PLEA SANTIAGO 2022
Will Cities Survive?

Wladimiro Acosta and the Helios System: 3 case studies

Comparative analysis and critical review

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ABSTRACT: Wladimiro Acosta was a pioneer in the use of meteorological science for architectural purposes. His Helios System, a methodology that he created in the 1930´s for designing with the sun in temperate warm climates, has proven to be grounded and sound. This paper reviews its application in three case studies across Argentina. The analysis is carried out through contemporary knowledge, solar and thermal simulations. Results prove that Acosta´s system works across different climates in the country and translates into sound thermal performances, even for contemporary standards.
KEYWORDS: Solar design, Helios System, Wladimiro Acosta, Argentinean modern architecture

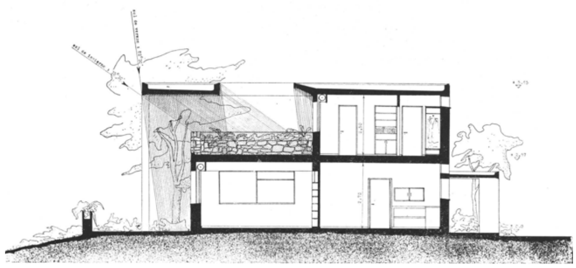
1. INTRODUCTION

Wladimiro Acosta was an absolute pioneer in the use of meteorological science for architectural purposes. Previous research carried out by the author (1) reviewed the validity of his Helios System, a methodology that he created in the 1930´s for designing with the sun in temperate warm climates. The research also pointed out his deep knowledge in the field that he gathered through climate, geographical, cultural and technical studies, as soon as he migrated to Argentina. His understanding about thermal comfort was accurate and he was probably the first architect to consider the science holistically from climate studies to building physics and how can design impact on physiological sensations:his theory compares with the contemporary approach to environmental design. This paper critically reviews the application of the Helios System into 3 case studies across Argentina. Conclusions are drawn from design features, solar, and thermal simulations. The work of Acosta is a key reference for Argentinean architects, as one of the first modern architects to practice in the country and with a strong line of thought rooted locally.

2. THE HELIOS SYSTEM

It is a design methodology for the temperate warm climate dominant in Argentina:the “starting point is the orientation of the building for which the decision is subject to solar access, breeze capture, and moisture regulation” and points out North as the most advantageous one, followed in order by NE, and East and West. The “shading slabs” are the most prominent feature: a “combination of large projecting slabs of 2m or more, elevated at a double height of 4,50 to 6m, and vertical protections N-S oriented” (Figure 1). As for the openings, Acosta explains how to adjust the size according to orientation for solar control, and how to consider shape and position to enhance daylight distribution and natural ventilation. He also suggests that all windows should have an operable upper part for winter ventilation purposes (Acosta, 1936).

Figure 1:
Section of a house with the Helios System



3. METHODOLOGY

The review of the designs is grounded on contemporary knowledge and simulation tools. Climate data was extracted from Meteonorom v8.0 (1980-2020), solar simulations were performed with Ladybug, and thermal simulations with EnergyPlus through Honeybee. A shading mask was performed on the shading systems to evaluate their effectiveness, sun hours were used to see how sunny outdoor spaces are, and solar radiation was calculated in summer and winter to study how much solar heat is regulated by Acosta. A version without the shading slab is calculated to evaluate how much heat it offsets in summer. Thermal simulations were used to understand conditions in free running mode as well as the heating load to compare with contemporary standards. All the houses have double brick walls with an air gap (U-value 2.7W/m^{2}K), single glazing (U-value5. 7W/m^{2}K) with night shutters (night U-value 1.87W/m^2K), and concrete slabs (U value 3.17W/m^2K). Infiltration was set as a "leaky building" for the EN standards, which translates approx. into 1ach. Free running zone operative temperatures were evaluated against the adaptive comfort zone based on EN 15251 (cat. II). For the heating load, the setpoint was 20ºC to match the EN norm.

4. CASE STUDIES: HOUSES AND CLIMATES

Case studies are summarised in Table 1 (Acosta and Gaite, 1976), together with climate data. The first one is the House in Ramos Mejía, in the outskirts of Buenos Aires, for the world-known photographers Grete Stern and Horacio Coppola. The second is the House in La Falda, Córdoba, emblem of the Helios System, as he presented the system to the public with this case study. The last one is the House in Bariloche, in the south of Argentina, for a couple with two kids. He designed several houses with this prototype, but only built this example. This house is not widely published.

