LOW ENERGY OFFICE BUILDING IN LLAVALLOL, BUENOS AIRES. A UNIVERSITY- COMPANY EXPERIENCE

[1]Czajkowski, Jorge Daniel; [1]Gómez, Analía Fernanda
[1]Laboratory of Sustainable Architecture and Habitat. Faculty of Architecture and Urbanism. National University of La Plata.
47 St. n°162- 1900 La Plata – Buenos Aires Province- Argentina
e-mail: jdczajko@gmail.com

ABSTRACT

This work is framed by a convention of work for third parties between the Laboratory of Sustainable Architecture and Housing and Isover Saint Gobain Argentina Company. We have to develop the project of a sustainable and low energy 900 m2 building in the factory land, in Llavallol town, province of Buenos Aires.
The architectonic/technological project will be a model to describe innovative solutions respect to conventional solutions of building in Argentina. Besides, it has the intention to show a low energy/ energy+ building at reasonable cost, with local academic, professional and business knowledge in a developing country, together with good energy performance expectations which will show improvements compared to traditional techniques.
We show the design process and the energy performance results of the first building of its kind in Argentina.

Keywords: low energy building, sustainable design, energy efficiency

1.- Introduction

The development was carried out in 2011 and the construction did not started before 2014, because of many ups and downs, mainly due to the international economic crisis. Initially the company delivered the program needs and the protocol Isover Multi Comfort House (MCH) along with material requirements. The team proposed a preliminary draft validated by Energy Plus simulations with an adjustment of the usual construction systems in the country, to meet the MCH.

Solutions with dry type construction systems, like Steel Framing, presented overheating problems in winter and led us to incorporate internal thermal mass. The technique of "cold beam" was adopted to maintain a quasi-constant temperature inside the enclosure using recirculating water from the Pampeano aquifer, located 40m below ground.

Additionally, rainwater mixed with reuse of treated greywater can be used in toilets and urinals flushing systems. The wastewater is treated prior to pour it into sewers. We suggest a system of photovoltaic generation and solar thermal collectors for heating and sanitary water.

2.- Building location

The building is situated in Llavallol Town [3],, in the district of Lomas de Zamora, 21.7km SO from Buenos Aires City (Lat -34.799° Long -58.420° y 24m above sea level). According to IRAM Standard 11603, its climate is humid warm temperate (IIIb zone), with $HDD_{18°C}$= 1200ºD, annual mean temperature is 16,7°C, minimum design temperature is 1°C and maximum design temperature 35°C (Fig. 1).

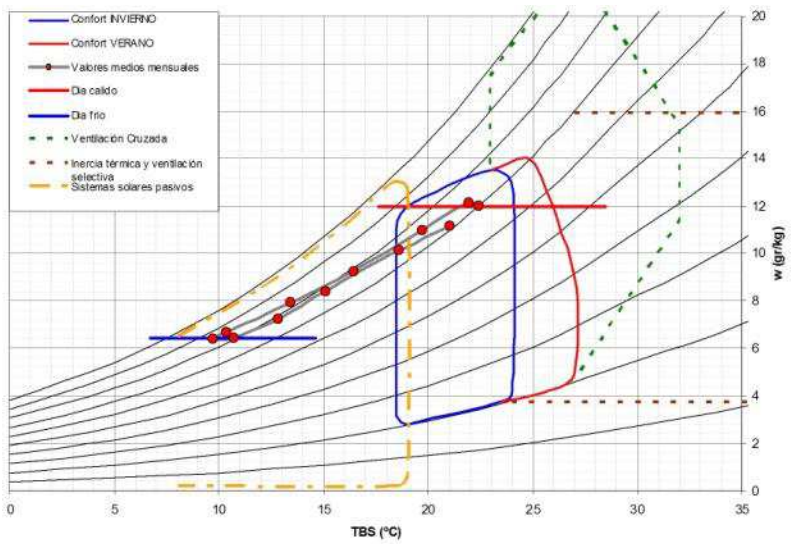

Fig. 1 "La Plata bioclimatic characteristics, Buenos Aires, Argentina. Data from temperature and humidity average showing typical warm and cold days based on B. Givoni model. Program": Psiconf 1.0. Source: Czajkowski J et Al.

The building is situated in the Company plot of land, by del Rey Stream, in a floodable area. The worst flood occurred on September 26th, 2012, when the whole area, including the factory, was flooded 1.3m above soil level. All the buildings must be raised as a preliminary condition. There are additional restrictions like retreat of buildings from the stream axis, reducing the available area to build and conditioning the layout of the new building (Fig. 2). Best views are NNW, onto the stream. Looking north, we can see the factory and two low-rise office buildings. The plot limits with Vasa Company land at SW and with a sport area at SE.

