4650,45	kWh
FLUX PONDERAT / UT ACTIVADA			1162,61	kWh

QUADRE RESUM DE PERDUES TERMIQUES SEGONS POSICIO D'HABITATGE	Pèrdues a través dels tancaments exterior	Pèrdues a través dels tancaments interior	TOTAL
Ha :: coberta	2,33 kWh 42,3%	3,18 kWh 57,7%	5,51 kWh 100%
Ha :: solera	2,24 kWh 41,4%	3,18 kWh 58,6%	5,42 kWh 100%
Hb :: coberta	1,43 kWh 25,1%	4,27 kWh 74,9%	5,70 kWh 100%
Hb :: solera	1,34 kWh 23,9%	4,27 kWh 76,1%	5,61 kWh 100%
Hb :: façana	1,74 kWh 35,4%	3,18 kWh 64,6%	4,92 kWh 100%
Hc :: central	0,84 kWh 11,7%	6,35 kWh 88,3%	7,19 kWh 100%

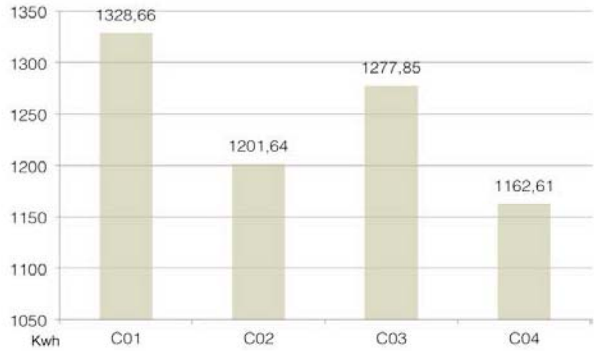


Fig. 25: complex MZB combination 05 Fig. 26: complex MZB combination 08

3.4 MZB final results

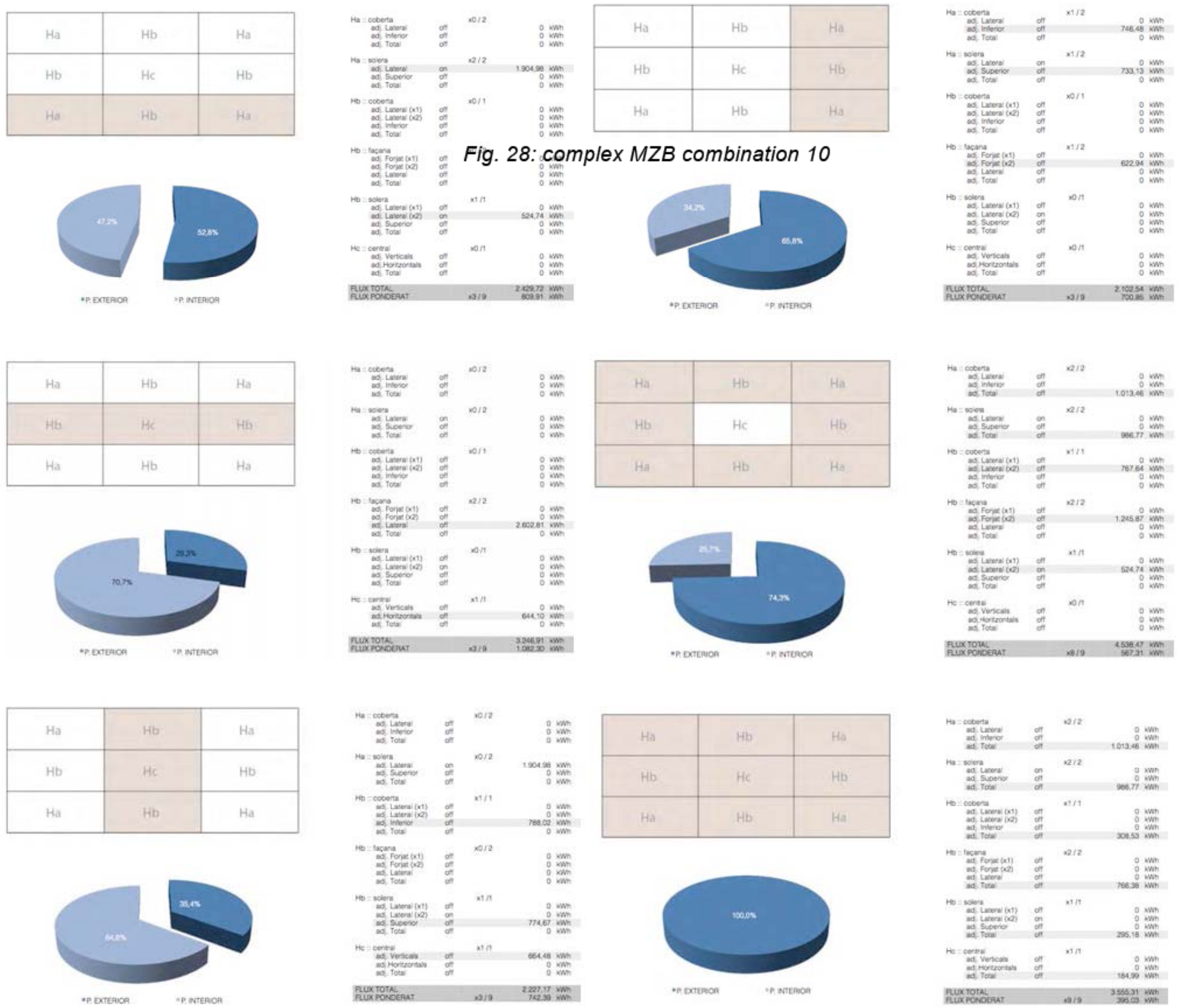
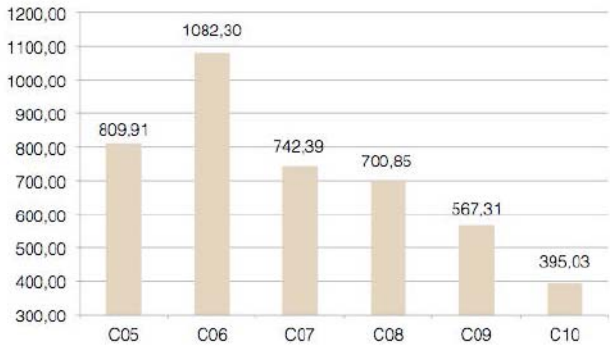
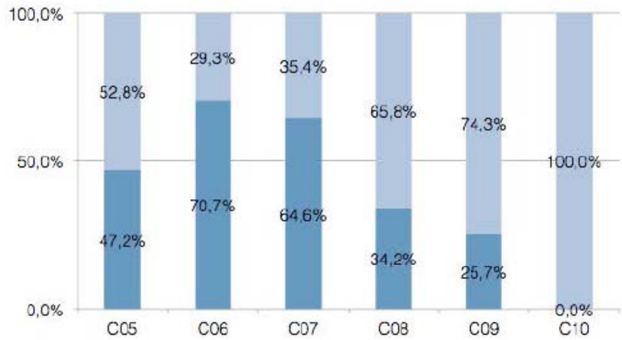


