Taylor & Francis
Taylor & Francis Group

Architectural Science Review

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/tasr20

A contemporary review of Grupo Austral's housing typologies for Argentina's countryside

Florencia Collo & Simos Yannas

To cite this article: Florencia Collo & Simos Yannas (2020): A contemporary review of Grupo Austral's housing typologies for Argentina's countryside, Architectural Science Review, DOI: 10.1080/00038628.2020.1779023

To link to this article: https://doi.org/10.1080/00038628.2020.1779023

Published online: 06 Aug 2020.

ARCHITECTURAL SCIENCE REVIEW
https://doi.org/10.1080/00038628.2020.1779023

A contemporary review of Grupo Austral's housing typologies for Argentina's countryside

Florencia Collo[a] and Simos Yannas[b]

[a]Atmos Lab, London, UK; [b]Architectural Association School of Architecture, London, UK

ABSTRACT

The paper reviews four housing typologies designed by Grupo Austral in 1939 for rural regions of Argentina. The design of each dwelling was adapted to the different climatic regions of the country, which range from warm subtropical to cold desert. Grupo Austral's design proposals demonstrate an outstanding environmental awareness. In this paper, the design features of these houses are evaluated against present knowledge and advanced environmental simulation tools. The original building specifications are found to compare very well with contemporary environmental design practices.

ARTICLE HISTORY
Received 31 May 2019
Accepted 3 June 2020

KEYWORDS
Rural housing; modern architecture; Grupo Austral; Argentina's countryside; design with climate; thermal comfort

Introduction

Environmental design knowledge is still underdeveloped in Argentina. There have been no contemporary exemplars to follow and vernacular architecture has received little attention as a source of inspiration. The current situation of rural dwellings is critical, with cheap generic solutions being applied to social housing without regard to local conditions. The research presented in this paper aims to provide a number of useful examples drawing upon the environmental design heritage of a group of Argentinian architects that became known as the Grupo Austral. Grupo Austral shaped the Argentinean discourse on modern architecture in the 1940s, greatly influencing subsequent generations of architects by its activism. Rural urbanism was the topic of the group's second publication in 'Nuestra Arquitectura' in 1939 (Bonet et al. 1939a). This work presented a regional plan and four dwelling typologies for the countryside of Argentina, each corresponding to a different climatic region ranging from the warm regions in the North to the cold desert zones of the South. Each design variant was meant to respond explicitly to climatic conditions. A review of these four schemes is presented here evaluated against current knowledge and state-of-the-art computational tools. Comparisons are thus drawn with current housing typologies making it possible to assess the relevance of Grupo Austral's proposals today.

Grupo Austral

Grupo Austral was an association of young architects that burst onto the cultural scene in the late 1930s with a radical agenda that aimed to break down existing structures and become the avant-garde of Argentinean modernism. Their agenda was to 'fight for the progress of architecture' (Bonet et al. 1939b). Even though other architects (such as Acosta or Vilar) had already embraced a modernist outlook, they all stayed outside the general debate about the future of Argentinean architecture. For Liernur (1994), an expert in Latin American modernism, Austral was to Argentina what Gropius had been to the Bauhaus, a generator and disseminator of ideas. Their major imprint was to install architecture as 'a cultural fact and not merely professional'. Austral's activities encompassed contact with similar groups from other countries and with other disciplines, as well as with local actors. They propagated their ideas by publishing manifestos, projects and collages in widespread magazines and newspapers of the time. Their built work can be inscribed in what Frampton called 'critical regionalism' (Frampton 1992), which can be considered as modern architecture that still values local culture. Although they do not have any built work as a group, there are at least five works that can be considered as authored by the group's members. Best known are the Ateliers for Artists of Suipacha y Paraguay by Bonet, Lopez Chas and Vera Barros (Figure 1), and the BKF chair by Bonet, Kurchan, and Ferrari Hardoy (Figure 2); both these projects were published under the name of the group in 1939 (Bonet, Vera Barros, and Lopez Chas 1939). According to Liernur what is striking in their work is the 'unstable coexistence of opposites', for example, the contrast between the 'progressist declaration of the façade and the rustic treatment of the terrace', or the use of steel and glass contrasted by crafted elements inspired from folk wisdom (Liernur 1994).

Austral's rapid recognition came from the support they received from Le Corbusier, with whom their three leading members – Ferrari, Kurchan and Bonet – had worked in 1937–38. This relationship helped elect Ferrari and Vivanco as the Argentinean delegates to the CIAM (1947–51), thus granting them a status of international avant-garde architects participating in the discussions shaping the discipline across the globe. The myth of Grupo Austral was consolidated when MoMA consecrated the BKF chair internationally in four exhibitions from 1944 to 1958 (MoMA (Museum of Modern Art) archives, https://www.moma.org/). The

CONTACT Florencia Collo florencia@atmoslab.io Atmos Lab, Unit 77, 5 Corbridge Crescent, London E29EZ, UK

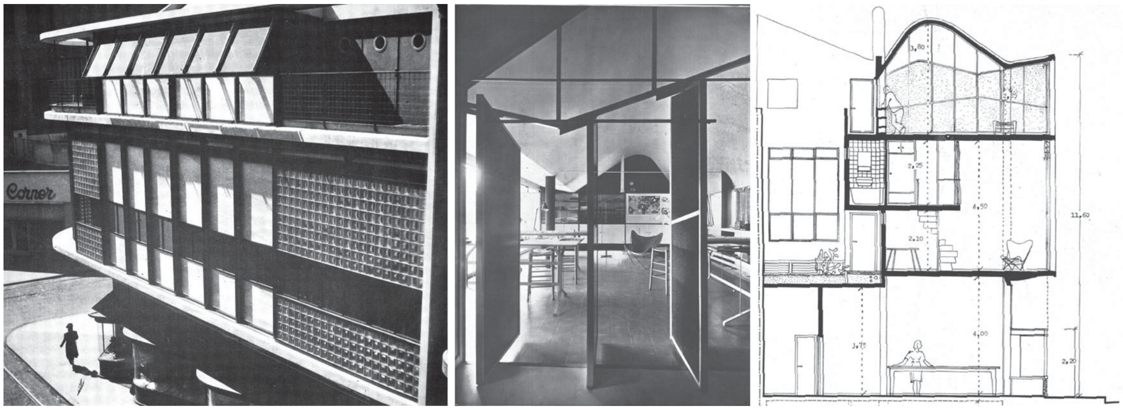


Figure 1. Artist's ateliers in Paraguay y Suipacha, by Bonet, Ferrari Hardoy, and Kurchan – Grupo Austral.