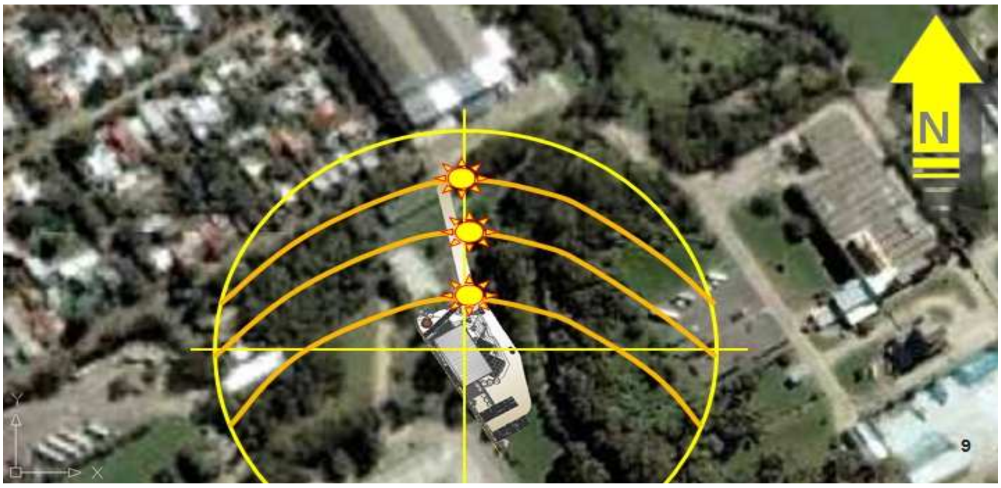

Fig. 2 “Building location on Isover Saint Gobain Company plot on Google satellite image”. Source: the authors

3.- The building requirements

The requirements comprehended from 750 to 900 m^2 for administrative and management offices, a showroom for the Company’s products, a conference hall, training rooms, toilets and service areas. The client asked for an ambiguous image related to various uses but with a high visual impact.

The building should tend to consume energy from low-energy building level (20 to 30 kWh/m^2year to 0-energy level (<15kWh/m^2year). The *MINERGIE®* (42 kWh/m^2año o 13.300 $Btu/ft^2/yr$) Standard— which applies to *low energy housing* in Germany—requires higher energy consumption only in heating than those mentioned above.

This issue gave place to a long debate about which the reference value should be reached for an office building with an average thermal load by occupancy. The occupancy intensity was uncertain in each floor throughout a typical year.

There are no Standards in Argentina for very highly efficient buildings except for IRAM Standard 11605 A Level and energy labelling in heating (IRAM Standard 1900) [4]. In LAyHS Laboratory, we had formulated indicators and energy efficiency levels based on audits, modelling, and simulations, which are also precedents of national Standards [5], [6]. We also had to fulfil Buenos Aires Province Law 13.059/03, Reglamentary Decreet 1030/10. There was no inconvenient to achieve this goal as the required level is medium/low energy efficiency.

As ISOVER Multi-Comfort Standard is based on German Standard Passive House for housing in cold climate, we had to consider the following requirements: a: energy demand for heating no larger than 15 kWh/m^2year (4746 btu/ft^2year), and.for cooling, no larger than 15kWh/m^2year, b: peak thermal load lower than 120 kWh/m^2year (37900 btu/ft^2year) and c: exchange air rate no bigger than 0.6 times/hour whole building volume ($n_{50} \leq 0.6$ / hour) at 50 Pa (N/m^2).

Fig. 3 “NEE façade”. Source: the authors.

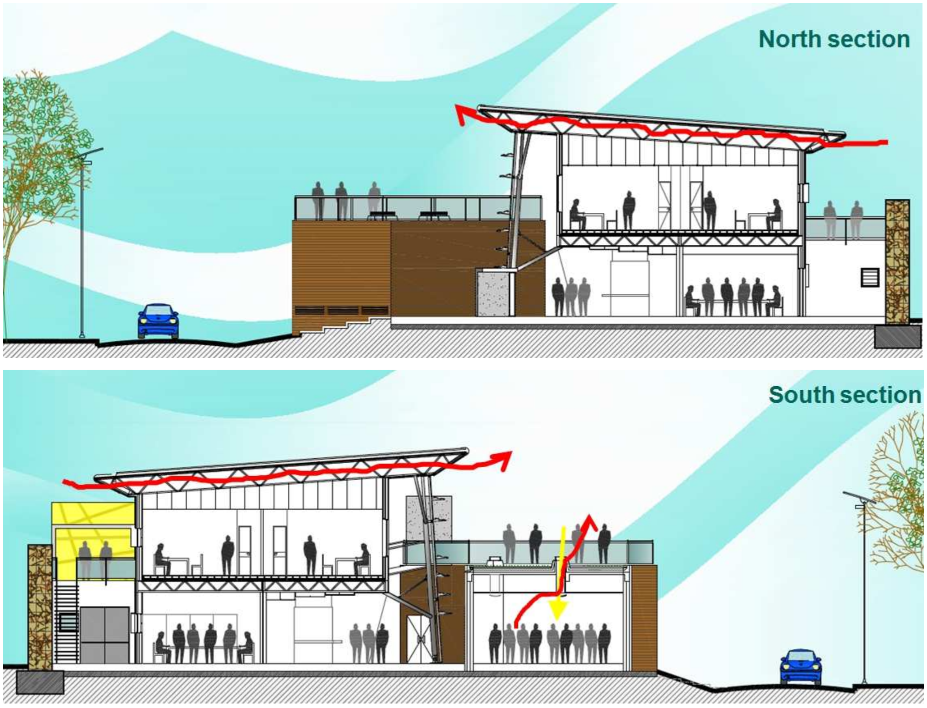

Fig. 4 “up “Administrative sector cross section”, down:” Conference hall, showing ventilated umbrella-shaped roof””. Source: the authors.