Fig. 28: complex MZB combination 10





In the final results interpretation of the simple model made on a hypothetical MZB, we have to deal with the difficulty that it is no longer a model with the same surface area of contact, as it was in the first cases (combinatorial 01-04). Now, in the absence of energy transmission between units "activated" simultaneously, this contact surface or transmission will be reduced, thus preventing an effective comparison. However, this simulation enables us to identify certain utilization strategies that would enable us to improve the thermal efficiency of the building in its totality. Indeed, we realize that there are large variations in the thermal losses depending on which houses are "activated" regardless of the total number of houses.

3.4.1 First of all, we could suggest the activation of all the perimeter units (combinatorial 09) to establish a thermal crown to keep the whole block of houses at a comfort temperature. This strategy greatly reduces the thermal losses since we are delimiting a new surface of internal perimeter where the thermal break is not as accentuated. In this way, we could be able to achieve a reduction of up to 47.58 % compared to the worst of the combinations according to thermal efficiency (combinatorial 06).

3.4.2 Finally, we can confirm that the strategy that would give us the best efficiency regarding the thermal efficiency of the entire building in a synchronous model, for instance, in a single instant of time, is to activate all units at the same time, avoiding the largest number of thermal breaks and therefore reducing the surface thermal transmission in the façade, which is supposed to be correctly insulated. This strategy reduces thermal losses up to 63.5% but is not very widespread in our country.

4. Final conclusions

Having seen the results, we can say that we have come up with most of the answers of the hypothesis initially raised. To begin with, we have seen, with relatively unsophisticated systems, how internal losses through the enclosure walls exist in both UZB and MZB.

According to the UZB managed by a single thermal generator, we find out that the value of these losses can reach up to 20.46 %, which is a significant amount, bearing in mind that we are talking about buildings with a lot of volume and therefore a high thermal homogeneity. In addition, it must be remembered that the building chosen for this study, the ETSAV building, has a very little thermally efficient façade since, for example, all the overtures, which represent a 35, 4% of the façade's surface, are resolved with simple glass and aluminium frames without breaking of thermal bridge. Therefore, if we would decide to improve the thermal efficiency of the façade, we would see the losses value through the interior edge would droping enormously and in consequence the 20.46% value that we obtained with our first simulation would increase extremely in comparison with the results that we could achieve with a thermal efficiency façade improvement. Consequently, we believe that for this type of buildings, it is necessary to do a strategic thermal sectionalisation in order to minimize the internal losses.

According to the MZB, which could represent all the residential buildings managed by individual thermal generators, we can confirm that this building type is more affected by this phenomenon. The typical features of this type of constructions, with very small units, as could be seen in the different houses in a block of flats or rooms in a hotel complex, naturally lead to this result. There are lots of clearly defined spaces with different utilization patterns and heating protocols. According to our models, we found out that depending on the situation of the studied unit within the building as a whole and above all of the occupation and at the same time air conditioning units around it, the values relating to the thermal loss through the interior partitions is ranged between 25.7 % and more than 70 %. This proves that these enclosure walls are truly relevant to the flux of thermal energy and we therefore believe that they are the next huge topic to consider in the improving of the thermal efficiency of residential buildings, as they represent the most extensive building type in all the developed world.

Due to the good results of our research, we suggest that it would be necessary to continue in this research line since the high values of thermal losses reached by the interior partitions, particularly in residential or highly fractured buildings, has us expect this can be a very good place in which to focus our efforts if we have to reduce the consumption of our buildings. Furthermore, our research opens a new path to a much more extensive research that may reach a high level of specialization. For this reason, we are already considering the fact of continuing with a much more detailed research using more specialized calculation programs such as DesignBuilder with engine of Energy+ in order to include many of the parameters in the simulation that we have not included in this research because of our willingness to make a preliminary study which was precisely what opened this new path to technological research in architecture.

Full paper in catalan: http://upcommons.upc.edu/pfc/handle/2099.1/16451