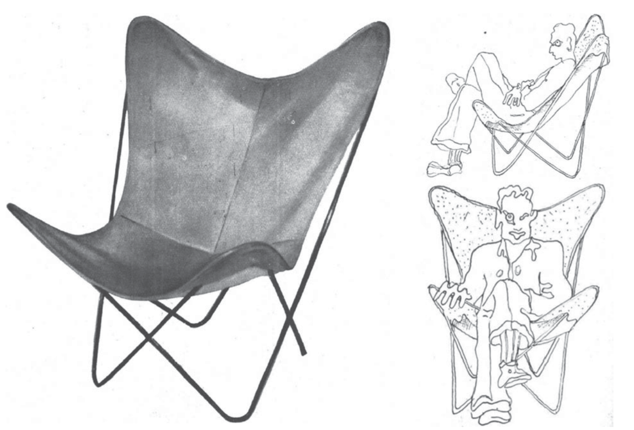


Figure 2. BKF chair, by Bonet, Ferrari Hardoy and Kurchan.

group's activities peaked between 1937 and 1941, and slowly dissolved thereafter due to different engagements of its members.

The housing plan

In 1939, a public competition was announced for rural housing (BNA 1939). The objective was to provide rural populations with new housing solutions adopting a contemporary, economical and easy-to-implement design approach. The competition brief required a housing unit for three distinct climates across Argentina: warm, temperate and cold. The building programme was fixed, consisting of living-room, two bedrooms, a barn, kitchen and bathroom. It also required a building system that could be applied using local materials and labour (SCA 1939).

Austral did not enter the competition as a team probably due to disagreements between the members of the group (Liernur 1994). However, individual members did submit projects of their own, ending by winning the first prizes in the warm and cold climate categories. In the projects presented in this paper, the group considered the temperate zone as being too large and divided it into a 'temperate-north' and a 'temperate-south'. Landscape, technology, lifestyle and climates were studied and prefabrication was favoured being expected to reach a larger number of families in less time. Material selection was based on criteria of durability, thermal properties, maintenance, waste reduction, cost, execution time, ease of construction, local availability and local workforce (Bonet et al. 1939a).

Methodology

The weather data used by Grupo Austral on their design proposals have been published by the group (Bonet et al. 1939a). Each region had a reference city as representing its climate. These regions and cities are shown in Figure 3. For the comparisons undertaken for this paper, contemporary data were obtained from the Meteonorm 7.0 database (Global Meteorological Database 7.0, https://meteonorm.com/) and from Energy Plus EPW files (https://energyplus.net/weather). Tucuman (latitude 27°S) was the designated city for the warmer climate, Nueve de Julio (latitude 35°S) in Buenos Aires for the temperate climate. Grupo Austral used the same weather data for the two temperate climate zones. For the simulations performed in this paper, two different weather files were used with Oliveros in Santa Fe (latitude 32.5°S) for temperate-north, and Tres Arroyos

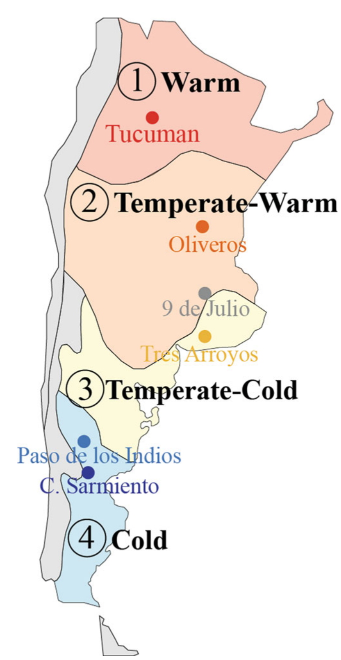
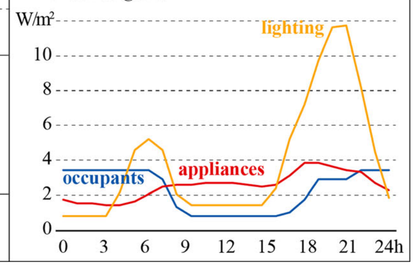


Figure 3. Climate regions according to Grupo Austral and reference cities.

Table 1. Material specification and internal gains.

Material specifications	Original	Upgraded			
	All climates	Warm	Temperate-North	Temperate-South	Cold
U_{walls}	0.7	0.44	0.44	0.44	0.32
U_{floor}	2.3	0.68	0.68	0.68	0.68
U_{roof}	0.8	0.29	0.29	0.29	0.29
U_{window}	5.7	5.7	2.7	2.7	2.3
infiltration	1 ach	0.75 ach	0.6 ach	0.6 ach	0.5 ach
fresh air per person	variable	31 m³/h	25 m³/h	35 m³/h	25 m³/h

Internal gains



(latitude 38.4°S) for temperate-south. Colonia Sarmiento (latitude 45°S) was the original choice for cold climate, but due to the lack of an appropriate weather file, data for Paso de los Indios (latitude 44°S) was used instead.

The Grupo Austral designs were assessed on geometric criteria, solar radiation studies processed with Ladybug Tools (Roudsari and Pak 2013), daylight analysis carried out with Radiance (Ward Larson and Shakespeare 1998) under Honeybee (Roudsari and Pak 2013), wind simulations performed with Butterfly (Roudsari and Pak 2013) and OpenFOAM (Weller et al. 1998), and thermal simulations performed with Energy Plus (US Department of Energy 2017) under the Ladybug Tools platform.

Thermal properties were estimated from Grupo Austral's descriptions of materials. For air infiltration, a constant 1.0 ac/h was assumed in all four climates given that construction techniques of the time were not particularly airtight. A further set of thermal simulations was performed with material specifications of the Grupo Austral's designs upgraded to contemporary standards and airtightness. Occupancy schedules and estimations of internal heat gains were based on assumed occupancy by a household of four one of whom assumed to be in the house continuously. The resulting schedules and internal gains are summarized in Table 1 together with the *U*-values and infiltration rates.

Simulated free-running zone operative temperatures were evaluated against the adaptive comfort zone based on EN 15251 category III (European Norms 2007). The annual number of hours with indoor temperatures within the comfort range were estimated as weighted averages of living room and bedroom temperatures. To create a benchmark, the designs were simulated again with annual space heating and cooling loads calculated for a heating setpoint of 19°C and a cooling setpoint of 28°C.[1]

The use of simulation, and especially multizone thermal simulation of buildings, makes it possible to draw performance comparisons that would not otherwise be feasible. To compare the performance of Grupo Austral's designs with current practices, further thermal modelling was undertaken in order to include the latest government housing plans that were launched in 2015. Information on these was provided by the National Innovation Directory for Sustainable Development (Author's visit, 2016). The government plans distinguished between 'regular' prototypes, designed by the Housing Provincial Institutes and commonly built in the area, and 'environmental' prototypes that incorporated further improvements introduced with the help of environmental consultants. The 'regular' prototypes are organised in urban blocks with plots oriented to the four cardinal points in equal proportions. Every house shares a party wall with another one which is mirrored with the first one. To carry out the simulations, the most advantageous orientation was always chosen.