In any case, we explained that those standards were thought for cold to very cold climates, with more than 3000 HDD, moderate short summers, similar to Patagonia climate at 45 to 55° South Latitude, different from Buenos Aires Metropolitan Area.
We agree to propose a sustainable research design exercise and generate innovative techniques. The obtained results would be used as a precedent for future national standards by monitoring the building and its energy performance.
In Fig. 3, the external image of the building shows the entrance, a services block with the company colour, the conference hall embedded in the curtain wall, with a green terrace as extension of the administrative sector, and a large ventilated umbrella-shaped roof.
In figs. 3 and 4 the draft shows a double-height entrance area looking NNE with horizontal outer sun screens to protect the glazing. Sunlight studies revealed that the surface is practically shaded from 9AM. We chose this orientation because of the

views to the forest and the stream, even when bioclimatic criteria discourage this orientation.

Fig. 5 “Ground and 1st floors”. Source: the authors

If we had located the building looking North, the workers would have had no view other than the factory with no benefit in sunlight.

4.- Envelope technology

We defined three different sectors for the envelope: a- the main double-floor volume in Steel Framing system, b- the conference hall in traditional way, reinforced concrete structure and 9-hole hollow bricks 12cm width, c- the service sector with reinforced concrete in walls and roof 12cm thick.

These systems are usual in Buenos Aires. Figures 6 to 8 show details and specifications, employing ISOVER products. There was no aluminium frame for triple panel glass to reach K= 0.80 W/m^{2}K at the moment of the construction, so we replace it with a two-window system: an inner panel with triple-operation system and an outer oscillating panel, both with double panel glazing.

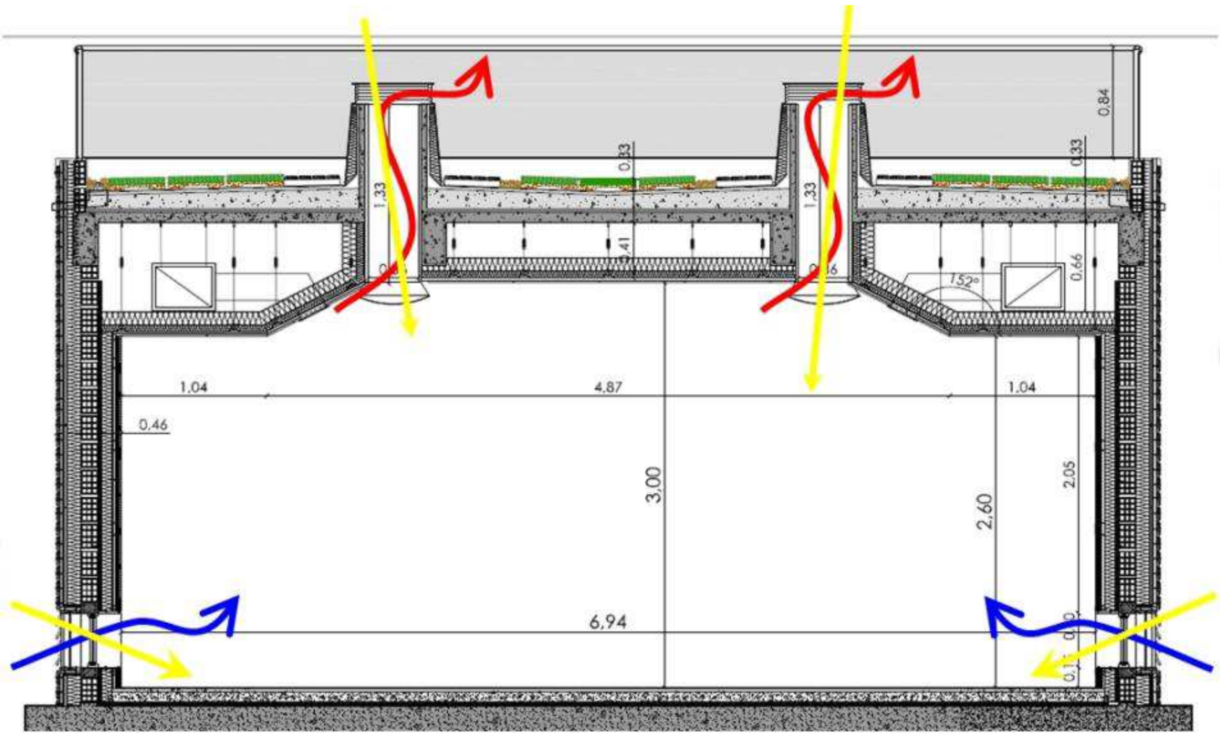

Fig. 6: “Cross section of the conference hall showing the envelope layers, low small windows for daylight and ventilation ceiling frames with cooling ducts and green terrace”. Source: the authors

The conference hall receives daylight and natural ventilation from roof ducts and light and ventilation from small windows near the floor. The terrace is green and the administrative sector opens towards it.

This sector has a light double envelope: an inner element with a small volume to cool and an outer one, with ventilation between both elements at roof level (Fig 8).