4.1 The climates

The climate of Buenos Aires (latitude 34ºS) is characterised as Cfa in the Koppen-Geiger classification, temperate, with no dry seasons and hot summers. The outskirts are more continental than the zones next to the river with a higher diurnal variation, reaching at least 12ºC. Summers are hot, with an average high temperature of 31ºC and very high solar radiation, reaching 867 W/m^2. 47% of the time it is sunny, and the direct component is twice to three times the indirect one, which explains the importance of an effective shading system. The high diurnal variation calls for the use of thermal mass to stabilise temperatures. Winters are mild, with an average temperature of 10ºC in the coldest months. Mornings are cold (average of 4ºC), but days are sunny (around 45% of the time) and solar radiation is intense, reaching more than 400 W/m^2, which brings temperature to 16ºC on average in the afternoon.

The climate of La Falda is Cfb, temperate with no dry season and warm summers. The latitude is 31.5ºS, lower than Buenos Aires, but at 900m altitude, and in a much more continental area. The yearly average is slightly lower (17ºC for Buenos Aires, 15.8ºC for La Falda), but the diurnal range is higher, especially in winter. Summers reach an average high of 28.5ºC and are 42% sunny. In winter, it is common to wake up with 1ºC, but temperature reaches on average 16ºC in the afternoon, due to the higher solar radiation and proportion of sunny days (69%). This climate calls for special attention in capturing the winter sun.

The climate of Bariloche (latitude 41º, altitude 900m) is classified as Csb, temperate, with dry and warm summers. The annual average is 10.8ºC, which is very low. In summer, skies are sunny, with an average total radiation of 924 W/m^2 a day -more than in Buenos Aires and in La Falda. Temperatures in the morning are as low as 8-9ºC, but the afternoon reaches 23.6ºC on average. Winters are very cold, with a temperature average of 2ºC. During 1/3 of the days, temperature starts the day below 0ºC, and rises during the afternoon due to the high solar radiation. This can happen from early March to early November. Wind speeds are very high (average of 5.6m/s), which adds up to the cold.

4.2 The houses: comparative analysis

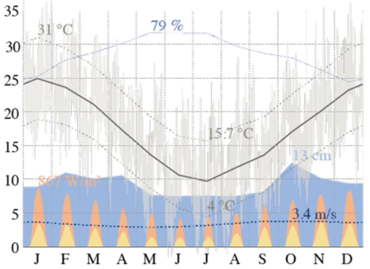
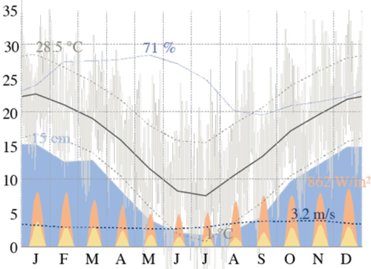
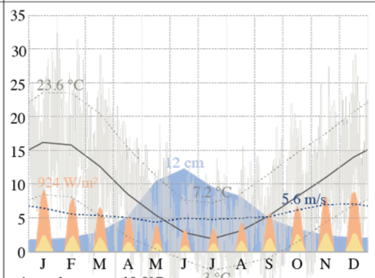
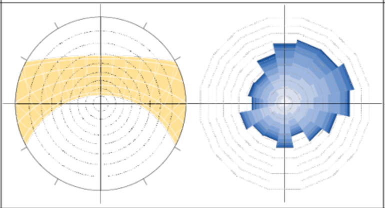
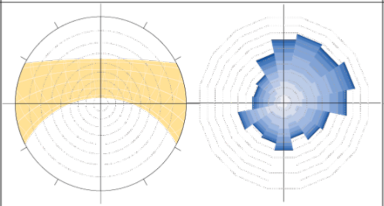
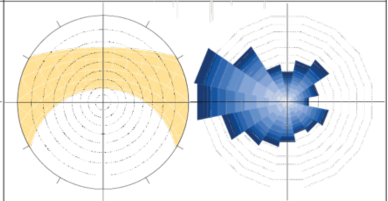
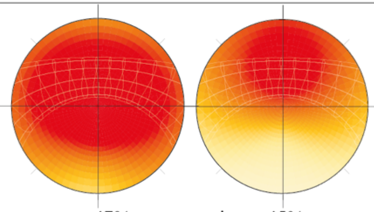
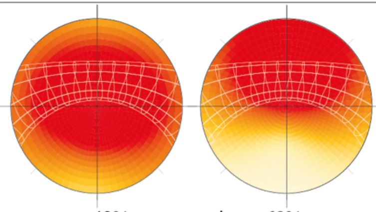
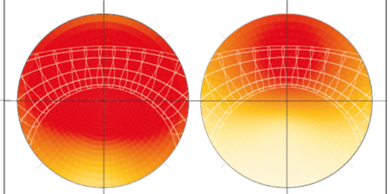
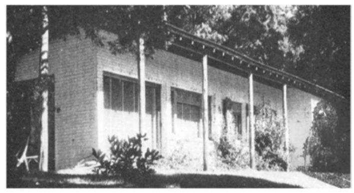
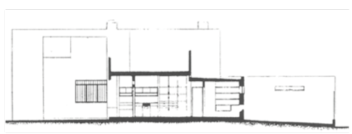
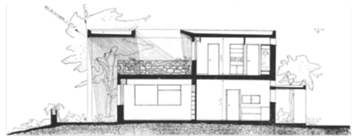
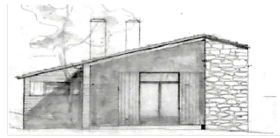
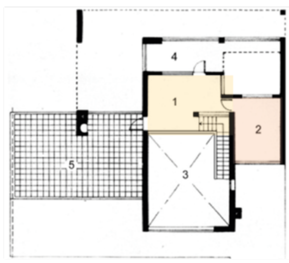
Acosta applied the principles of the Helios System in all his housing designs. The consistency with which he applies them is remarkable as none of the designs are similar in plan, but they all still follow the concepts. It is interesting to notice that the aesthetics of the houses is unique and distinguishable, an aesthetic where one can instantly recognize the challenges of the climates.