The climates

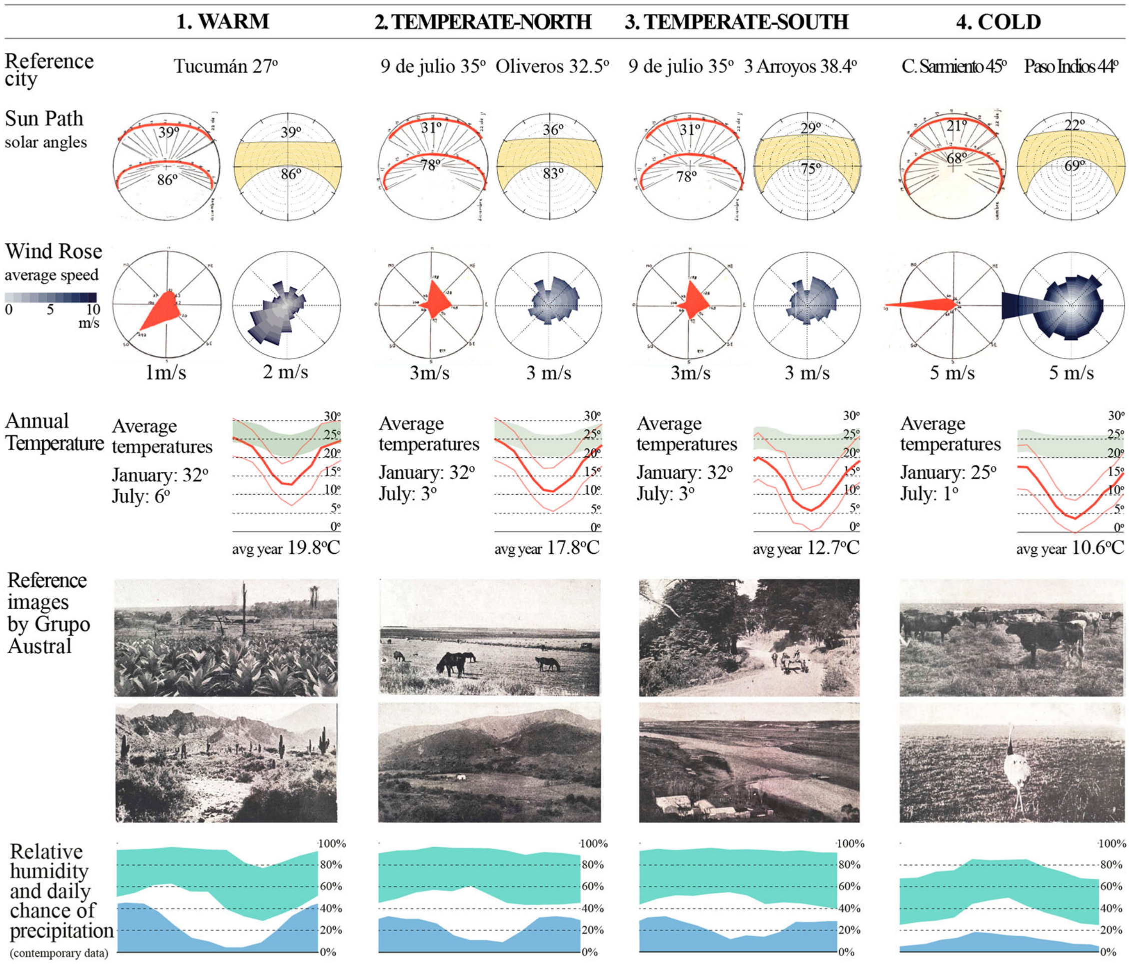
The climatic regions considered here represent the entire spectrum of Argentina's inhabited regions, ranging from warm subtropical to desert cold. Weather data considered by Grupo Austral are included in Table 2 together with contemporary information. For each city, data on the left column represents the information provided by Grupo Austral and data on the right column is the contemporary one extracted from Meteonorm. Grupo Austral illustrated climatic conditions using sunpath diagrams, wind roses, average summer outdoor air temperature in January and average low in July (32°C is given as the average high in January for the three warmer climates – even if it does not seem plausible, the data comes from the original publication by Austral). Although standard procedures to display climatic data did not exist at the time, the sunpath and wind rose diagrams used by Austral are fairly accurate representations.

Tucuman was the city representing the warmest climatic region with an annual average temperature of 19.8°C. The average high temperature in January reaches 32°C whereas the average low in July can fall to 6°C. Diurnal range is about 10–12°C all year round. Prevailing winds come distinctively from South-West, with an annual average velocity of 1–2 m/s. Summer is the wet season, with a daily chance of precipitation reaching 46% and very high levels of humidity. The winter is dry, with a daily chance of precipitation of only 4% and average humidity below 40%. Data from Grupo Austral matches averages drawn from Meteonorm.

For the temperate climates, Grupo Austral used climate information from 9 de Julio. Here, weather data from Oliveros and 3 Arroyos were considered. Oliveros has an annual average temperature of 17.8°C, with an average high of 32°C in January, and an average low of 5°C in July. Tres Arroyos has an annual average of 12.7°C, with average high of 20°C and average low of 6°C. Daily variations are of at least 10°C all-year long. Prevailing winds come from the North East quadrant with an average velocity of 3 m/s. The humid season is again during summer, but with less severity.

The coldest climate is represented by Paso de los Indios, located in an arid cold desert climate. The average annual temperature is of 10.6°C, with an average high of 23°C in January and low of 0°C in July. Temperatures from Meteonorm are similar to

Table 2. Climate analysis by Grupo Austral and contemporary correlation.



the data employed by Grupo Austral, with variations of some 1°C. Prevailing winds come clearly from the West, with mean velocity of 5 m/s. The daily chance of precipitation is very low: during summer there is only a 5% chance and the peak occurs in May with 19% chance. Relative humidity is quite low and remains almost permanently below 40%.

Review of building typology

An example of how Austral presented their climate information and design proposals is shown in Figure 4. The four schemes (Domus 1–4) are summarized in Table 3. Grupo Austral described Domus 1, which they proposed for the warmest climate, as 'open towards the fresh winds and eternally in shade. The house is on pilotis as the solution for the warm region. In the semi-outdoor space under the house, a large part of domestic life will take place during spring, summer, and autumn' (Bonet et al. 1939a). Elevating the house is thus justified by the space generated underneath, which can be used on any day of the year. The ground floor provides a large living area, protected from sun and rain, but open to breeze from any direction. The house itself is shaded by slab projections in all orientations and by extended walls that block the lower eastern and western sun. While the larger openings face south and are shaded with long projections, there are no openings towards the west, and walls towards east and north have only small windows. The living room is oriented toward the prevailing winds as well as open to cross ventilation. The kitchen is provided with independent openings and the barn is detached from the house to enable heat dissipation through the building envelope. The brick walls provide heat storage keeping the interior cooler. The design relies on wind, shade, and thermal mass to keep temperatures down during the hottest periods.

Domus 2 and 3 are described as 'The courtyard as the main element. The house as the extension of the courtyard. Inside it, most hours are spent. A space open to the sky but limiting the horizon' (Bonet et al. 1939a). Both typologies are adapted to the seasonal variations of temperate climates, using courtyards to regulate the interaction with the exterior climate. These can be enjoyed during the hot summer afternoons as they are both protected from the west sun and partially open to prevailing winds. On both designs the living rooms are facing north for passive solar heating in the colder periods. The thermal mass of the brick walls helps to moderate peaks and capitalize on solar gains.