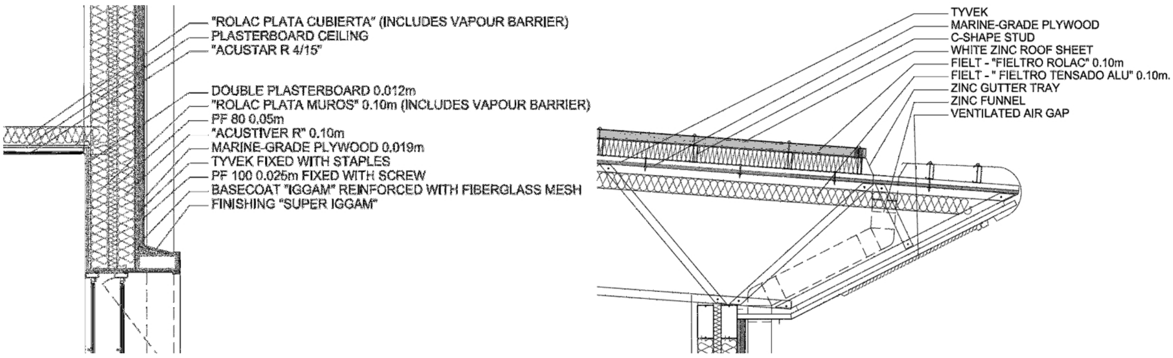

Fig. 7: “Conference hall construction details”. Source: the authors.

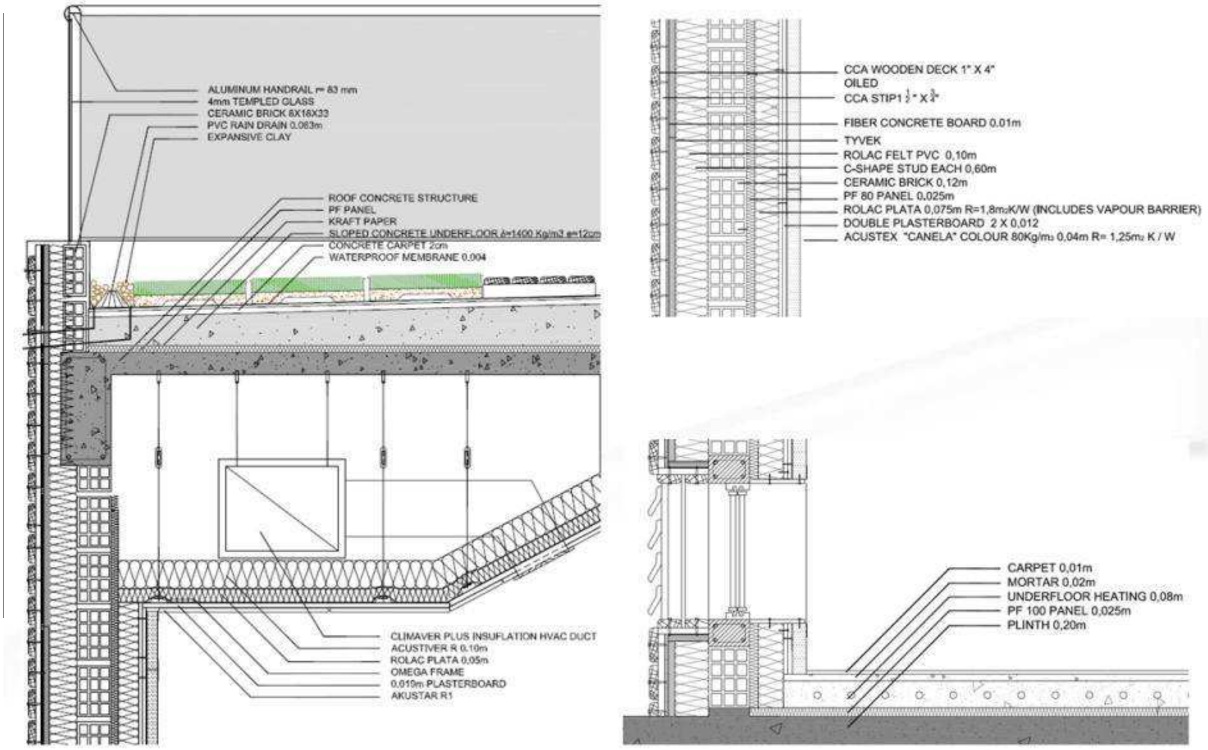

Fig. 8: “Wall and roof construction details at western administrative sector”. Source: the authors

5.- Thermal and energy performance

In Table 1, we show the cooling thermal loads of two different kinds of building: one is conventionally built and the other is an improved version.

A traditional envelope shows the following thermal transmittances (K or U) for roofs: 1-7 W/m^{2}K, walls: 1-3 W/m^{2}K, doors: 1-7W/m^{2}K, windows: 3-6 W/m^{2}K and floors: 2-3 W/m^{2}K. These are the usual levels we can find in all buildings across our country, from 24º to 55º S. In the Buenos Aires Province, Buenos Aires and Rosario Cities, IRAM Standards about thermal comfort in buildings are compulsory by means of laws or building codes. Nevertheless, in practice, this is not the case. In the rest of the country, there is no regulation about private building thermal quality.

The conventional building would require a 321.4 kWh/m^{2}year energy demand in heating if the equipment worked all day long, and a 160.7 kWh/m^{2}year energy demand, if it worked half day long. The required cooling power would be 65 Ton or 220kW.

