VENTILATION RELATED TO USER HABITS.
Considerations on Environmental Envelope Rehabilitation.

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ABSTRACT

Application of ventilation techniques, as well as the use of any passive environmental solution in a rehabilitation, requires knowledge of the particularities of the **climate** and the specific characteristics of the **building stock**. In a theoretical approach, these two variables would be enough to predict indoor behaviour. Nevertheless, in practice, one third variable needs to be considered, as **user habits** can completely change the equation. This study is referred to a continental dry template climate, particularly to the city of Mendoza (32.88º south latitude, 68.85º west longitude and 827 m.a.s.l. Annual cooling DD (base 23°C): 138 °C day/year, Annual heating DD (base 18°C): 1384 °C day/year). The selection of the studied buildings was based in presenting the most common housing typologies and their envelope characteristics. There were selected three different low density housing typologies. The actual thermal performance of each building was monitored a 20–day period each season. Different hypothetical scenarios were compared in order to understand the influence of ventilation as a passive technique in rehabilitation and the relationship of this strategy with user habits. Conclusions address the possibilities of ventilation as a passive technique in rehabilitation. Criteria of intervention is provided according to user habits.

KEYWORDS
ventilation, building stock, user habits, envelope, rehabilitation

INTRODUCTION

As the rate of replacement of old buildings with new buildings is very slow, the existing building stock in cities will eventually be rehabilitated in order to reach certain desired "up grading" levels of comfort and modernity to create the necessary conditions to put the dwelling back into the market with an economic redevelopment. This modernization, however, usually leads to increased energy needs, which are usually covered by conventional, non renewable, energy resources, with the consequent contribution to the pollution of the city environment and thus, to global warming. (Ganem et al, 2003)

A series of studies carried out world wide over the last decades have shown that the improvement of the environmental behaviour of existing buildings is a key factor for the rationalisation of non-renewable energy consumption in cities. The objective of this paper is to understand the possibilities of ventilation as a passive technique in rehabilitation.

Application of **ventilation techniques**, as well as the use of any passive environmental solution in a rehabilitation, requires knowledge of the particularities of the **climate** and the specific characteristics of the **building stock**. In a theoretical approach, these two variables would be enough to predict indoor behaviour. Nevertheless, in practice, one third variable needs to be considered, as **user habits** can completely change the equation.

CLIMATE

The site's particular climatic characteristics would present advantages and constraints in an intervention. Analysing both, the passive ventilation strategy will begin to take a general shape. This study is referred to a continental dry template climate, particularly to the city of Mendoza (32.88º south latitude, 68.85º west longitude and 827 m.a.s.l. Annual cooling DD (base 23°C): 138 °C day/year, Annual heating DD (base 18°C): 1384 °C day/year).

Figure 1 shows Bio-climatic Chart and Wind characteristics for Mendoza. Temperatures vary from –6ºC in Winter to 37ºC in Summer, with daily swings of about 10 to 20ºC. Our concern for this work is to focus on temperatures that exceed the comfort boundary, where **ventilation** strategies can make a difference to prevent overheating. Ventilation is proposed as a potential strategy to be used in first steps of environmental rehabilitation. Summer maximum temperatures exceed the comfort range. In Autumn and Spring temperatures also may pass this limit. Overheating may happen nine month out of twelve, with the certainty that the three summer months will actually be hot.