The house variant for the warmer climate has a larger, more protected courtyard with both shaded and open spaces. The house itself is split, to encourage heat dissipation and better ventilation. The living room and bedroom are protected from the west sun by the kitchen and barn respectively. The living room opens toward the north and is provided with horizontal shading. Bedrooms face east and are partially protected by horizontal shading and adjacent extended walls.

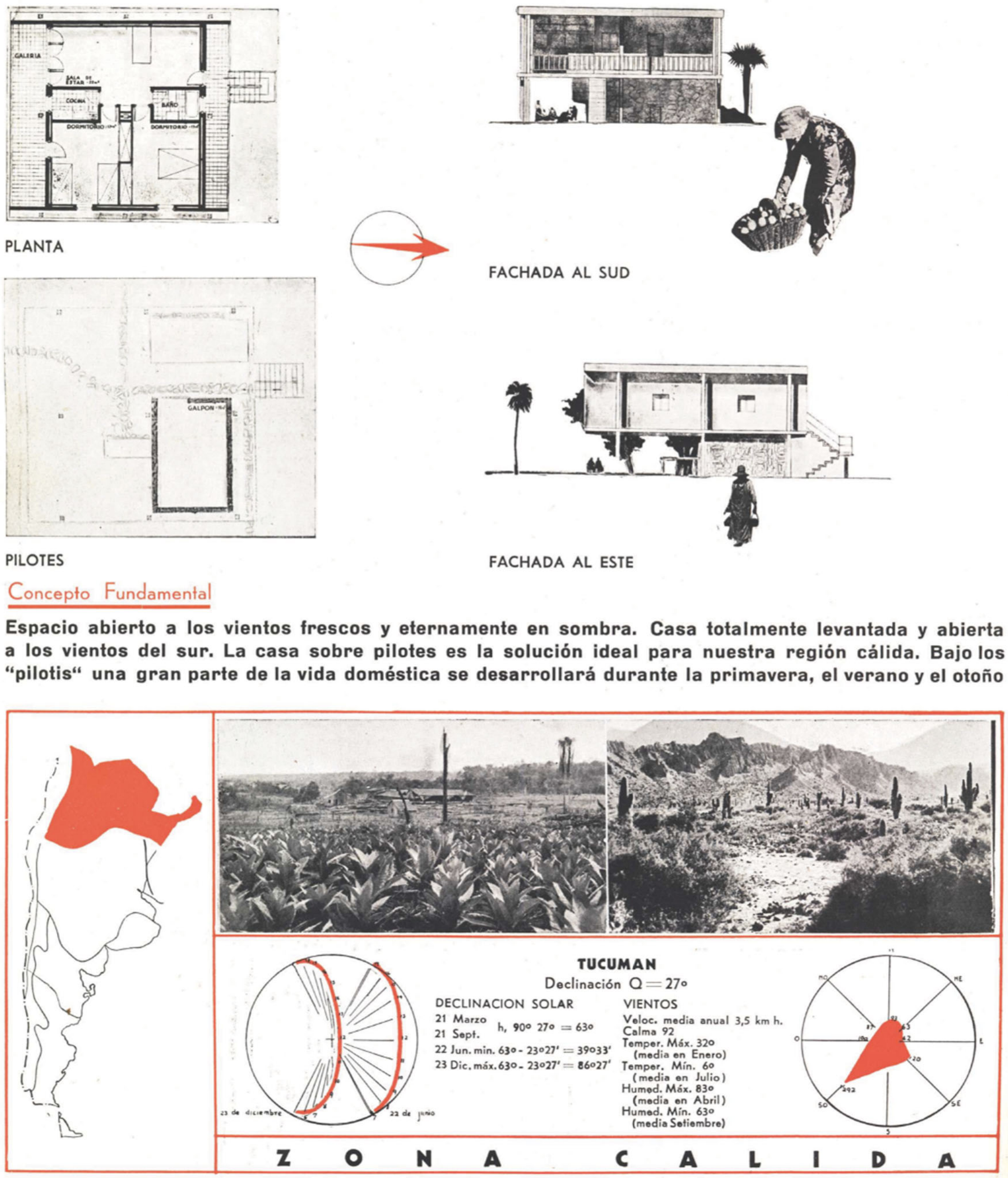
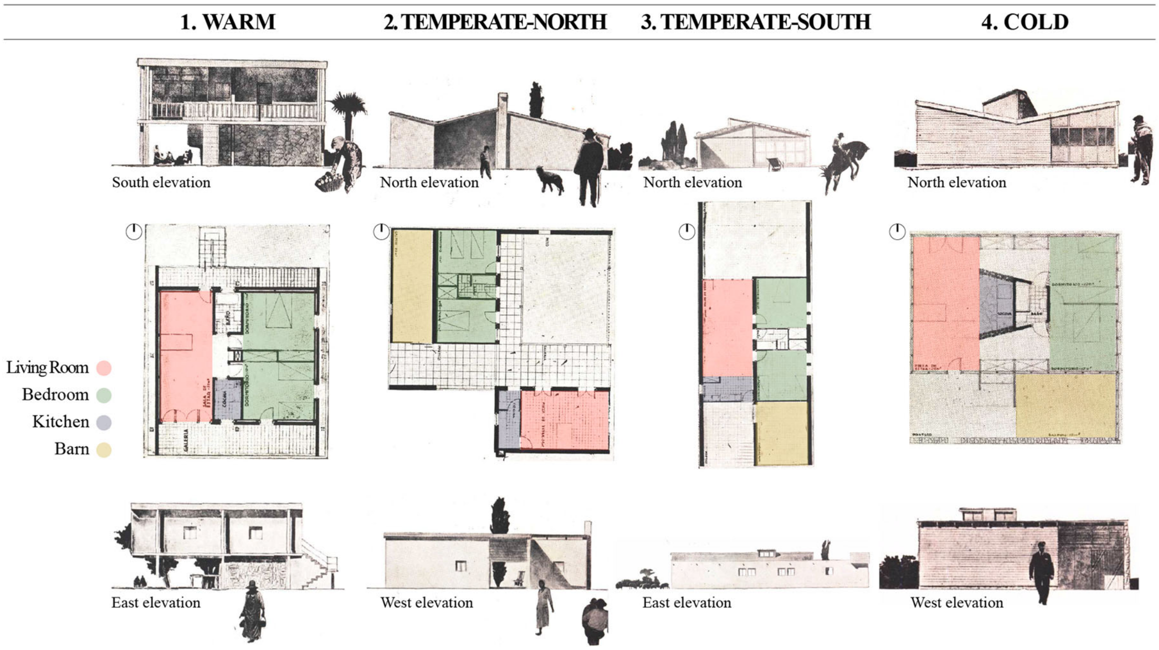


Figure 4. House presentation by Grupo Austral.