To deal with heat, in general, Acosta relies on the shading slab as horizontal solar protection, avoids openings on the west orientation where the sun is more intense, and creates cross ventilation through large openings at occupant height with mosquito nets. He designs different window types based on the specific position, orientation and use, whether sliding, pivoting, fixed or glass louvered. Shaded outdoor spaces below the shading slab can always be enjoyed during the hotter hours.

To deal with the cold, Acosta ensures big openings towards the north receiving full winter sun, and limits heat losses in all other orientations. Service functions and storage systems towards the south act as buffer spaces for the main rooms. All openings are equipped with an upper opening to ventilate above occupant height, and night shutters to further control heat losses. He also installs chimneys, concentrating night-time use in the warmer area. At the time insulation did not exist, so he used double layer brick walls with an air gap acting as insulation.

The house of Ramos Mejía was finished in 1939. It is inside the urban tissue, in a typical double plot of the city -17.5m wide- with a large garden. As most of the plots in Buenos Aires, it is rotated 45ºC from the cardinal points, with the front façade facing SW and the back one facing NE. The living-room, bedrooms, nursery, and kitchen are facing NE, and are protected by the system´s shading slab. The window-to-wall ratio reaches 30%. Towards the SW, Acosta positions the garage, storage, entrance, and the big photography atelier. He purposedly designed a very large window with U glass (to prevent from such a large heat loss) towards the

Table 1: Case studies and climates

	House in Ramos Mejía, Buenos Aires, lat 34º alt.0m	House in La Falda, Córdoba, lat 31.5º alt. 900m	House in Bariloche, Río Negro, lat 41º alt. 900m
Climate summary Monthly data — avg temp. ···· avg high/low ···· wind speed — humidity precipitations Daily solar radiation total diffuse	 Annual average: 17.2ºC	 Annual average: 15.8ºC	 Annual average: 10.8ºC
Sun path & wind rose 0 2 4 6 8 10 m/s			
Calla dome and % of sunny days for summer and winter 0 70 140 210 280 350 kWh/m²	 summer: 47% sunny winter: 45% sunny	 summer: 42% sunny winter: 69% sunny	 summer: 58% sunny winter: 45% sunny
Helios system			
Section			
Plans main living areas work areas bedrooms kitchen buffer storage	 	 	

SW to get most of the year indirect light and incorporated other light sources from the NE and SE to add lighting variety (Acosta, 1946).