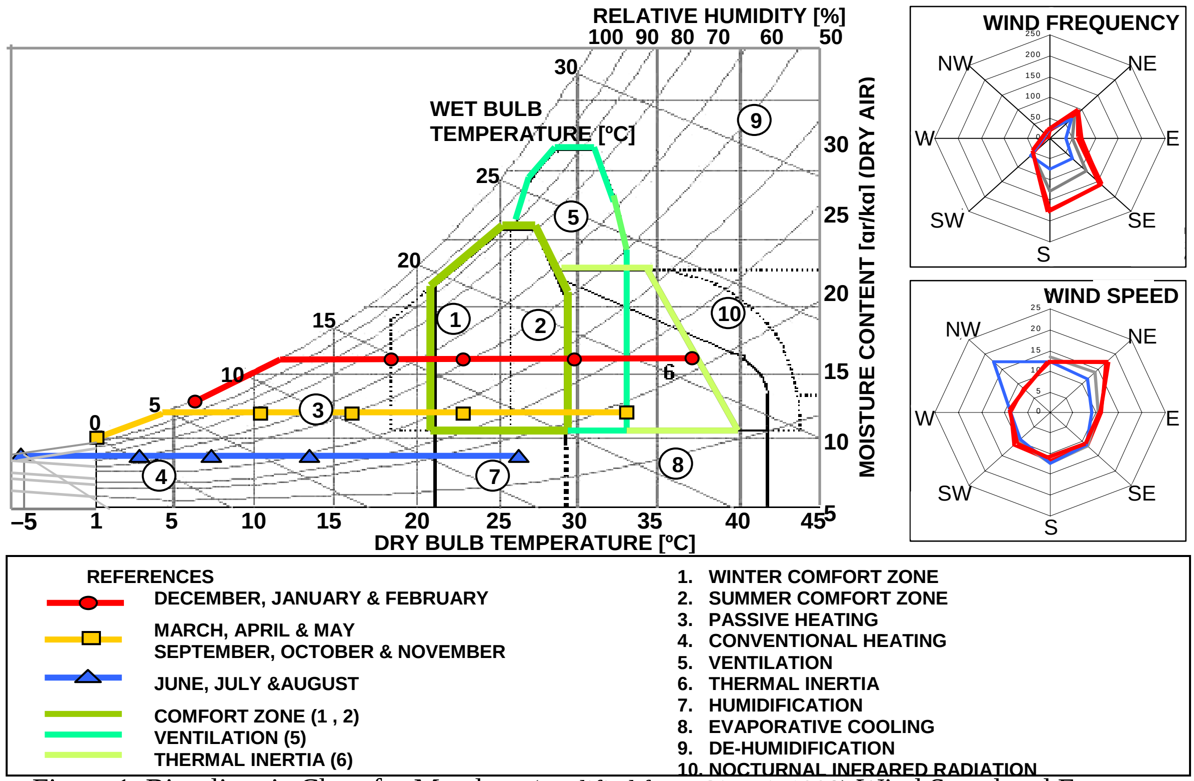


Figure 1. Bio-climatic Chart for Mendoza (modified from Givoni, 1998) Wind Speed and Frequency

According to the Bio-climatic chart, **Ventilation** and **Thermal Inertia** are suggested as adequate passive strategies to regain internal comfort. It is important to know wind's characteristics to analyse how to best profit from this natural resource. As observed in Figure 1, in summer, winds come usually from the **South, South-East** with an speed of 12 km/hour.

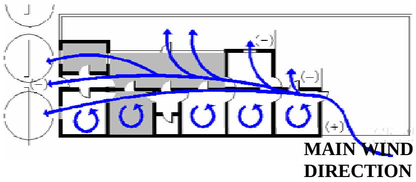
There are two ways in which **Ventilation** can improve comfort: One is by a direct effect providing a higher indoor air speed by opening the windows to let the wind in, thus enhancing the cooling sensation of the inhabitants. This strategy is termed **Comfort Ventilation.** The other way is to ventilate the building only at night and thus cool the interior mass of the building. During the following day the cooled mass reduces the rate of indoor temperature rise. This strategy is termed **Nocturnal Ventilative Cooling** (Givoni, 1998) Both strategies will be analysed and criteria of use will be given for environmental rehabilitation.

BUILDING STOCK

The city of Mendoza presents an homogeneous distribution of the density of constructions, with a noticeable preference of inhabitants to live in individual houses. Today, buildings up to 10 meters high conform the 90% of the existent urban tissue. Due to the age distribution of the building stock and economical needs in the city of Mendoza, the demand in the coming years will increasingly reside in the maintenance, rehabilitation and adaptation of the building stock.

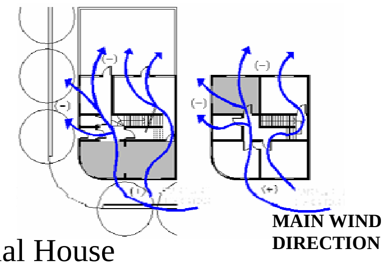
The selection of the studied buildings was based in presenting the most common housing **typologies** and their **envelope** characteristics related to ventilation possibilities. There were selected three different low density housing typologies.