The Domus 3 in the temperate cold climate (Figure 5) is more compact to conserve heat, fully open to the north to allow solar access, but protected from the stronger east and west sun with extended walls. The courtyard of this variant is better protected from the prevailing winds than the courtyard for the warmer climate, and more exposed to the sun. The main rooms have the same orientation, but with larger openings and no horizontal shading. The kitchen is partially integrated into the living room. One of the bedrooms is also protected from the south by the barn whereas the other is exposed to the northern sun. Even though the core concept of these two houses is the same, design variations show that each one is tailored to its particular conditions.

Domus 4 was conceived by Grupo Austral as: 'Compact house. The southern climate converts fire into the vital element of the house. The entire household takes place around it' (Bonet et al. 1939a). The kitchen is therefore located centrally, as a heat source for the entire dwelling. There are no wall extensions in any direction so as to avoid obstructions and help capture the low sun of the higher latitudes. The living room warms up from the kitchen heat as well as from large north-facing windows. A large clerestory to the west captures afternoon sun, its high position protecting occupants from glare and the chilly effect of prevailing wind coming from that direction. On the south, buffer spaces help reduce exposure for the living room and one of the bedrooms.

Table 3. Typology design by Grupo Austral according to climate.



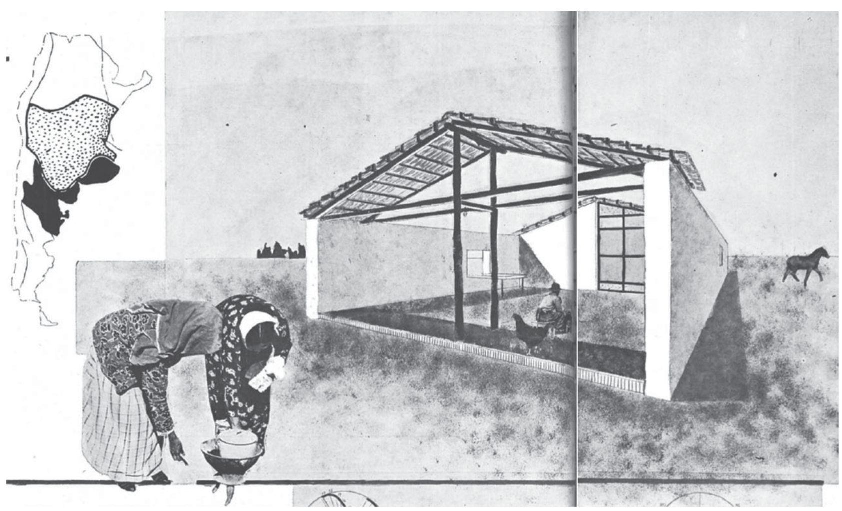


Figure 5. Image of the temperate-cold house by Grupo Austral.

All four designs are simple, austere, sensitive, in line with the modern movement, as well as strongly rooted in their respective climates.

Comparative analysis

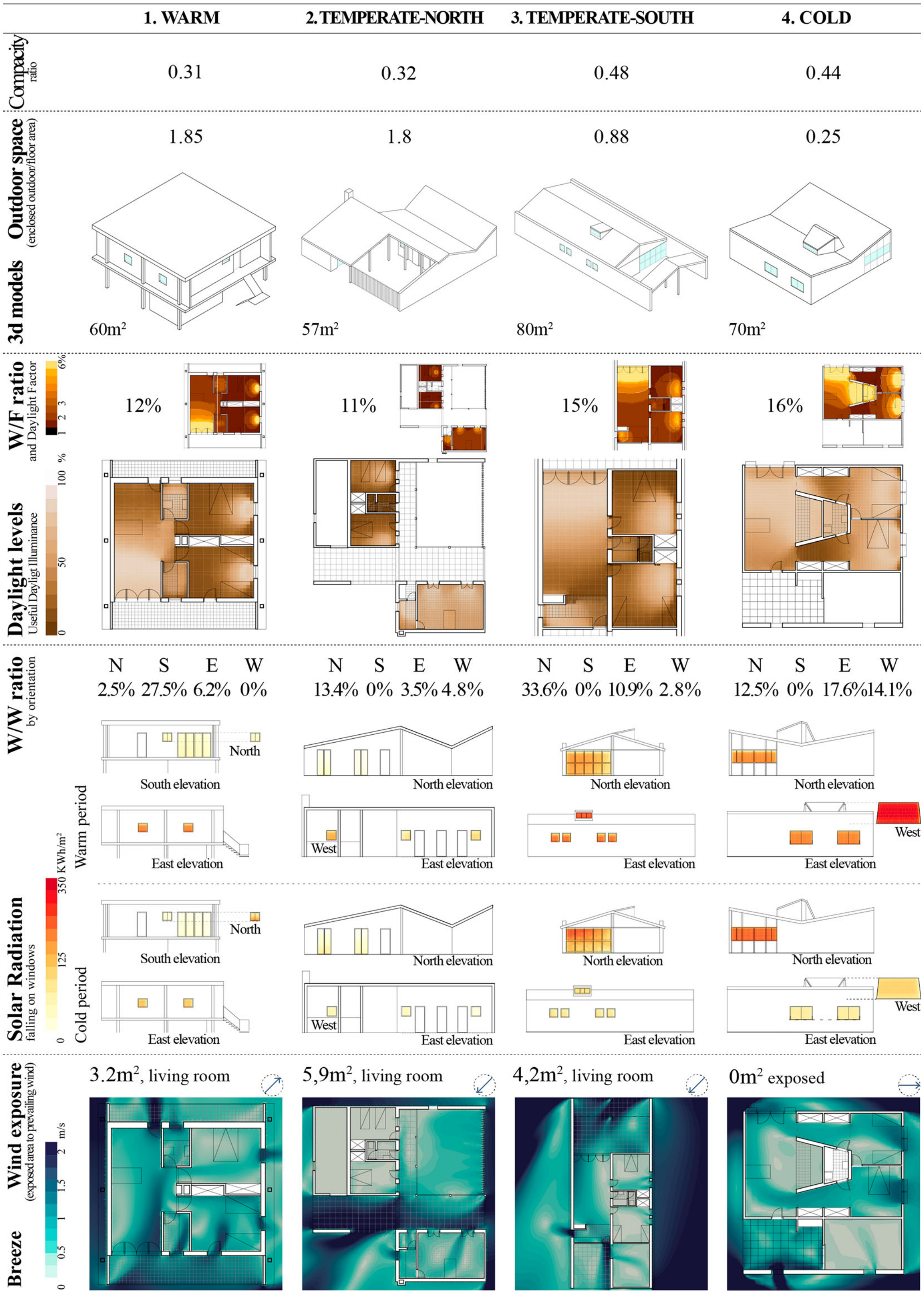
Three-dimensional models of the houses were reconstructed (Table 4). Geometric analysis and environmental studies are summarized in Table 5. In general, compacity ratios increase gradually as climates become cooler. The largest difference is between the two designs for the temperate climates. Outdoor area increases as climates become warmer.