The improved case shows the following thermal transmittances: for roofs 0.12 W/m^{2}K, walls, 0.12W/m^{2}K, doors, windows, 0.8 W/m^{2}K, and floors, 0.5W/m^{2}K. This means a sensible reduction in energy demand for heating; 72.7kWh/m^{2}year if equipment worked all day long or 36.4kWh/m^{2}year, if worked half day long. The cooling power would be 27 Ton or 91kW. The improvement arises to 77.4% in energy demand for heating and 58.5% in power for cooling.

If we analyse separately each rows, we notice that losses by conduction reduced solar gains with sunscreens and specific glazing: 77.9%, artificial lighting with specific lamps and daylight: 54.9% and sectored servers for office equipment: 13.9%.

Thermal Load	Conventional building		MCH building	
	W	%	W	%
Q conduction	72686	33.13	10399	11.48
Q solar	65524	29.87	14474	15.98
Q sensible people	9635	4.39	8366	9.24
Q latent people	7995	3.64	6942	7.66
Q sensible equipment	8344	3.80	7180	7.93
Q latent equipment	0	0.00	0	0.00
Q lighting	11280	5.14	5088	5.62
Q sensible outer air	12915	5.89	11214	12.38
Q latent outer air	30996	14.13	26914	29.71
TOTAL	219375	100	90576	100

Table 1: "Cooling thermal loads comparison, between a conventional building and the improved version ("Multi Comfort House")". Source: the authors.

5.1.- Winter thermal performance

A thermal simulation with EnergyPlus shows that the building will reach an inner average temperature around 15ºC, if considering no occupancy in a closed building or in natural evolution. If considering the rooms separately, in the conference hall, the temperature will vary between 13ºC and 17ºC because of its homogeneous envelope insulation in 15-day cycles. On the other side, the entrance and exhibition area will have average amplitude around 4ºC in 15-day cycles because of its glazing envelope When analyzing the coldest day (7/22) with minimum temperature -2ºC, maximum temperature 9ºC and thermal amplitude 11°C, the conference hall shows 15ºC without a significant amplitude and the entrance shows minimum temperature 12ºC and maximum temperature 17°C [Fig 9].

This first simulation with the building empty, predicts thermal issues when occupied. If it were a house, it would not imply a problem but this is not the case. The building would overheat when occupied, office equipment working and lights, on because of the envelope low heat dissipation.

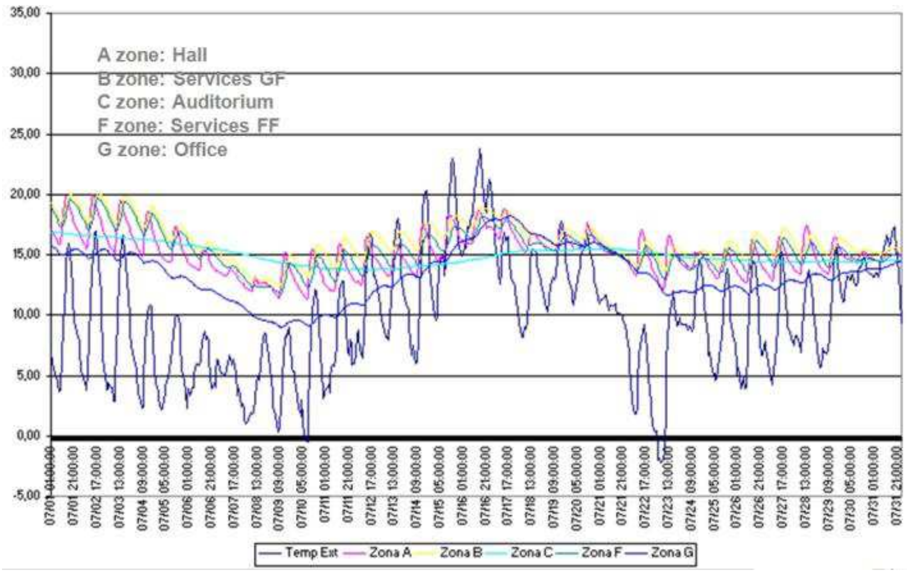

Fig. 9 "Simulación en EnergyPlus del edificio MCH en condición de invierno (mes de julio) y en evolución natural (cerrado y no ocupado). Temperaturas en °C en ordenadas y días del mes de julio en absisas".

We simulated full occupancy in the offices, conference hall, training rooms with ceilings and Climaver © cooling ducts. The results shows an expected overheating, with peak temperatures near 30°C, together with thermal amplitude around 11°C [Fig 10]. An automated control would turn the heating system on 67% days of July or the occupants should open the windows to low inner temperature. In any case, we could discuss the need of a heating system. The high thermal amplitude in the conference hall and offices is a consequence of a lack of thermal mass to buffer these variations. A third simulation [Fig 11] added thermal mass in the conference hall floor and the administrative sector walls. We tried three options of additional thermal mass in walls, which did not show significant differences among them: a. Gypsum board with phase change microcapsules (Micronal PCM Smartboard); b. solid brick walls 12cm thick or; c. reinforced concrete 9cm thick.