(1) 1880 – 1930: Mediterranean Half Patio House



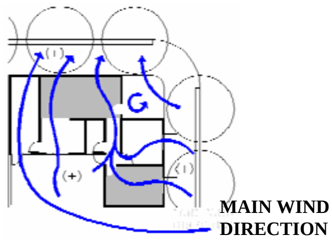
Form/Comp Coeff.[1]	Open / 0.70
Walls Conductance	1.42 W/m^2.K
Roofs Conductance	0.44 W/m^2.K
Average Weight	> 1500 kg/m^3
Openable Surface	15% simple glass
Ventilation Possib.	Within spaces
Envelope Flexibility	High

(2) 1930 – 1945: Modern Movement Rational House



Form/Comp Coeff.[1]	Compact /0.95
Walls Conductance	2.10 W/m^2.K
Roofs Conductance	0.93 W/m^2.K
Average Weight	> 1500 kg/m^3
Openable Surface	20% simple glass
Ventilation Possib.	Crossed/Comfort (2)
Envelope Flexibility	Low

(3) 1940 – 2000: New-Colonial House



Form/Comp Coeff.[1]	Semi-compact/ 0.85
Walls Conductance	2.10 W/m^2.K
Roofs Conductance	0.52 W/m^2.K
Average Weight	> 1500 kg/m^3
Openable Surface	10% simple glass
Ventilation Possib.	Crossed/Comfort [(2)]
Envelope Flexibility	Medium

The actual thermal performance of each building was monitored a 20–day period each season. Data was recorded on a 15 minute basis. Figures 2 to 4 show a selection of 5 days.

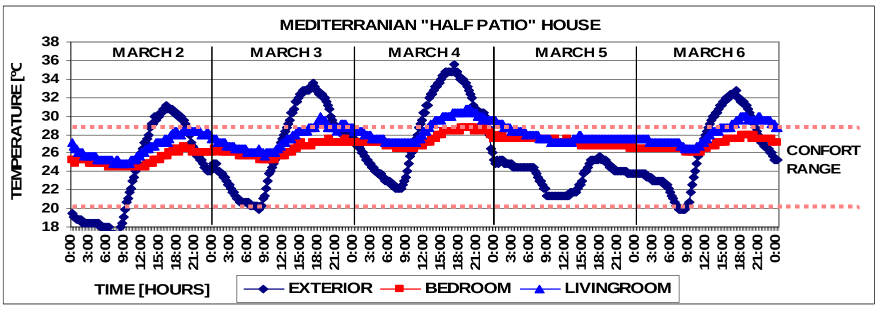


Figure 2. Temperature Measurements. Mediterranean "Half Patio" House.

[1] Compactness Coefficient: from 0 to 1, been 1 the most efficient relationship between envelope and volume.
[2] Easily crossed in public areas and mostly within each space in private areas of the house

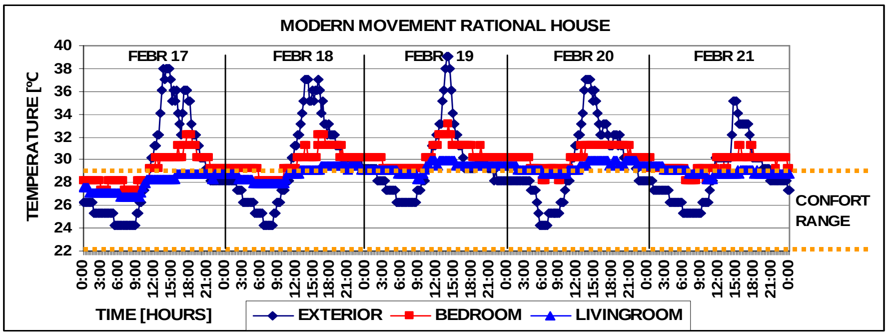


Figure 3. Temperature Measurements. Modern Movement Rational House.

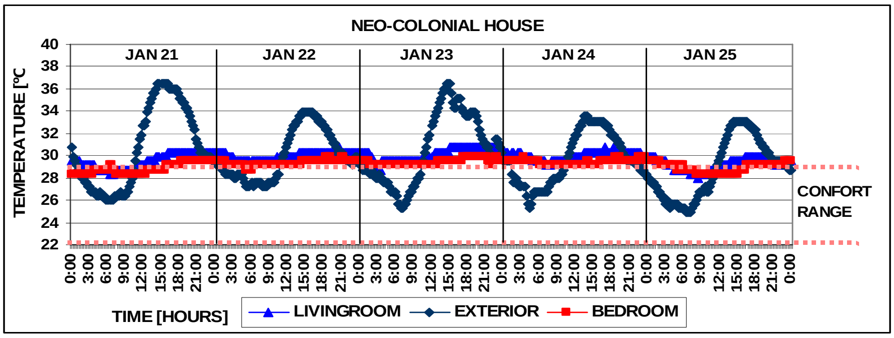


Figure 4. Temperature Measurements. Neo-Colonial House.