Window-to-floor ratios increase at lower latitudes. Daylight calculations show that the cooler climates allow more daylight inside. However, Useful Daylight Illuminance calculations show that daylighting patterns are consistent across the different climates, as smaller window-to-floor ratios are compensated by higher sky illuminance.

Windows and walls are better shaded as climates become warmer, which is explicit in the original drawings. Simulations of solar incidence on windows show a clear gradation, from barely receiving any direct solar radiation in the warmest climate, to those in the coldest climate that are exposed to the sun throughout the year. Results prove that solar considerations were attentively integrated in the designs.

Looking at wind exposure, simulations show how breeze easily flows when everything is open in the living rooms, whilst bedrooms remain protected. The house of the warmest climate is fully exposed, with two rooms open to cross ventilation. The two temperate houses and outdoor spaces are protected from the wind by extended walls. Initial simulations show the designs to be effective in controlling direct sun, daylight

Table 4. Comparative environmental analysis of the four houses in their respective climate.



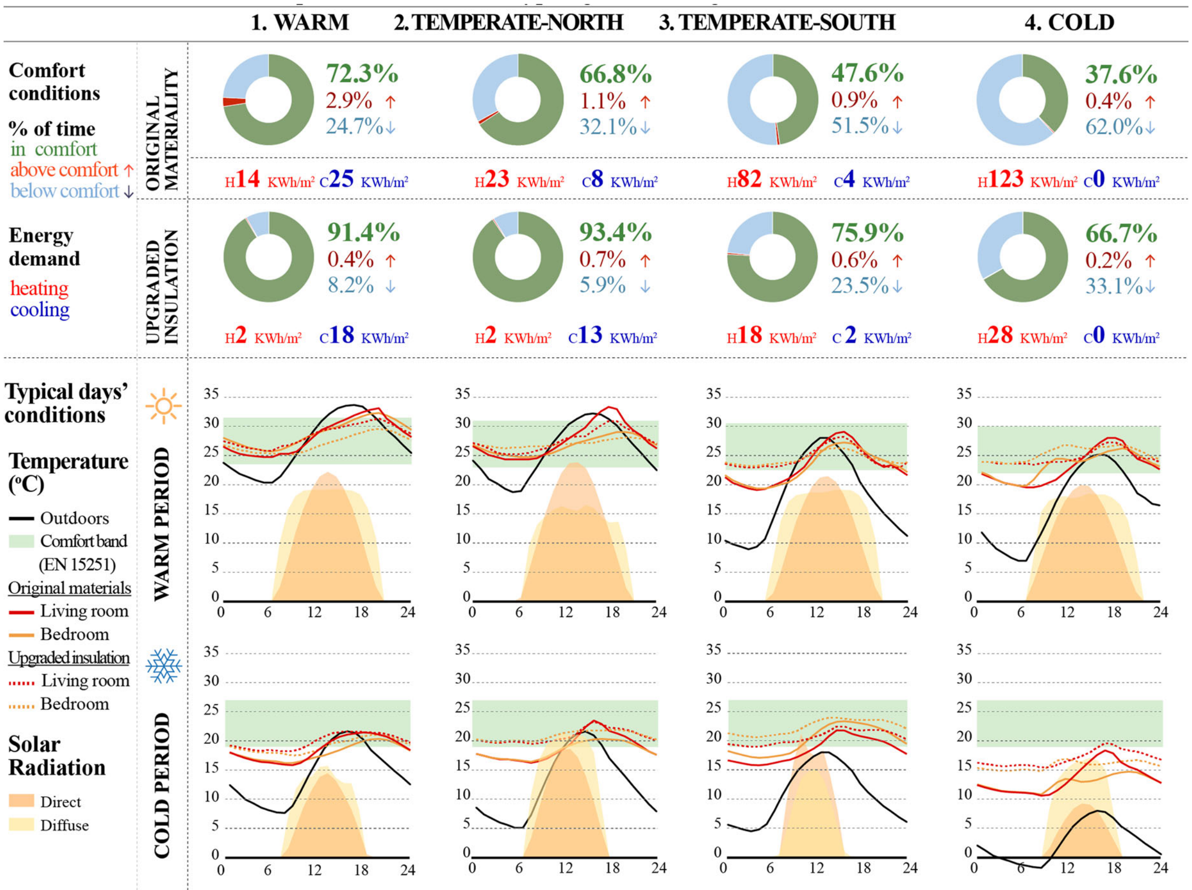
and wind in each climatic context with careful attention given to adapt the designs progressively to the warmer or colder conditions.

Thermal performance

The original material specifications provided by Austral were based on the availability across the country of the materials required for elevated timber floors, thatched roofs and brick cavity external walls. All elements incorporated air cavities as a form of thermal insulation. The resulting *U*-values are listed in Table 1. For upgrading, a layer of thermal insulation was assumed to be added, as well as double glazing in the three colder climates to match contemporary specifications as shown in Table 5.

The design for the warmest climate is shown to achieve indoor temperatures within thermal comfort for 73% of the time with only 3% overheating. During a typical summer day, while outdoor temperatures rise to peaks of 33–34°C, temperatures inside are kept within the comfort range by the thermal mass of the brick walls. Indoor temperatures never rise above those

Table 5. Thermal performance of the four typologies with original materials and added insulation.



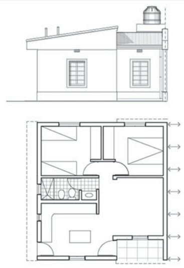
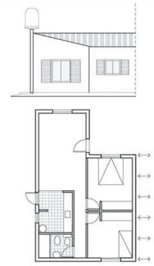
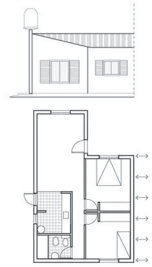
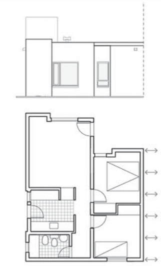
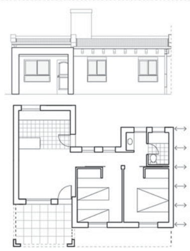
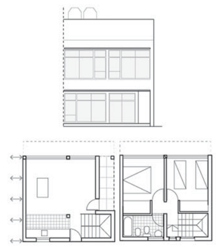
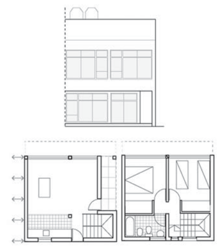
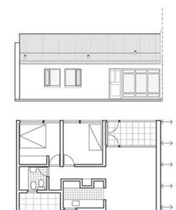
outdoors, which demonstrates the suitability of the adopted strategies. In terms of energy demand for cooling, maintaining indoor temperatures below 28°C results in a cooling load of some 44 kWh/m^2 per year. However, daytime occupation of indoor spaces is meant to be limited given the fully shaded and ventilated outdoor space that is provided for this house variant. In winter, solar gains are sufficient to bring indoor temperatures within comfort during daytime. The majority of hours below comfort (24%) happen at night and early morning, when occupants remain warmer in bed. The house would have a heating demand of 14 kWh/m^2, which is fairly low. Adding a layer of thermal insulation improves indoor conditions tackling both heat and cold, raising comfort hours to 91%. On cold days temperatures stay inside the comfort band, falling below only at night with insulation helping to raise indoor temperatures by 1–3°C. This improvement would correspond to a heating demand below 4 kWh/m^2, which is negligible. Overheating is also reduced, bringing indoor summer temperatures within comfort all day and reducing the cooling demand by 20%.