The house in La Falda was finished in 1940, and Acosta used it to present the Helios system to the wide public as he probably considered it its finest example (1943). The site was large and Acosta could choose the positioning and orientation of the house. The plan is relatively compact: living room, coin de feu and bedrooms are facing North, whereas circulation, kitchen and storage are facing South. He also positioned work areas towards the south -a studio and ironing zone- in order to have bright indirect light to perform the tasks. The window-to-wall ratio towards the north is large -34%, followed by the east one -26%- where he locates the dining room and a secondary bedroom. West and south window-to-wall are minimised -10 and 13% respectively-, as openings are only intended for minimum light purposes and cross ventilation. The Helios shading slab is intended for the large living room of the ground floor.

The house in Bariloche (1959) is the smallest one, as the climate calls for compacity and reduction of heat loss. It was located on a steep slope facing the beautiful Lake Mascardi towards the west, which prompted Acosta to rotate the house from the traditional North orientation. All main rooms are therefore facing west to get the low sun and the views: this deviation is possible due to the much colder climate. The living and dining room has openings towards the East, North and West. The kitchen and bathroom are orientated east, together with circulation and storage. This orientation has the steep slope, so the solar potential is reduced, especially in winter. The window-to-wall ratio towards the North and West reach 19%, whereas towards the east they are reduced to 11%, and no openings face south. In order to reduce the heat loss in this very cold climate, Acosta designed an inclined roof with a large air gap in between acting as insulation. Here, the Helios System is narrower and shorter, as the climate requires less protection.

5. SIMULATION ANALYSIS

5.1 Solar simulations

Results are shown in Table 2. The shading mask of La Falda proves that the system prevents the direct sun from reaching the glazed surfaces throughout the day for the 4 to 5 hottest months. During the rest of the year, the sun enters the living space throughout the day. During winter, the large windows in the north orientation receive high amounts of radiation (approx. 300 kWh/m^2) which translates into a significant amount of passive heat. East and West windows also receive a fair amount (180-190 kWh/m^2) to heat up the house. During summer, large north windows receive around 1/3 less radiation than in winter, which shows the success of the design. Without the Helios System, north windows would receive 50% more solar radiation in summer, which would add too much heat to an already hot atmosphere. The east and west orientation receive high amounts of radiation: in the east, the sun is welcome as it reaches the windows when temperatures are still 15-20ºC, whereas in the west, windows are minimal serving only service zones. This reduces significantly the heat added to the house. The garden receives the sun all year round, and the shading slab creates a shaded exterior area for summer.