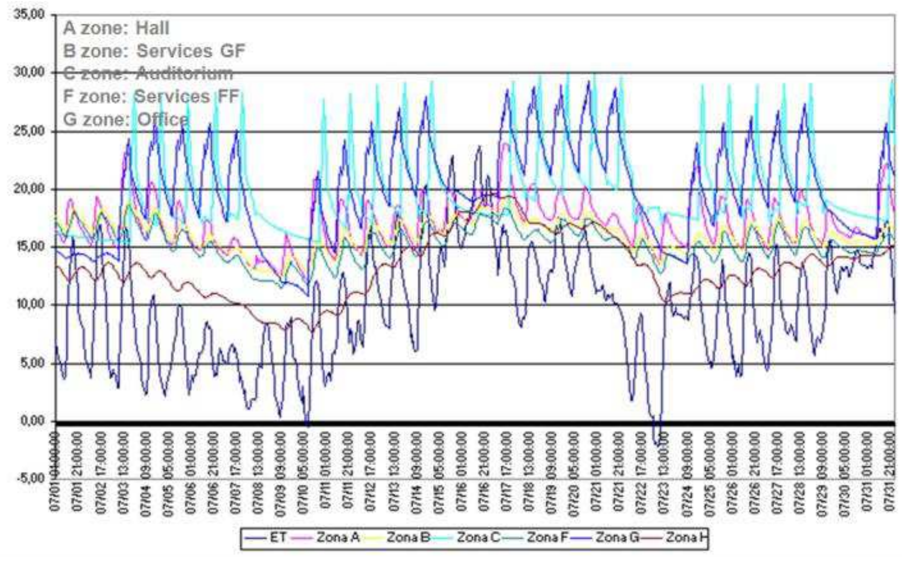

Fig. 10 "EnergyPlus simulation: MCH building in winter (July) with full occupancy. Y-axis: temperatures (ºC). X-axis: days (July)". Source: the authors.

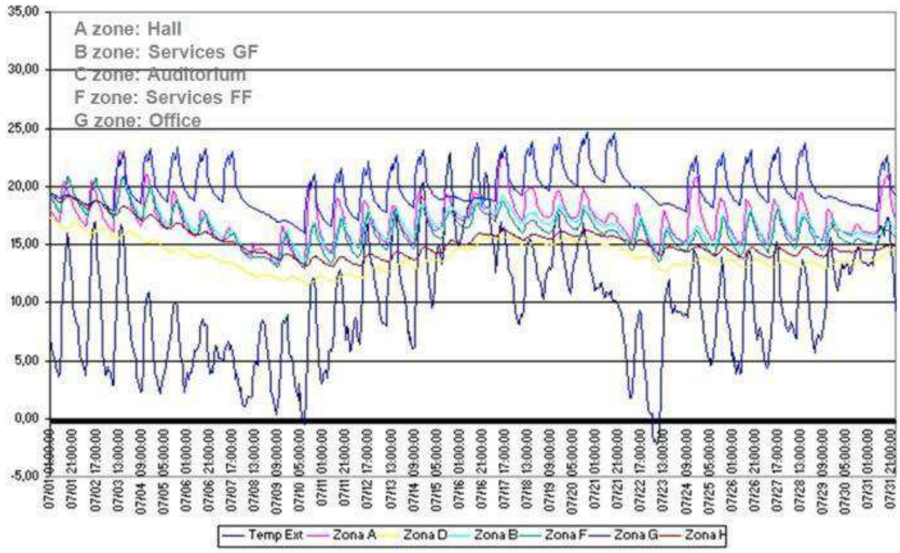

Fig. 11 “EnergyPlus simulation: MCH building in winter (July) with full occupancy, adding inner termal mass. Y-axis: Temperatures (°C), X-axis: days (July)”. Source: the authors.

We disregarded option a as it is a competitor’s product, and option c because it is expensive.
We finally chose b with plastered solid brick walls. Fig. 11 shows the amplitude reduction: 60% average with peaks near 25°C. On the coldest day, with full occupancy, inner temperature will vary between 18°C and 21°C and in the warmest day, it will vary between 23 and 25°C. A monthly analysis shows that— except for the services area— the temperature will vary from 14°C to 25°C and the mean monthly temperature will be 19,5°C.
If there were mean occupancy, the building would not be comfortable enough, especially in the first floor offices, considering no heating system and only thermal gains by occupancy, outer climatic conditions, and sunlight.
As bioclimatic design may not result reliable, we designed a conventional floor and wall. Solar collectors on parking area with cumulative tanks in the basement will provide heating.

5.2.- Summer thermal performance

A thermal simulation of the MCH building shows a mean inner temperature near 19ºC with minimum temperature 27ºC and maximum temperature 32ºC. We considered the building empty, with night natural ventilation and closed during the day but with ceiling vents open, in January (summer).
If we observe each thermal zone in detail, we can see that the conference hall maintains a nearly constant temperature 27°C. As it happens in winter, the entrance and exhibition hall has daily variations with average amplitude 5°C.