USER HABITS

It must be noticed that measurements were performed in inhabited houses. Occupants managed envelope openings as desired and not always leading to reach comfort. From now on, measurement analysis will be regarded from the climate and building point of view adding the user component leading to a holistic comprehension of the phenomena.

Buildings' thermal inertia stand out in a **first** analysis of measurements. The important flattering of the interior temperature curves is accomplished by the high mass that present all typologies. This is a general characteristic of Argentinean construction. However, all inertia flatted curves are not the same, been less variable the Neo-Colonial Chalet typology which presents the smaller percentage (10%) of openable surface. The Modern Movement Rational House with 20% of openable surface reports the highest temperatures in hottest hours of the afternoon. This situation is related to the lack of sun shading in openings and daytime ventilation, resulting in the approach of indoor temperatures to the outdoor situation.

The **Second** observation will be regarding discomfort interior temperatures registered in all typologies on hottest days. Nowadays economic issues prevent the abuse of air conditioning in Argentina. Even though most houses have this type of mechanical equipment, they are not in all rooms and they are on a few hours a day. As discomfort exists in a permanent basis in summer, as soon as people can economically spear the cost, mechanical condition will probably be the solution they would apply to regain comfort increasing pollution and non-renewable energy consumption. The need of a an **environmental** rehabilitation is clear.

Third observation points attention into the fact that there are important differences in day-night exterior temperatures and houses remain 10 to 15ºC above external temperature at night time. There is therefore an opportunity to apply Nocturnal Convective Cooling and show users how a different management of the envelope approaches comfort without added costs and avoiding pollution. The crucial issue is therefore the prediction of how energy efficient the ventilation strategy will actually be in a rehabilitation. At this point it is important to quantify the potential influence in the lowering of interior temperature of envelope regulation of openings and filters (ventilation). Figure 5 shows temperatures of a Modern Movement Rational House identical to the first one presented in Figure 3, and also measured in the same period of time. It has a completely different temperature behavior because it is instinctively managed by is occupants with the Nocturnal Ventilative Cooling strategy.

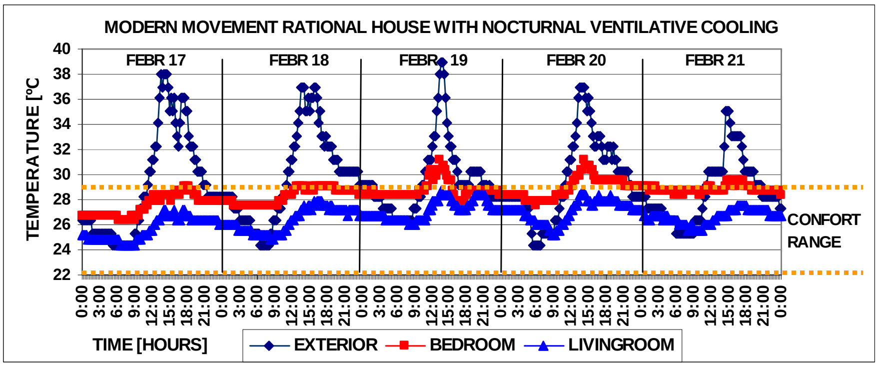


Figure 5. Modern Movement Rational House with Nocturnal Ventilative Cooling.

Even though the bedroom presents some temperatures above comfort, the general situation has improved greatly. Night temperatures in the Living-room reach the minimum exterior measurements. By natural strategies this is the lowest you may go! The private area of the house (bedrooms) is more difficult to cross ventilate due to privacy partitions. The ventilation strategy may be complemented to guaranty comfort even in hottest days of summer.