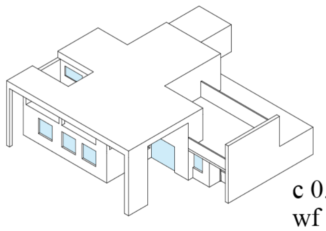
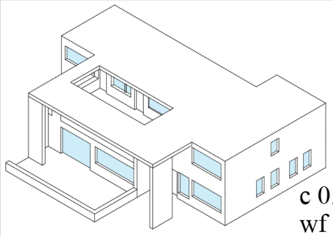
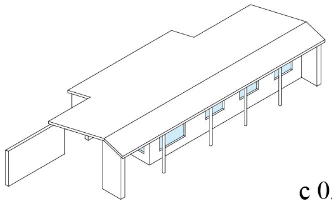
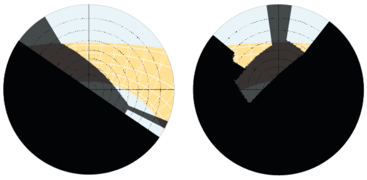
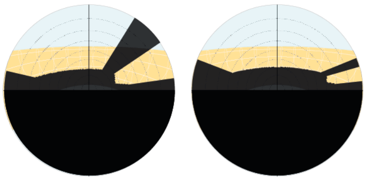
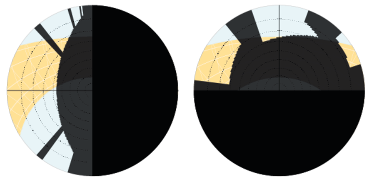
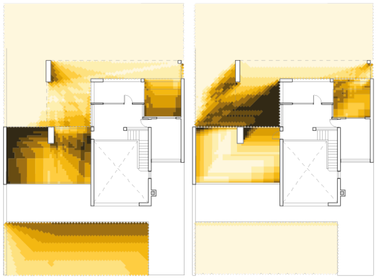
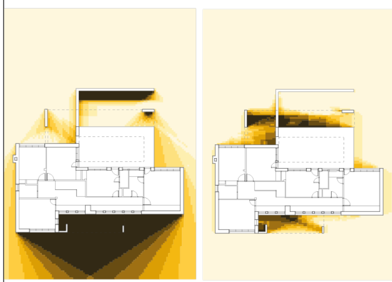
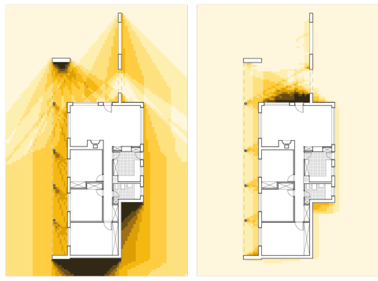
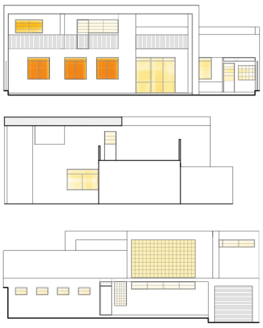
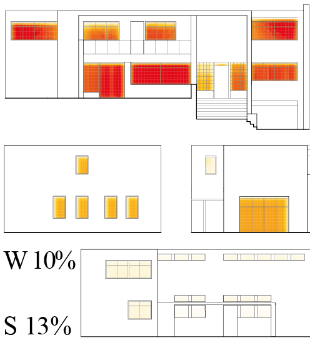
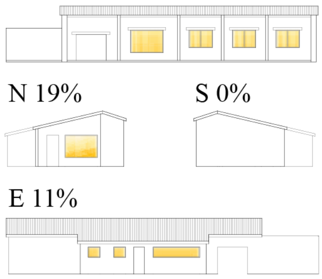
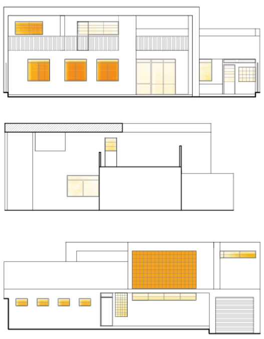
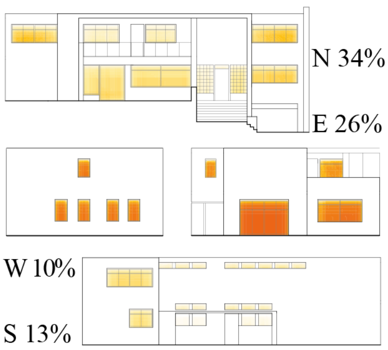
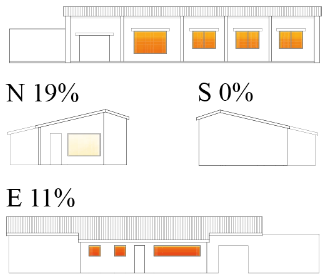
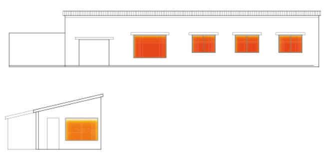
In Ramos Mejía, the slab protects the main NE windows from the intense and high midday sun. Windows receive radiation during the morning in summer, and up until 1-2pm in winter. The NW orientation is protected all year round (except some hours during winter) to avoid adding heat during the afternoon. Both orientations receive very similar amounts of radiation in summer and in winter (around 220 kWh/m^2), which proves the ability of Acosta to control the sun. Without the shading system, windows would receive 25% more radiation during summer. It is worth recalling that controlling the sun in the NE and NW is harder than due north due to the lower angles. The SW and NW orientations have very little windows, to prevent the heat of the afternoon, except for the atelier, for which the intentions were explained earlier. As in the case of La Falda, the garden is in full sun all year round, but the slab creates a protected shaded area during summer.

In the Bariloche case, the sun reaches the glazed surfaces all year round to add heat to the cold atmosphere. The shading slab protects the west windows only from the high midday summer sun and reduces the solar radiation on these surfaces from approx. 280 to 210 kWh/m^2, some 25%.