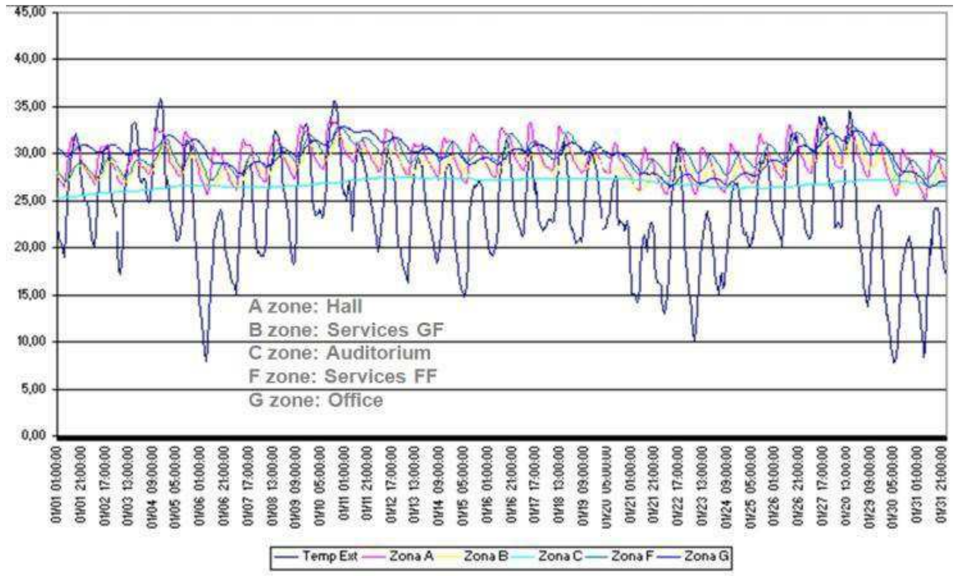

Fig. 12 “EnergyPlus simulation: MCH building in summer (January) with natural evolution (night ventilation and no occupancy). Y axis: temperature (°C) and X axis: days (January)”. Source: the authors.

If we analyse the warmest day (1/4) with a minimum temperature 21°C, a maximum one 36°C and amplitude 15°C, the conference hall has 26°C and no significant amplitude while the entrance hall has a minimum 27°C and a maximum 33°C [see Fig 12].

In the case of full occupancy and similar natural ventilation, the entrance and exhibition area performs in the same way as previously, while the conference hall and the administrative area become overheated.

The conference halls reaches an average temperature 30°C with mean maximum 33°C and mean minimum 27°C, considering from Monday to Friday. The conference hall reaches average temperature 30ºC with maximum 33ºC and minimum 27ºC, considering occupancy on business days.

The office area, which has a higher thermal load, reaches maximum 40°C and minimum 35°C, during 25%of the days, monthly. In any case, workers are not comfortable and it will be necessary to turn the cooling system on. In fig. 14, we show the benefit effect achieved when adding thermal mass and selective night ventilation if maximum do not exceed 35°C when minimum is 32°C. We also notice that mean monthly temperature maintains 30°C.

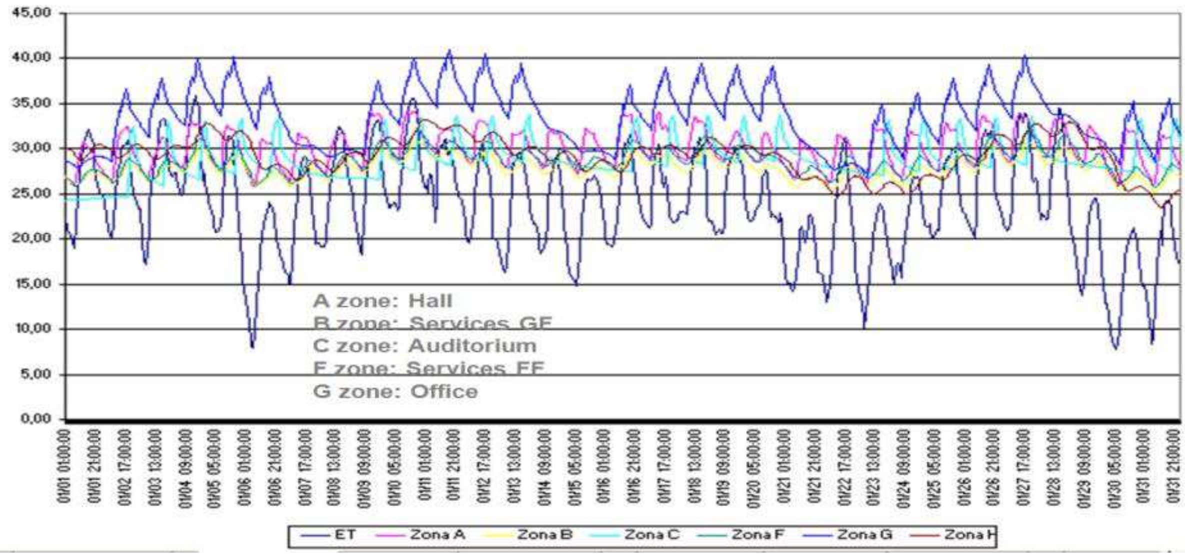

Fig. 13 "EnergyPlus simulation: MCH building in summer (January), with full occupancy. Y axis: temperature (°C) and X axis: days (January)". Source: the authors.