The house in the temperate-north climate achieves a similar performance with 67% of the time in comfort: the split plan, shading elements, and protection of the main rooms from the western sun help lower the overheating down to 1% of the time. Temperature patterns during summer days are similar to the warm climate case. Here bedroom temperatures remain in comfort whereas the living room temperature rises 1–2°C above the outdoor. The lack of cross ventilation penalizes performance during the warmest periods. At such times occupants can enjoy their patio, which is shaded and partly protected from strong winds. This inconvenience is not a handicap of the design, as it only adds 8 kWh/m^2 to the annual cooling demand. During the cold period, the house suffers from a relatively high amount of underheating (32%), with temperatures falling by 1–4°C below the comfort band at night and in the early morning. Solar radiation drives temperatures into comfort in the afternoons and evenings. Adding insulation raises comfort hours to 93% encompassing both daytime and night temperatures thus achieving the best performance overall.

The temperate-south climate is considerably colder than the temperate-north. The compacity of the house form and adequately controlled sun and wind combine to bring the temperatures of the house within comfort for 48% of time, with almost no overheating. Across the year, indoor temperatures at night and during the morning tend to be below comfort. During daytime and in the evening, high levels of solar radiation coupled with sufficient thermal inertia raise temperatures into the comfort band all year long. Adding insulation is beneficial, bringing night-time and morning temperatures into comfort almost all of the time, rising to an overall of 76% in comfort.

As for the house in the coldest climate, annual hours of thermal comfort fell to 38% owing to the very low outdoor temperatures, lack of thermal insulation and single glazing on windows. In the warm period, daytime temperatures remain in comfort, falling at night driven by the outdoor air temperature. The morning sun helps bedroom temperatures rise attaining a difference of almost 5°C with the living room. This changes later in the day

Table 6. Prototypes regularly built by local authorities and prototypes designed with the help of environmental consultants.

	1. WARM	2. TEMPERATE-NORTH	3. TEMPERATE-SOUTH	4. COLD
Regular prototypes built by the Provincial Housing Institutes	 U values roof: 0.62 walls: 1.47 glass: 5.7 floor: 0.68	 U values roof: 0.62 walls: 1.47 glass: 5.7 floor: 0.68	 U values roof: 0.62 walls: 1.47 glass: 5.7 floor: 0.68	 U values roof: 0.41 walls: 0.42 glass: 2.3 floor: 0.68
Environmental prototypes designed with consultants	 U values roof: 0.33 walls: 0.32 glass: 5.7 floor: 0.68	 U values roof: 0.33 walls: 0.32 glass: 2.5 floor: 0.68	 U values roof: 0.33 walls: 0.32 glass: 2.5 floor: 0.68	 U values roof: 0.39 walls: 0.42 glass: 2.3 floor: 0.68

when the large windows of the living room facing north and west help raise its temperature well above those of the bedrooms reaching 18°C when the outdoor air temperature is only 8°C. This reflects the effectiveness of the design strategies. In terms of heating demand, this represents 95 kWh/m^2, which is high but acceptable in this context. Adding thermal insulation will be naturally highly beneficial, doubling the time in comfort, and raising indoor temperatures during the coldest period by 1–5°C. Heating demand is reduced by two thirds to 28 kWh/m^2 which is quite low for a cold climate.

In general, bedrooms are cooler than living rooms, due to smaller size windows. The addition of insulation helps in all cases to attain very high percentages of comfort hours. The passive strategies adopted have proven to be well chosen, properly calibrated and remarkably efficient.

Comparison with contemporary housing

Comparisons were drawn between the Grupo Austral designs as upgraded with thermal insulation, and the prototypes currently promoted around the country.

The Provincial Housing Institutes of each region build social housing regularly to deal with the shortage, based on fixed designs that get repeated around the region as 'regular' prototypes. These are distributed in a traditional urban squared block and paired as shown in Table 6 (pairing is shown with arrows in the corresponding party wall). The same design is applied on all different orientations. In 2014, the National Government launched a plan aiming to reduce the energy consumption of these houses. Environmental consultants were called to help with the designs across the country, hereby referred to as the 'environmental' prototypes. The plan includes the monitoring of these houses following completion.

Thermal simulations were performed for all the prototypes in all cases assuming the most advantageous orientation, the results of these runs thus representing the best likely performance for these house designs. Unlike the Grupo Austral houses which are for detached dwellings, the contemporary prototypes are paired in semi-detached units and will thus experience a lower rate of heat loss owing to reduced exposure. Plans of the prototypes and the *U*-values of building elements are shown in Table 6. Comparative results of comfort hours and thermal loads are summarized in Table 7.

Whereas the house designs of Grupo Austral barely show overheating in passive mode (less than 61 hours a year), the four contemporary designs show large amounts of overheating in the warmer climates. In terms of cooling loads, the houses of Grupo Austral are either better or as good as the contemporary ones.

In the warmest climate the regular prototypes are definitely in disadvantage owing to their very large windows, lack of solar protection and compact form. Their cooling demand is double that of Austral's designs, and the houses have no outdoor shaded space to enjoy when it gets too hot indoors. In the environmental prototype, a very small outdoor space is incorporated, and the design is less compact, which helps to dissipate excess heat reducing cooling loads. However, cooling loads are still 50% higher than those of the Austral design.

As for the 'regular' houses in the temperate-north climate, again there is no strategy for solar control, and the plan is too deep with relatively small windows which will result in dark interiors. This house requires some 50% more cooling than the houses by Grupo Austral. Hours below comfort in passive mode add up to 26% and heating loads are of 26 kWh/m^2. These results show failing to benefit from solar gains and incurring high heat loss from single glazed windows. The 'environmental' prototype has very large windows facing north and protected in summer, and the main spaces benefit from thermal buffering which helps reduce the thermal loads. However, overheated hours remain above 3% in passive mode. Neither the 'regular'

Table 7. Thermal Performance Comparisons between Grupo Austral and government housing prototypes.