5.1 Thermal simulations

Results are shown in Table 3. The house in La Falda has a remarkable thermal performance. The main living room reaches 59% of the time in comfort: only at night it is not naturally in comfort and during some of the coldest winter days. During most of the winter, the space captures effectively the sun and raises its temperature naturally. During daytime, the house is some 5ºC warmer than outdoors, reaching comfort, and at night it is 15ºC warmer thank to the thermal inertia that keeps the heat. The heating load of the space and house is relatively high (50 kWh/m^2 for the living room and 75 kWh/m^2 for the full house). In reality, heating would only be required the days without sun during winter, which are not much. During summer, temperatures are in comfort throughout the day without overheating. At night and during the

Table 2: Solar analysis

	House in Ramos Mejía, Buenos Aires, lat 34° alt.0m	House in La Falda, Córdoba, lat 31.5° alt. 900m	House in Bariloche, Córdoba, lat 41° alt. 900m
<u>General data</u> - 3d view - Compacity - Window-to-floor ratio	 c 0.42 wf 28%	 c 0.53 wf 27%	 c 0.31 wf 25%
<u>Overhang:</u> - shading mask - orientation - height	 NE: 2.0m at 5.4m height NW: 2.0m at 5.4m height	 North: 2.2m at 5.4m height North: 2.2m at 5.4m height	 West: 1.5m at 3.6m height North: 1.5m at 3.6m height
<u>Solar access</u>: - sun hours on outdoor spaces on key days 0 2 4 6 8 hours a day	 21st of June 21st of December	 21st of June 21st of December	 21st of June 21st of December
<u>Solar gains</u>: - solar radiation falling on glazed surfaces - window-to-wall ratio by orientation Winter period 0 70 140 210 280 350 kWh/m²	 NE 30% NW 6% SW 31%	 N 34% E 26% W 10% S 13%	 W 19% N 19% S 0% E 11%
Summer period 0 70 140 210 280 350 kWh/m²	 NE 30% NW 6% SW 31%	 N 34% E 26% W 10% S 13%	 W 19% N 19% S 0% E 11%
Summer period House without Helios System 0 70 140 210 280 350 kWh/m²			

mornings, temperatures are around 20ºC (outdoors is around 15ºC) whereas in the afternoon it reaches some 28ºC, which is still in comfort. The inertia of the walls stabilises temperatures and keeps them below outdoors during the hottest hours.

The main space in the Ramos Mejía house is fairly protected as it is exposed only to the NE. It remains 46% of the time in comfort and is only cold during some winter days and nights. On average, temperature is naturally between 13 and 16ºC in winter, but during sunny days, it reaches the comfort band. This translates into a sound thermal performance, as the space only needs 20 kWh/m^2 of heating. Compared to the entire house (total of 83 kWh/m^2), this space requires the least amount of heating (together with the bedrooms), which reveals Acosta´s strategic thinking. During summer, the house is also in comfort and protected by the shading slab. The main room only overheats during 1% of time, which is low for a climate that reaches an average high temperature of 31ºC in January. The thermal inertia of the walls and slabs and cross ventilation help to reduce temperatures and keeps them inside the comfort band. The space maintains the daily average at night (24ºC) and increases its temperature up to 28ºC during the day, which is up to 5ºC lower than outdoors during peak hours.

The house in Bariloche is cold across the year due to the general very low outdoor temperatures. Main rooms are in comfort for around 30% of the time spanning from early October to end of March. During summer, the house has temperatures between 20 and 26ºC, and is in comfort naturally. During winter, temperature inside swings from 6 to 12ºC naturally, which is 5 to 10ºC above outdoors. For a house without insulation and in a climate with such low temperatures, the performance is not bad. However, Acosta was well aware that this was not his best example which is why he kept the design far from the public eye: this house is only published in his complete works and has little information.

6. DISCUSSION

Solar simulations show that Acosta could accurately predict the sun´s position and its effect in all the latitudes and use it to design efficiently. The system proves to work properly in all the cases as solar radiation is minimised on glazed surfaces in summer but maximised during winter. Thermal simulations validate his methodology as sound performances are achieved in the main rooms of the house with no overheating.

7. CONCLUSION

The principles of the Helios System were reviewed in a previous paper. Its application into case studies is consistent and proves to be effective for a sound thermal performance. Its simplicity and versatility allow adaptation to different contexts which suggests that it can still be implemented today in housing designs across the country.

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