Potential of successful rehabilitation with ventilation techniques as a first rehabilitation improvement in the hot season has worked very good for the Modern Rational House (Figure 5). In order to quantify the Nocturnal Ventilative Cooling potential of the Mediterranean Half-Patio House and the Neo-Colonial Chalet, simulations were performed with the transitional simulation program SIMEDIF (Flores et al, 2000). Results are shown in Figures 6 and 7.

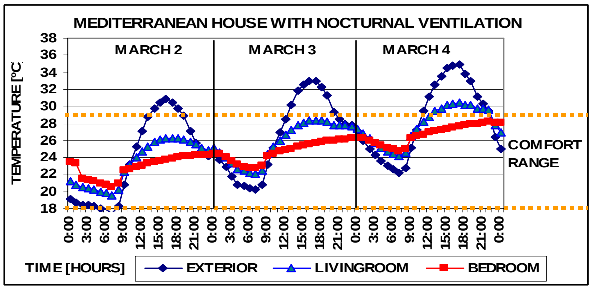


Figure 6. Simulated Mediterranean Half-Patio House with Nocturnal Ventilative Cooling.

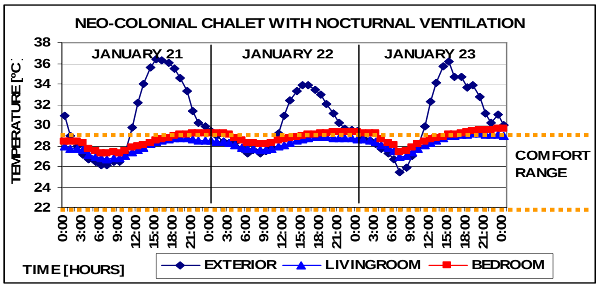


Figure 7. Simulated Neo-Colonial Chalet House with Nocturnal Ventilative Cooling.

Simulations of the Neo-Colonial Chalet (Fig. 7) present the same advantages and constraints that the Rational House (Fig.5), but with less openable area. This difference results in less variable cycles and a more constant temperature. The Mediterranean House presents a different scenario. Without the possibility of cross ventilation, the hottest rooms are the ones with more envelope area exposed to the exterior, in this case the Living-room. An envelope rehabilitation strategy to prevent overheating, probably related to sun shading, is needed as a complement. Nevertheless, internal temperatures lower considerably with the Nocturnal Ventilative Cooling strategy been a very recommendable and cost-effective way to start environmentally ameliorating comfort.

CONSIDERATIONS ON ENVIRONMENTAL ENVELOPE REHABILITATION WITH VENTILATION

- Nocturnal Ventilative Cooling: envelope management

This is the main strategy recommended for climates such as Mendoza's with diurnal temperature swing of more than 15ºC and a high mass building stock. This strategy works best combined with an appropriate insulation and sun shading of the envelope to prevent daytime heat gain that end in overheating. The final performance depends greatly on users'daily habits.

- Comfort (daytime) Ventilation: air movement management

When indoor conditions exceed comfort limits during daytime but temperatures are still lower than the outdoor ones. Air movement with ceiling or wall fans with the maintenance of the house completely closed will upper the limit of the comfort range 2-3ºC from the established one. In Mendoza, usually this may be enough to regain indoor comfort without compromising the rising of temperatures to the point that they could equal the ones registered or to be registered outside by opening the windows.

Daytime ventilation, by opening the house during the day, results in the behaviour of indoor spaces following the outdoor. It is only recommended in Mendoza when, due to an special meteorological situation, the outdoor temperature did not descended during night-time. The building is overheated from the day before and internal and external temperatures are the same. The movement of air gives occupants a psychological perception of coolness. It is important to be aware that temperature will not go bellow outside levels.

CONCLUSIONS

This paper has identified ventilation opportunities as a passive technique in first steps of summer rehabilitation. Choosing appropriately the ventilation type required for each climatic situation, it is possible to improve the interior temperature performance without added costs.

Nocturnal Ventilative Cooling is a very recommendable strategy in the city of Mendoza and similar climates with important day-night temperature swings. By analysing the existent building stock in the particular case of Mendoza, it was demonstrated that this strategy works in all existent typologies, even though each one presents a different potential of cooling by ventilation. Nevertheless, final temperature performance will depend on users' correct envelope management and not on typology .

There were also identified cases where the nocturnal ventilation strategy must be complemented in hottest days in order to maintain comfort during the day. This may be achieved by suitable sun protections and by diurnal air movement by fans.

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