	1. WARM	2. TEMPERATE-NORTH	3. TEMPERATE-SOUTH	4. COLD
Grupo Austral % of time in comfort / above / below	91.4% 0.4% ↑ 8.2% ↓	93.4% 0.7% ↑ 5.9% ↓	75.9% 0.6% ↑ 23.5% ↓	66.7% 0.2% ↑ 33.1% ↓
heating / cooling	H2 KWh/m^2 C18 KWh/m^2	H2 KWh/m^2 C13 KWh/m^2	H18 KWh/m^2 C2 KWh/m^2	H28 KWh/m^2 C0 KWh/m^2
Regular prototypes % of time in comfort / above / below	86% 5% ↑ 10% ↓	71% 3% ↑ 26% ↓	53% 1% ↑ 46% ↓	64% 0% ↑ 36% ↓
heating / cooling	H7 KWh/m^2 C37 KWh/m^2	H26 KWh/m^2 C20 KWh/m^2	H71 KWh/m^2 C3 KWh/m^2	H28 KWh/m^2 C0 KWh/m^2
Environmental prototypes % of time in comfort / above / below	90% 4% ↑ 6% ↓	90% 3% ↑ 8% ↓	83% 1% ↑ 16% ↓	61% 0% ↑ 39% ↓
heating / cooling	H4 KWh/m^2 C27 KWh/m^2	H5 KWh/m^2 C12 KWh/m^2	H18 KWh/m^2 C1 KWh/m^2	H36 KWh/m^2 C2 KWh/m^2

prototype nor the environmental one have outdoor space for use when needed.

Regarding the two colder climates, the houses of Grupo Austral surpass the contemporaries in almost all aspects. The difference between the performance achieved by the two contemporary prototypes is significant. The 'regular' prototype fails to capture solar gains and keep the heat inside, thus its performance is the worst overall (46% of time below comfort resulting in 71 kWh/m^2 of annual space heating demand). The 'environmental' prototype betters Grupo Austral's in passive performance remaining similar in terms of thermal loads.

For the coldest climate, the 'regular prototype' has windows that are too small and protected on the sides, thus not taking advantage of solar gains. The 'environmental' prototype has a winter garden which helps to warm up the house. However, none of the designs adopted a smart strategy to control heat losses through buffer spaces. This is particularly evident in the coldest climate where a small double door is located behind the kitchen instead of using it to shelter the living space. With regard to thermal performance, the house of Grupo Austral displays the best performance, with 33% of time below comfort, compared to 36% for the regular prototype and 39% for the 'environmental' variant.

Discussion

Grupo Austral's designs were shown to respond consistently to climatic variations as becomes clear by the comparative studies. By encompassing not only interior spaces but also the outside, the house in the warmest climate offered an outdoor space that is as large as the house itself, completely shaded and open to air flow in all directions. The two patios in the temperate climates were open to the sky but being surrounded by the building offered a measure of both sun and wind control. The house for the coldest climate did not have an outdoor space, only a covered entrance.

Concerning the interior, living rooms are placed in the most advantageous area of the plan, which in the temperate and cold climates is facing north. In the warmest climate, the living area is facing south to avoid direct sun and benefit from cross ventilation. In all the cases, bedrooms face east for morning sun. Barn and kitchen are intentionally positioned as thermal buffers for habitable rooms reducing the effects of high solar incidence or excessive heat loss.

Overhangs and window sizes were carefully calibrated to provide solar control and wind protection in each context, which is evident in the simulation results summarized in Table 4.

In terms of thermal performance, designs by Grupo Austral show high percentages of time in comfort with barely any overheating, which suggests the effectiveness of the adopted strategies.

The comparison with contemporary prototypes showed the designs by Grupo Austral to fare very well. The contemporary prototypes experienced more overheating and lacked access to shaded outdoor spaces.

Conclusion

The analysis presented in this paper have shown that the design concepts of Grupo Austral's Regional Plan were remarkably well founded and closely adapted to their respective climates, despite the lack of relevant scientific knowledge at the time. Plan layouts were well thought out, passive strategies were adequately chosen, and the dwellings harnessed sun and wind effectively in all cases. These attributes translated into sound thermal performance, that could become optimal by upgrading the building fabric to contemporary thermal specifications. The four upgraded Grupo Austral schemes compare favourably with both the standard and the best practice prototypes now promoted for rural housing around Argentina. Grupo Austral had been widely known and respected among architects in Argentina for the remarkable quality of their designs and their strong progressive influence. The research presented in this paper has revealed a quality that had not been previously acknowledged in their architecture, and that is a quality of 'critical regionalism' that has still a lot to offer.

Note

1. In the later 1930's and early 1940's, there was no air conditioning in Argentina's countryside, not even by fans. Electricity was produced by local generators for use during evenings only. Space heating was using the fireplace, kitchen heat or kerosene heaters.

Disclosure statement

No potential conflict of interest was reported by the author(s).

References

BNA (Banco de la Nación Argentina). 1939. "Concurso Nacional de Anteproyectos Para Viviendas Rurales." *Concursos*, 1825–2006.

Bonet, Antonio, Juan Kurchan, Jorge Ferrari Hardoy, et al. 1939a. Ăustral 2: Plan Regional, Urbanismo Rural y Vivienda.Ňuestra Arquitectura no. 122, Buenos Aires, Argentina, pp. 36–51

Bonet, Antonio, Juan Kurchan, Jorge Ferrari Hardoy, et al. 1939b. "Austral 1: Voluntad y acción." Nuestra Arquitectura no. 119, Buenos Aires, Argentina, pp. 51–59.

Bonet, Antonio, Alejandro Vera Barros, and Abel Lopez Chas. 1939. "Austral 3: Casa de Estudios para artistas en Buenos Aires." Nuestra Arquitectura no. 125, Buenos Aires, Argentina, pp. 40–55.

EnergyPlus Development Team. 2017. *EnergyPlus Engineering Reference: The Reference to EnergyPlus Calculations*. *EnergyPlus Version 8.7*. US Department of Energy.

European Norms. 2007. *EN 15251: Indoor Environmental Input Parameters for Design and Assessment of Energy Performance of Buildings Addressing Indoor air Quality, Thermal Environment, Lighting and Acoustics*. Brussels: CEN.

Frampton, Kenneth. 1992. "Critical Regionalism: Modern Architecture and Cultural Identity in Modern Architecture: A Critical History." Thames and Hudson, pp. 314–327.

Liernur, Jorge F. 1994. "Arquitectura Moderna: El grupo Austral, Argentina, 1938–1942." Revista de Arquitectura no. 172, Buenos Aires, Argentina, pp. 25–40

Roudsari, Mostapha Sadeghipour, and Michelle Pak. 2013. "Ladybug: a Parametric Environmental Plugin for Grasshopper to Help Designers Create an Environmentally-Conscious Design." Proceedings of the 13th International IBPSA Conference Held in Lyon, France Aug 25–30th.

SCA (Sociedad Central de Arquitectos). 1939. "Concurso de Anteproyectos Para las Viviendas Rurales del Banco de la Nación Argentina." *Revista de Arquitectura* 226: 515–548.

Ward Larson, G., and R. Shakespeare. 1998. *"Rendering with Radiance: The Art and Science of Lighting Visualization*." San Francisco: Morgan Kaufmann Publishers, Inc.

Weller, H. G., G. Tabor, H. Jasak, and C. Fureby. 1998. ""A Tensorial Approach to Computational Continuum Mechanics Using Object-Oriented Techniques." *Computers in Physics* 12 (6): 620–631.