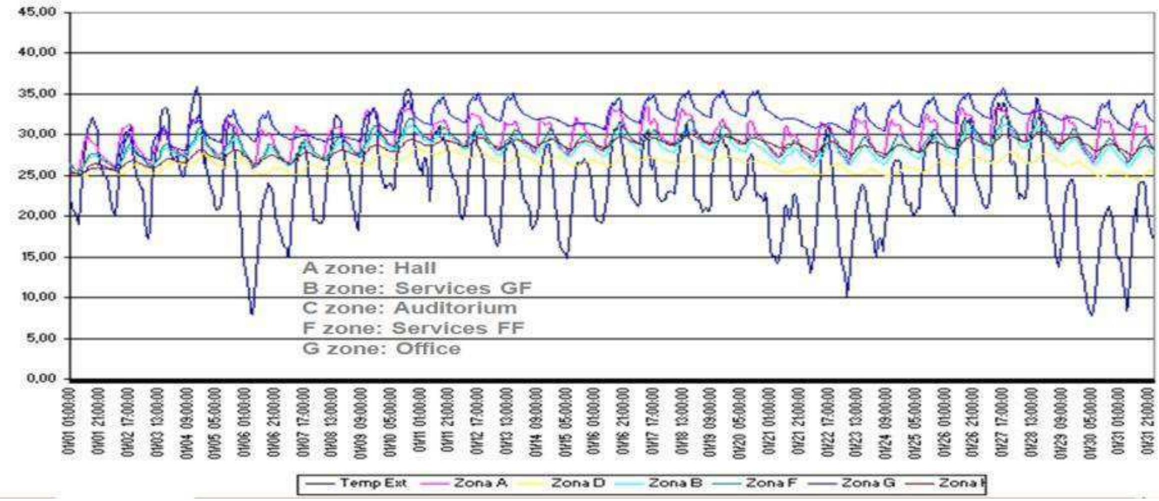

Fig. 14: "EnergyPlus simulation: MCH building in summer (January), with full occupancy and inner thermal mass. Y axis: temperature (°C) and X axis: days (January)". Source: the authors.

6.- Facilities and services

The sanitary facilities look for minimizing drinking water consumption until 80%. To achieve this goal, we separate the water providing system, which is highly integrated. Toilet and urinal valves as well as outer faucets will be feed with treated water and rainwater from a tank, by a pressured independent pipe. We will treat grey waters from sanitary facilities with a phytosanitary system developed by Santa Catarina Federal University for the Efficient House [7]. It was built in Florianópolis and suceeded in the country. We will use a variety of reeds which grows in the stream that flows by the plot as they are adapted to channel pollution. The same system will apply to black water before pouring into the sewer.

7.- Investment and construction costs

A cost analysis showed that this building, if conventionally built, would cost 470 Euros/m^2 in 2011. An improved version better insulated and according to current laws would cost 634 Euros/m^2. MCH option, proposed in this paper, would demand 773 Euros/m^2.

7.- Conclusion

At present, there are no low-energy buildings in Argentina. Its construction would imply the access to unknown ways of projecting and construction, only known in developed countries. The design process shows the feasibility to materialize low/ energy plus buildings at reasonable costs, with the knowledge of local professionals, academics, and businessmen, in developing countries.

This work demonstrates that the relation University/Company lets generate innovative proposals, apart from a central or peripheral location.

It also lets anticipate a new paradigm of international architecture but with a lower relative environmental impact.

AKNOWLEDGEMENTS

We acknowledge ISOVER Saint Gobain Argentina S.A Company, President, Lic Nestor Silva Gómez, marketing manager Lic. Pablo Messineo and arch. Silvina Lopez Planté for the confidence in LAyHS and the National University of La Plata. Besides, we want to thank graduate and undergraduate students who integrated the team: Carolina Vagge, María Belén Salvetti, María Paz Diulio, María Natalia Alonso, Mariela Marsilese and María Gracia. Bianciotto.

REFERENCIAS

[1] Multi Comfort House ISOVER - [*http://www.isover.es/Multi-Comfort-House*]
[2] EnergyPlus - [*http://apps1.eere.energy.gov/buildings/energyplus/*]
[3] Czajkowski, Jorge; et al. (2003). Evaluación del comportamiento energético en viviendas urbanas auditadas en La Plata, Buenos Aires, Argentina. Anais ENCAC - COTEDI 2003, Curitiba, PR, Brasil. Pp 889.
[4] Vagge, Carolina y Czajkowski, Jorge. (2012) Impacto de la aplicación de la Ley 13059 de Eficiencia Energética en relación a la nueva Ordenanza de Usos del Suelo de la ciudad de La Plata y la Norma IRAM 11900 de Etiquetado de Edificios. Revista Ambiente Construido. Edit. ANTAC. Brasil. ISSN 1678-8621.
[5] Salvetti, María Belén y Czajkowski, Jorge. (2011) Eficiencia energética en calefacción para edificios de oficinas. Propuesta de indicadores y valores admisibles. Actas ELECS 2011 Vitória ES. VI Encontro Nacional, IV Encontro Latinoamericano sobre Edificacoes e Comunidades Sustentâveis. ISBN 978-85-89478-39-7
[6] Salvetti, M. B.; Czajkowski, J.; Gómez, A. (2010) Ahorro de energía en refrigeración de edificios para oficinas. Propuesta de indicadores de eficiencia y valores admisibles. Avances en energías renovables y medio ambiente. Edit. INENCO-UNSa, Salta. ISSN 0329-5184. Vol: 13, Tomo 1, 8 Pág.
[7] Casa Eficiente UFSC (2009). [*http://www.labeee.ufsc.br/sites/default/files/publicacoes/livros/CasaEficiente_vol_IV_WEB.pdf*]